BROCA'S

LIGATIONS AND AMPUTATIONS

TRANSLATED BY

ERNEST WARD

A. E. Norb

LIGATIONS

AND

AMPUTATIONS

BY

A. BROCA,

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WITH 510 ILLUSTRATIONS

BRISTOL: JOHN WRIGHT & SONS LTD.

LONDON: SIMPKIN, MARSHALL, HAMILTON, KENT & CO. LTD.

TORONTO: THE MACMILLAN CO. OF CANADA LTD.

1917

2438

PRINTED AND PUBLISHED BY
JOHN WRIGHT AND SONS LTD., BRISTOL, ENGLAND

TRANSLATOR'S PREFACE.

THIS modest book has been translated in the hope that it may prove useful to English-speaking students of medicine as well as to French, and of interest to the many whose attention has recently been drawn again to these aspects of operative surgery. In peace time the teaching of Amputations and Ligations is regarded as little more than a means of introducing the student to the principles of surgical technique; but in war time these operations assume a special importance.

To many surgeons it seems astonishing how little alteration there has been in these branches of surgery during the last fifty years. Professor BROCA believes that, far from advancing, some of the guiding principles in performing amputations have been gradually lost sight of in recent years: in this volume he emphasizes their importance, and adds the information he has gathered from his war experiences.

The descriptions are given in careful detail, which is of especial advantage to the inexperienced, as it is often the little points which take longest to discover. It is chiefly a knowledge of little points which makes the difference between the recently appointed hospital surgeon and the man with several years experience on the staff.

Naturally, there are differences in the teaching of the two countries; but I have simply translated the book as it is written, without any editing or foot otes, leaving the reader to find the differences himself. The title alone I have altered, from "Précis de Médecine Opératoire," to "Ligations and Amputations," not wishing to appear to claim a wider scope for the book than it possesses.

E. W.

December, 1916.

PREFACE.

This book has a very definite object: to serve as a guide for students preparing for their practical examination in operative surgery. I do not claim that it is an original work; and if I am accused of infringing Farabeuf's admirable book, it will indeed be praise. All that I know, all that my fellow-students, contemporary or junior, know, of surgical anatomy and of operative surgery—ligatures, amputations and disarticulations—has been taught us by Farabeuf, either by his written or spoken words or by his actions.

But the student hardly reads Farabeuf's book; it is too long, and the operative procedures described are too numerous, for his taste; that is why this little book has been written, wherein one procedure is described for each operation.

The procedure best suited for operations on the cadaver has been selected; for although the contrary is sometimes urged, this is also the best for operations on the living whenever the condition of the soft parts allows.

It is advantageous, more often than is usually thought, to shorten the limb and cut a good flap in order to obtain a useful stump and so, eventually, a serviceable artificial limb. I have seen, alas, numberless stumps of every quality, and only too often have noted that the artificial limb will be poor, because the bone is insufficiently covered or the scar badly placed.

I do not insist further on this point, because, as I have just said, this book is written only for students who take knife in hand for the first time. The practical operative surgery which they are compelled to undertake is of use principally because students are thus compelled to revise their anatomy as it is applied to operations; it helps them also to attain that manual dexterity which every practitioner needs. For this purpose nothing is more valuable than ligatures and disarticulations.

I have been careful to describe, with each operation, the anatomical facts, a knowledge of which is necessary in order properly to examine the different regions, to find the landmarks of internal structures, and to proceed with safety.

The anatomical drawings in the text are nearly all from Farabeuf; some are taken from his book, others from the excellent wall diagrams which he used when teaching his students or his prosectors.

The illustrations of operative technique are from drawings, executed with great skill by M. Reignier, from a collection of stereoscopic photographs which I produced myself. I have tried to enable the reader to follow in these figures the successive positions, attitudes, and movements of patient, operator, and assistant, and to study by their means the proper handling of a knife; in short, to understand the general rules of surgical technique. To prevent confusion, the hands of the assistant are tinted grey. I have endeavoured as far as possible so to arrange each figure, and the description which accompanies it, that the reader need not turn a page in order to follow some step or movement; and it has generally been possible to group on the same page the successive movements of each stage of the operation.

A. B.

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BROCA'S LIGATIONS AND AMPUTATIONS.

SECTION I.
THE LIGATURE OF ARTERIES.

CHAPTER I.
GENERAL INSTRUCTIONS.

STUDENTS can never perform too many of these operations; they are excellent for training their manual skill, and give them also an accurate knowledge of the course of vessels, nerves, and tendons—the structures, that is to say, which must not be divided accidentally in everyday surgical procedures, such as the opening of an abscess.

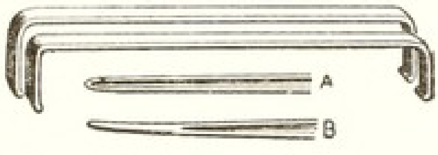


Fig. 1.—Retractors and directors.

The *instruments necessary* are :—

1. Scalpel.
2. Dissecting forceps, which hold well at the points.
3. Director.*
4. Two retractors, of which Farabeuf's model is the most convenient (*Fig.* 1).
5. An aneurysm needle.

The successive steps of the operation are :—

A.—The search for the vasculonervous bundle.

B.—Isolation of the artery.

C.—Ligature of the artery.

Place yourself always facing the line of your incision, the body parallel to it.

A. *The search for the vasculonervous bundle* must proceed methodically step by step. The skin and subcutaneous tissue are first divided, then the deep fascia, after which the muscular interstices are entered, and the position of the various structures which serve as landmarks is noted in passing. It is important always to make sure *the joints of the subject are supple*, and to move them therefore if they are stiff.

* It is better to have two of these: one grooved to the end (*Fig.* 1 A), with a point capable of tearing the connective-tissue planes and piercing easily the fascia which is to be divided (see p. 4); the other, probe-pointed (Nélaton's director, *Fig.* 1 B), is very convenient for clearing arteries.

1. Before incising the skin the *line of incision* must be determined. It runs nearly always parallel to the course of the vessel, but exceptionally it may cross it (ligature of the external iliac, for instance, the subclavian, and the axillary in its first part). Beginners would do well to mark with a dermographic pencil the course of the vessel. This is ascertained by attention to the *surface anatomy* as revealed by inspection and palpation : skin folds, tendinous or muscular eminences and the corresponding hollows, bony projections, and the lines of joints, are noticed. In many cases (carotid, brachial, radial, and femoral arteries) the line of the vessel can be verified by palpating with the whole hand the intermuscular groove in which it lies (*Fig.* 2).

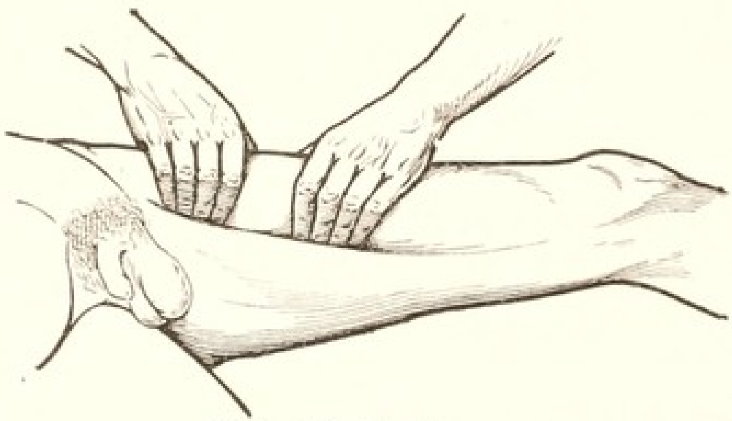


Fig. 2.—Palpating the groove.

In the limbs these lines run parallel to the axis of the limb; and it is well to know that, operating carefully in this direction, a deep abscess, or the bone, can be reached without injury to the artery or nerves whose course has previously been noted. Do not hesitate to mark with a pencil the external landmarks just enumerated, so that they may be always before you ; and certain other points, too, may be marked, which indicate levels—for instance, in the neck, the cricoid and thyroid cartilages.

2. *To incise the skin*, begin by fixing and *stretching it between the left thumb and index finger*, which should be applied together over the line of incision and parallel to it, then separated so that this line appears between them.

With a little practice it is possible to divide the skin in one stroke without injury to the subjacent fascia, but beginners are often compelled to make one or two attempts before reaching the subcutaneous tissues. The most important fault is to make the *incision incomplete at the ends*—what may be called a ' tailed ' incision.

The skin should be completely divided at both ends, and under it the successive tissue planes also should be divided for the same length ; you will thus *be working in a rectangular space and not at the bottom of a funnel*; this is, moreover, the only way to separate properly the lips of the wound and to see into it clearly.

Take the scalpel fully in your hand as you would grasp a table knife, the free end of the handle resting against the thenar eminence, the sides held near their junction with the blade between the thumb and middle finger, the index finger stretched along the back of the blade above its heel. Now *prick* the skin perpendicularly with the knife at the left extremity of the line of your incision ; when you have passed through the skin—a sensation easily acquired—lower the handle, and with the blade slightly inclined to the axis of the limb, *draw* the knife from left to right in one stroke, cutting with the full blade; arrived at the right extremity of the wound, *raise the handle* again and bring the point out, again perpendicular to the skin.

Let me repeat: *draw the knife from left to right the whole length of the incision*; this is the typical direction of all movements in every operation. Make the lips of the incision gape equally by separating the thumb and index finger.

3. In the *subcutaneous tissue* the nerve filaments are always negligible; the veins, too variable in their anatomy to be serviceable landmarks, should be spared—on the cadaver, because to divide them floods the wound with black blood. The course of the principal veins, therefore (such as the median basilic, saphenous, and external jugular), should be known beforehand. They often show on the skin of the cadaver as a brownish line, or the precaution may be taken to make them prominent by centripetal pressure before incising the skin. When a vein is seen, it is freed by drawing the point of the knife gently along one of its borders (the border away from the direction towards which the vessel is to be displaced).

This brings you to the deep fascia, which should be seen, white and pearly, from one end of the incision to the other; note carefully its white or fatty lines and any longitudinal depressions there may be.

4. *For dividing the fascia* two methods are allowable, but in each case the limb must first be placed so that the subjacent muscles are tense:—

a. If the artery is some distance away, at the bottom of an interspace, or protected by a projecting muscle, cut directly. Holding the knife like a pen, prick the fascia perpendicularly to a depth of two or three millimetres at the extreme left of your incision, then divide from end to end from left to right.

b. If the artery lies just beneath the fascia, it is safer to use a director, the best being one which is not probe-pointed. At one end of the incision, right or left as the case may be, tear a little hole in the fascia, holding the instrument perpendicular to it, then, dropping the handle, gently push the director under the fascia to the other end of the incision. Proceed carefully so as not to perforate the artery when making the first opening, and after raising the fascia on the director, make sure you have not lifted the artery as well, by running the index finger along the groove. Next, place the back of a scalpel in the groove of the director, handle close to handle, and push, left to right or right to left as the case may be, until the point is arrested by the tip; bring the instruments away together parallel to the wound, without the point of the knife leaving the groove, which thus protects it and prevents it slipping into the depths of the wound (*Fig.* 3).

If Nélaton's probe-pointed director is used, nothing stops the knife, so it is prudent to push the probe point out at the other end of the incision and divide the whole fascia under your eyes (*Fig.* 4).

After division of the deep fascia, the limb is placed in a position to relax the muscles, and various manœuvres are necessary to separate them, to seek for an interspace, or to free a nerve or a vein. Retractors are now used, placed in position always by yourself; forceps, held always in the left hand like a pen; and a director or scalpel, according to the instructions which will be given for each special ligature. The rule is never to proceed without recognizing in passing the successive landmarks and the adjoining structures—muscles, tendons, or nerves. Never hold a retractor in the left hand while working with director or scalpel in the right.

Enlargement of the glands is sometimes troublesome, though it is true they accompany the veins by preference; if they overlap the artery, especially in the neck, remove them before proceeding further.

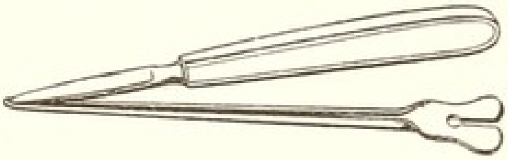


Fig. 3.

Fig. 4.—Dividing the fascia.

B. The artery is now reached. It is accompanied by two veins—a single one in the case of large vessels—and is to be freed from these, and cleaned, before tying.

In a vasculonervous bundle, structures can easily be recognized from their *appearance*. The *artery* is grey pink, tinged with purple, and is flattened, with a mesial longitudinal groove very obvious in large vessels; its walls are thick, and it can be rolled under the fingers when lying on firm tissues (beginners would do well to educate their index finger to recognize this). The *vein* is flaccid and blue, and its thin wall is not felt by the examining finger. The *nerve* is a white cord, uniformly cylindrical, which can be rolled under the finger.

C. To *clear an artery*, it must first be separated from its connective-tissue sheath. To do this, pinch the sheath longitudinally with a pair of forceps that bite well at the points, held in your left hand, and raise gently the little transverse fold in order to free it from its base; now with the point of your knife, held flat to the artery but perpendicular to the fold, make a little buttonhole at the base of the latter. Do not let go the forceps, but place the end of a director between the lip you hold and the artery. First give two or three little strokes in a longitudinal direction, until the opening is a third to half an inch long; then *clear the artery*. This is done by little strokes of the director, dropping its handle while the point is gently pushed between the deep surface of the artery and the sheath held stretched by the forceps. Do not stop until the other side of the artery is reached; then seize the other lip of the buttonhole and recommence the process in the reverse direction, so completing the work which was already three-quarters done. Do not now let go the sheath you hold, but instead of the director, pass an aneurysm needle through the tunnel. For

Fig. 5.—Pinching the sheath.

Fig. 6.—Buttonholing.

clearing large arteries, Nélaton's probe-pointed director is the best instrument. (*Figs.* 5, 6, 7.)

The aneurysm needle should nearly always be passed in a definite direction, the general rule being to enter it on the side where lies some structure that must not be injured, vein or nerve for instance. To avoid loss of time, therefore, in useless movements, clearing should be commenced on the side the needle should emerge, and finished on the side it should enter ; this allows the operator to put down his director and take up the aneurysm needle without changing the position of the forceps.

Fig. 7.—Clearing the artery.

The ligature should be passed at the middle of the incision exactly at right angles to the vessel. It is tied in a flat knot without dragging it towards one, so as to avoid loosening the artery for the whole length of the wound. The first half-knot is tied with a short pull on the two ends of the ligature, held carefully in the plane of the vessel ; the second half-knot should be correctly tied to form a *reef* knot, otherwise it may slip.

The following is a convenient method of practising reef knots with some string and a piece of wood. Take the two ends of the string by their extremities between thumb and index finger of the corresponding hands ; pass the right end in front of the left and fix it between the left index and middle fingers, which hand now holds the two ends crossed like a much elongated X. Take in your right hand the left end (which is now to the right), and pass it from before backwards under the right end (which is now most to the left). The knot will be a reef knot if the second half-knot is tied inversely ; that is to say, the end now to the right (originally left) is passed in front ; and then under this, from before backwards, is passed the left end (originally the right).

Chapter II.

LIGATURE OF ARTERIES IN THE UPPER LIMB.

1. GENERAL ARRANGEMENT.

The Brachial Artery is a large trunk situated on the inner side of the arm. It is found under the internal border of the biceps, accompanied by the median nerve, which passes in front of it nine times out of ten.

From its outer side and above, a large collateral vessel takes origin, the superior profunda, which rounds the posterior aspect of the humerus quite close to the bone, then leaves it on the outer side, between it and the supinator longus, at about the junction of the upper two-thirds with the lower third of the bone. This vessel is not itself exposed to danger, but is accompanied by the *musculospiral nerve*, which is endangered in fractures of the shaft of the humerus. The posterior and external aspects of the arm may therefore be incised without danger *nearly* to the bone.

To the inner side of the brachial artery and behind, separated by an intermuscular septum, descends the *ulnar nerve*.

These relationships are shown in *Figs.* 8 and 9, where it is seen that there is a danger zone on the inner side of the arm, where lie the median and ulnar nerves as well as the brachial artery (see also the sections, *Figs.* 14 and 15).

At the *bend of the elbow* (*Fig.* 9), the brachial artery lies between the biceps tendon externally and the median nerve internally. In front it is separated from the median basilic vein by the semilunar fascia. Posteriorly the elbow is only dangerous to incise on the inner side (*Figs.* 8 and 9), where the ulnar nerve passes between the olecranon and the internal epicondyle, bony prominences which are easy to feel.

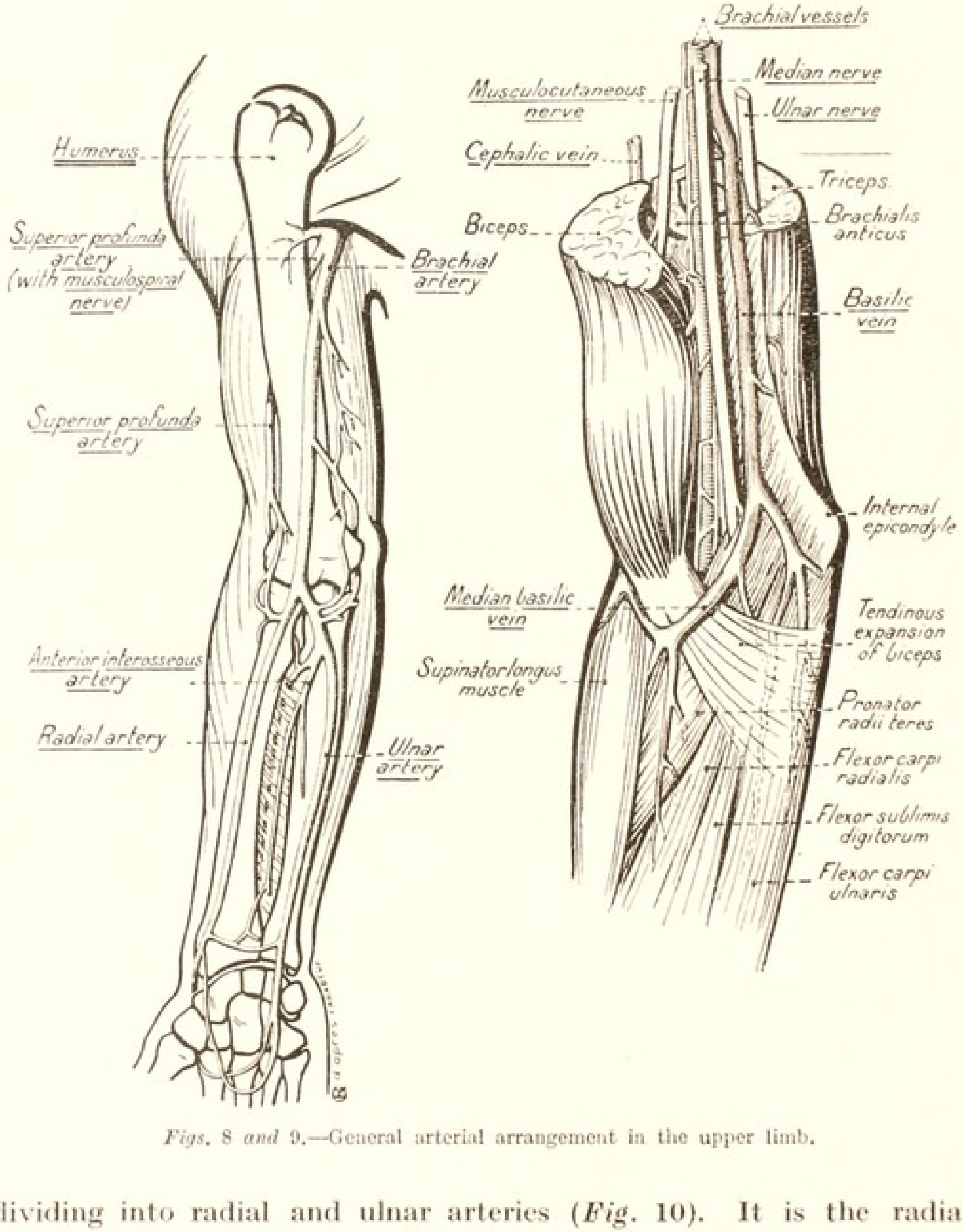
In the *forearm* also, the posterior aspect may be incised without fear of hæmorrhage or the division of a nerve, for all the large vessels and nerves are in front (*see Figs.* 16 to 18).

As shown in *Fig.* 8, at the line of the joint, or one finger-breadth below the inter-epicondylar line, the brachial artery divides into radial and ulnar arteries. The ulnar soon gives off a large interosseous trunk.

2. LIGATURE OF THE AXILLO-BRACHIAL TRUNK.

Course.—For the purposes of operation the axillary artery must be divided into two very different segments: the lower segment, which is approached by way of the axilla, must be studied at the same time as the brachial artery; the upper segment, which is approached under the clavicle through the pectoral muscles, must be considered with the subclavian.

The axillo-brachial trunk, then, if we may consider it in this way, begins at the level of the *coracoid process*, and ends in the forearm *one inch below the fold of the elbow*, and at the centre of the fold, by



Figs. 8 and 9.—General arterial arrangement in the upper limb.

dividing into radial and ulnar arteries (*Fig.* 10). It is the radial which continues in the same direction as the main trunk.

The upper landmark to search for is the *apex of the axilla*, which may be marked by sinking the index finger as high as possible into the axilla along the posterior surface of the great pectoral muscle, the finger pulp towards the head of the humerus, the arm being slightly abducted.

To *mark the bend of the elbow*, a director is placed, with one hand, transversely on the anterior surface of the limb, groove towards the skin, while with the other hand the elbow is flexed to the maximum. The director, thus caught in the angle of flexion, is forced against the apex of this angle, and marks by two grooves the place where its lips have pressed (*Fig.* 11).

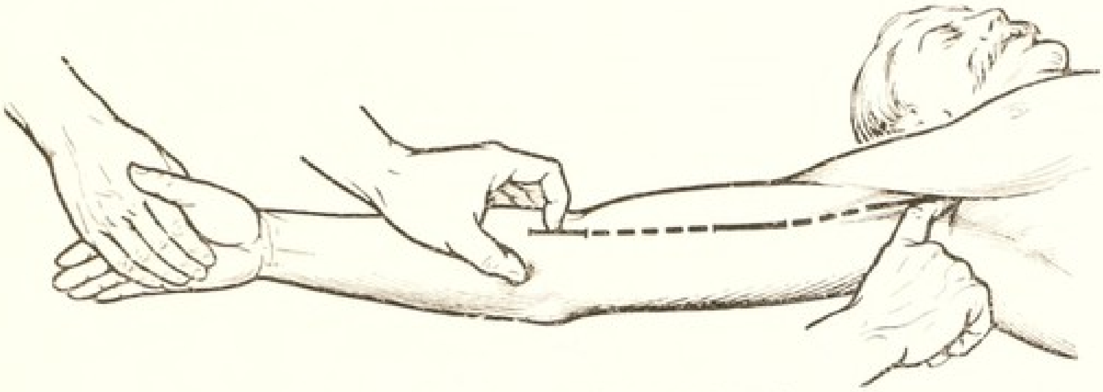


Fig. 10.—Line of the axillo-brachial trunk.

To mark the *mid-point of the fold of the elbow*, grasp the two humeral epicondyles between the thumb and middle finger, and search for the mid-point between these with the index finger ; the mid-point lies *against the inner border of the biceps tendon*, which thus gives a definite landmark. In a thin subject the tendon is seen and felt at once when rendered tense by extension and supination of the forearm. In a subject where the tissues are œdematous, or infiltrated with fat, flex

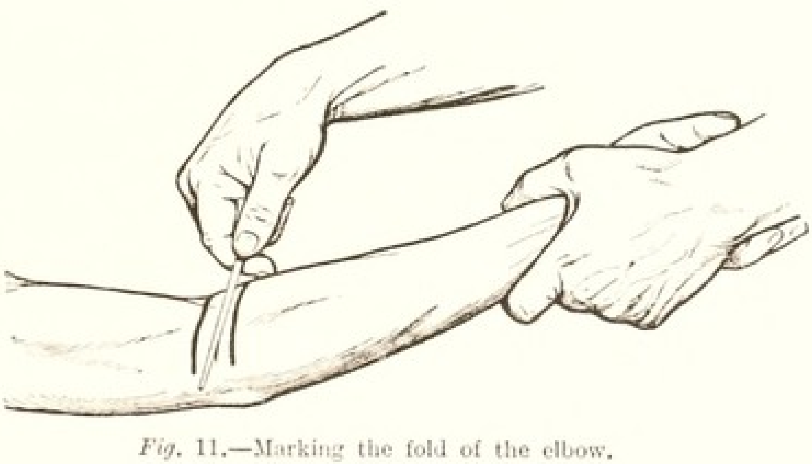


Fig. 11.—Marking the fold of the elbow.

the elbow to a right angle with one hand, and with the other pinch the fold of the elbow between the thumb and index finger, then extend and supinate the forearm, and the tendon, which you have pinched when relaxed, escapes from your grasp as it becomes tense ; a stroke with the nail then suffices to mark its inner border.

Along this line, which must be considered to run horizontally and transversely, as the arm is held abducted at a right angle, the artery is in close relation with the *short head of the biceps* (and in the axilla with the coracobrachialis also), which lies along its course to the outer side and above—or in front, if we consider the subject placed vertically.

This muscle mass causes a prominence on the antero-internal surface of the arm, which even reaches into the axilla in thin but muscular subjects ; below, it narrows into the tendon, which passes deeply at the bend of the elbow. In the arm, at its junction with the internal intermuscular septum, behind which lies the inner head of the triceps, a groove is formed easy to feel with the fingers.

With the arm abducted at a right angle, a tense cord may be felt (sometimes even seen) in this groove, when the subject is thin—the median nerve—and this may even be followed into the axilla, where it is continued by the brachial plexus.

Operation.—For all ligatures of this vessel the arm is held abducted at a right-angle, the surgeon inside, the assistant outside the limb.

The classical ligatures are :—

A.—In the axilla.
B.—At the middle of the arm.
C.—At the bend of the elbow.

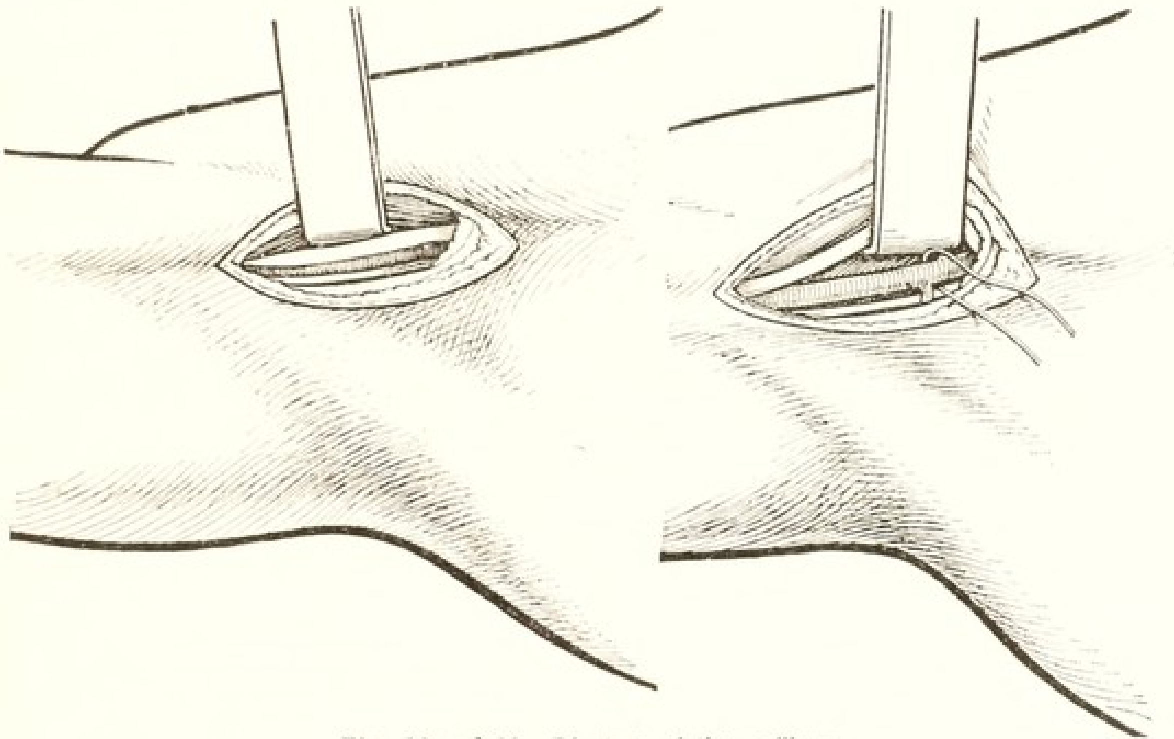
A. ***The Axillary in the Axilla.***—The subject should be brought right to the edge of the table and placed quite flat on his back ; the assistant, standing on the outer side, takes the limb by the forearm, and presents it abducted at least to a right angle, a little flexed at the elbow, the forearm semipronated, but with *no rotation*.

The operator seats himself opposite the axilla, and makes an incision three inches long at the upper end of the line described above. The *incision* should pass a little beyond the apex of the axilla, and extend for three-quarters of an inch over the chest wall. It should be behind the lower border of the pectoralis major—easy to see and feel—but close to this muscle ; over the prominence, often to be seen, of the coracobrachialis and biceps ; in front of the hair line, and also, when perceptible, of the prominence due to the brachial plexus. It must be remembered throughout the operation that the artery lies against the antero-external wall of the axilla, and that it is no use hunting for it posteriorly.

The skin in retracting reveals the lower border of the pectoralis major muscle, close to the posterior surface of which the *deep fascia is to be divided*, with the *knife held horizontally*. The large end of a retractor can now be passed under the *great pectoral*, which is *raised vertically* by the assistant. Just behind this muscle, against the external wall, the *coracobrachialis* and *biceps* muscles must next be found, and their sheath divided from end to end of the incision. The posterior border of these muscles is freed with a director and pulled aside on a retractor thrust deeply in (*Fig.* 12) ; a step which is facilitated if the assistant momentarily diminishes the abduction of the arm to relax the muscles.

In place of the muscle can now be seen and felt a tense cord, the *median nerve*, which must be freed from end to end of the wound with a stroke of the director—always given from arm towards the axilla, otherwise there is risk of injury to the nerve by piercing the fork made by the junction of its two roots. The nerve when freed is also taken on the retractor, and raised vertically (*Fig.* 13).

The *artery* is now found in the place where the nerve was lying. It must first be *isolated from the veins.* There is always a large *venous trunk to the inner side and behind,* a little lower and nearer to the operator, therefore, and this must be displaced backwards; it is a continuation of the internal brachial vein, reinforced by the basilic. The *external brachial vein,* before joining the main trunk, passes to a rather higher level and crosses the artery superficially; it often receives the circumflex veins (external collateral route), so that before proceeding further one must be sure that this venous system is not hiding the surface of the artery.



Figs. 12 and 13.—Ligature of the axillary.

Once liberated from the veins, the artery is cleared; then the aneurysm needle is passed, from behind forwards, on account of the position of the vein—that is, from below upwards, as the operator is seated. The artery must be cleared as high as possible in the axilla, so as to pass the ligature above the circumflex arteries, the origin of which is recognized before tying the knot (*Fig.* 13); one vessel arises in front, the other behind, at right angles to the main trunk; they mark the boundary between the axillary and brachial arteries.

I must lay stress on the point that the axillary structures lying behind the median nerve should never be displaced; always work high up and not low down. Sometimes the musculocutaneous nerve may first be met against the coracobrachialis, and not the median; it will be recognized by its size and course, running towards the coracobrachialis, into which it passes; knowing that it springs from the outer head of the median, that nerve is easily found.

B. ***Brachial in the Middle of the Arm.***—Make a *skin incision* two inches long, preferably two or three millimetres in front of the line of the vessel, certainly not behind it, so as to reach the fleshy body of the biceps and not pass behind the muscle border. For this first step and the following the elbow is extended.

There is nothing to fear in the *subcutaneous tissue*; the basilic vein is certainly behind the incision.

Open the *deep fascia* from end to end of the incision, over the biceps muscle, the border of which must always be seen before proceeding further. (When the incision is made behind the line of the vessel, and the border of the biceps is not seen in the wound, the internal intermuscular septum is reached, and the operator runs the risk of dividing this behind the artery; the ulnar nerve may then be taken for the median, and the inferior profunda artery for the brachial.)

Free the *border of the biceps* by a stroke of the director from end to end of the wound, and have it raised, vertically, on the broad end of a retractor, flexing the elbow to relax the muscle. In its place, under a thin layer of fascia, lies the *vasculonervous bundle*; open the fascia from end to end, either on a director or with the point of a scalpel; nine times out of ten the *median nerve* will now appear.

With a longitudinal stroke of the director, held flat to the arm, pass under the posterior surface of the nerve and have it raised, vertically, by the assistant, on the same retractor as the biceps.

In place of the nerve the artery, with its two accompanying veins, is now seen; clear the vessel, and pass the aneurysm needle indifferently from one side or the other.

Remember that in about one case out of ten the nerve is behind the artery.

C. ***The Brachial at the Bend of the Elbow.***—The elbow is held extended, the forearm supinated.

A nearly transverse *incision* is sometimes advised, but this is, in my opinion, very ugly, and does not give any better access than an incision *parallel to the vessel*, that is to say, made somewhat obliquely downwards and outwards along the internal border of the biceps tendon, over the point where the line of the brachial in the arm joins the line of the radial in the forearm.

The *incision* should be two and a half inches long, and is supposed to be made half above and half below the fold of the elbow; but since the artery deepens as it descends, just as does the biceps tendon, the work is made easier if two-thirds of the incision is placed above, and one-third below, the bend of the elbow: a modest trick that will never count against a candidate in an examination (*see Figs.* 10 and 11).

Always begin by an effort to *define the course of the median basilic vein* (*Fig.* 9), which may be made to fill and stand out by pressure from below upwards on the front of the forearm. If seen, the line of operation can easily be placed two or three millimetres outside it. In any case incise lightly, so as to divide the skin only, and pass through the subcutaneous tissue with care. If the *median basilic vein* be met, as is usually the case, liberate it by drawing the scalpel along its outer border, and have it drawn inwards (small end of the retractor).

There is now nothing more to fear until the *deep fascia* is reached, which must be cleaned most carefully in order to see the *tendinous expansion of the biceps*.

A little above the fold of the elbow there arises from the inner side of the biceps tendon a flattened tendinous sheet, which passes obliquely downwards and inwards, spreading out, fanwise, to be inserted into the crest of the ulna. In the fork between this ulnar tendon and the rounded radial tendon of the biceps lie the brachial vessels, the median nerve, and the upper part of the muscles arising from the internal epicondyle. The tendinous expansion joins the deep fascia, into which its fibres pass, and where they can be recognized by their obliquity. If the fascia is carefully cleaned, the upper edge of the expansion is easily seen; moreover, if pressed with the point of a director, the difference in thickness and tension will be felt from this edge downwards (*see Figs.* 9 and 19).

The *brachial artery*, accompanied by two veins, is *just under the aponeurotic expansion of the biceps on the same level as the main biceps tendon*. To *divide the bicipital expansion*, prick with the point of a director just above the upper border of the expansion, recognized as just explained, and pass the instrument obliquely downwards and outwards—that is, perpendicularly to the upper edge. Pass the left index finger along the groove of the director, and then divide the expansion on it. Next take each lip of the cut surface in turn in the forceps, separate it, free it by a longitudinal stroke of the director, and have it retracted (small end of the retractor). The artery lies between the two retractors. If the operation is well done, neither the biceps tendon to the outer side, nor the median nerve to the inner side, should be seen.

Pass the aneurysm needle from within outwards.

3. LIGATURE OF THE RADIAL ARTERY.

This artery is tied:—

A.—In the forearm.

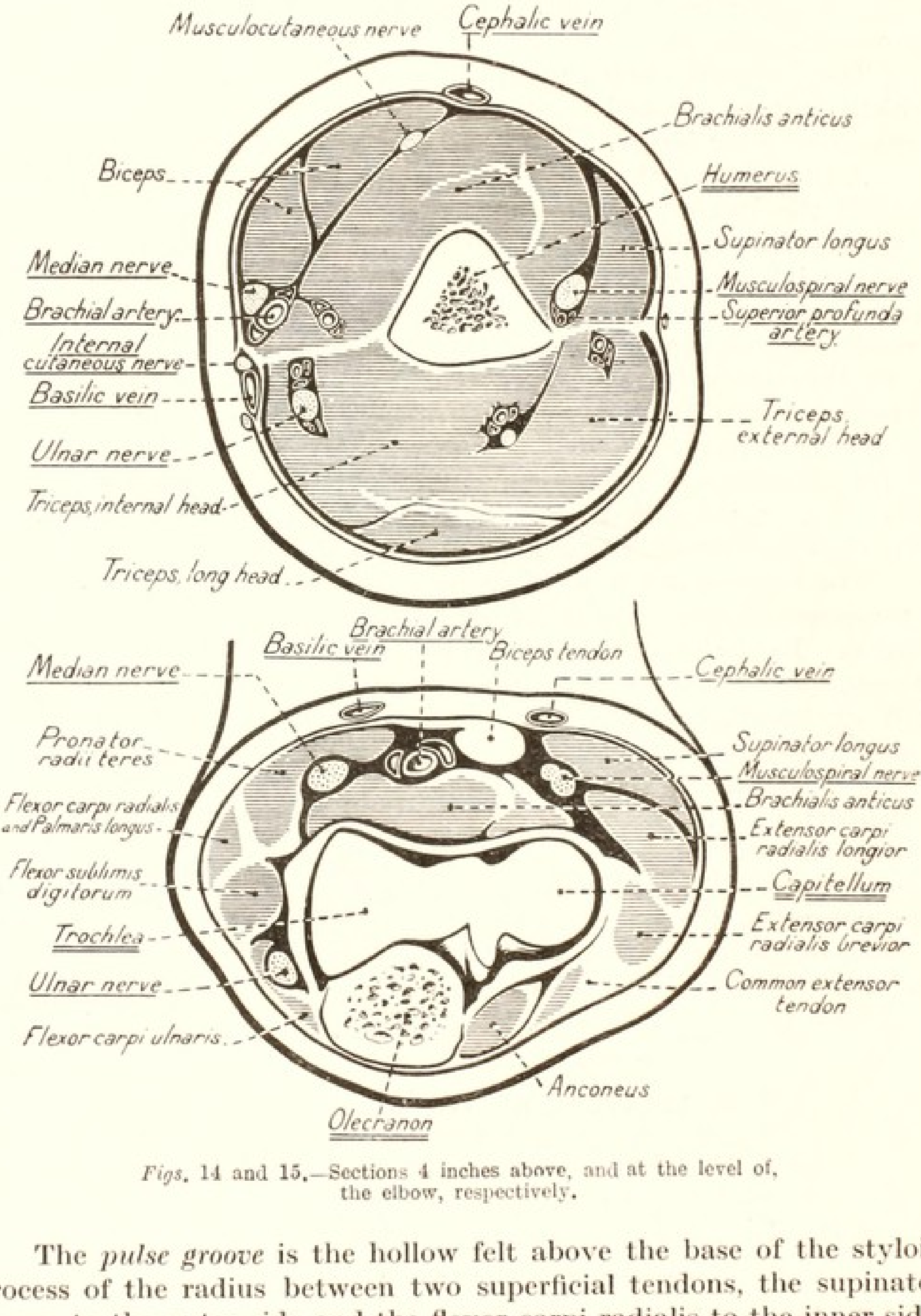
B.—In the anatomical snuff-box at the point where it passes to the posterior surface of the hand.

A. *In the Forearm.*

Course (*see Fig.* 19).—The radial artery takes origin at the bifurcation of the brachial, about one inch below the fold of the elbow. It passes externally, then dorsally (*see* p. 17) under the styloid process of the radius. It can easily be tied at any part of its course.

The incisions are made along a *line* which continues in the same direction as the line of the brachial artery, from *the mid-point of the fold of the elbow to the pulse groove* (*Fig.* 20).

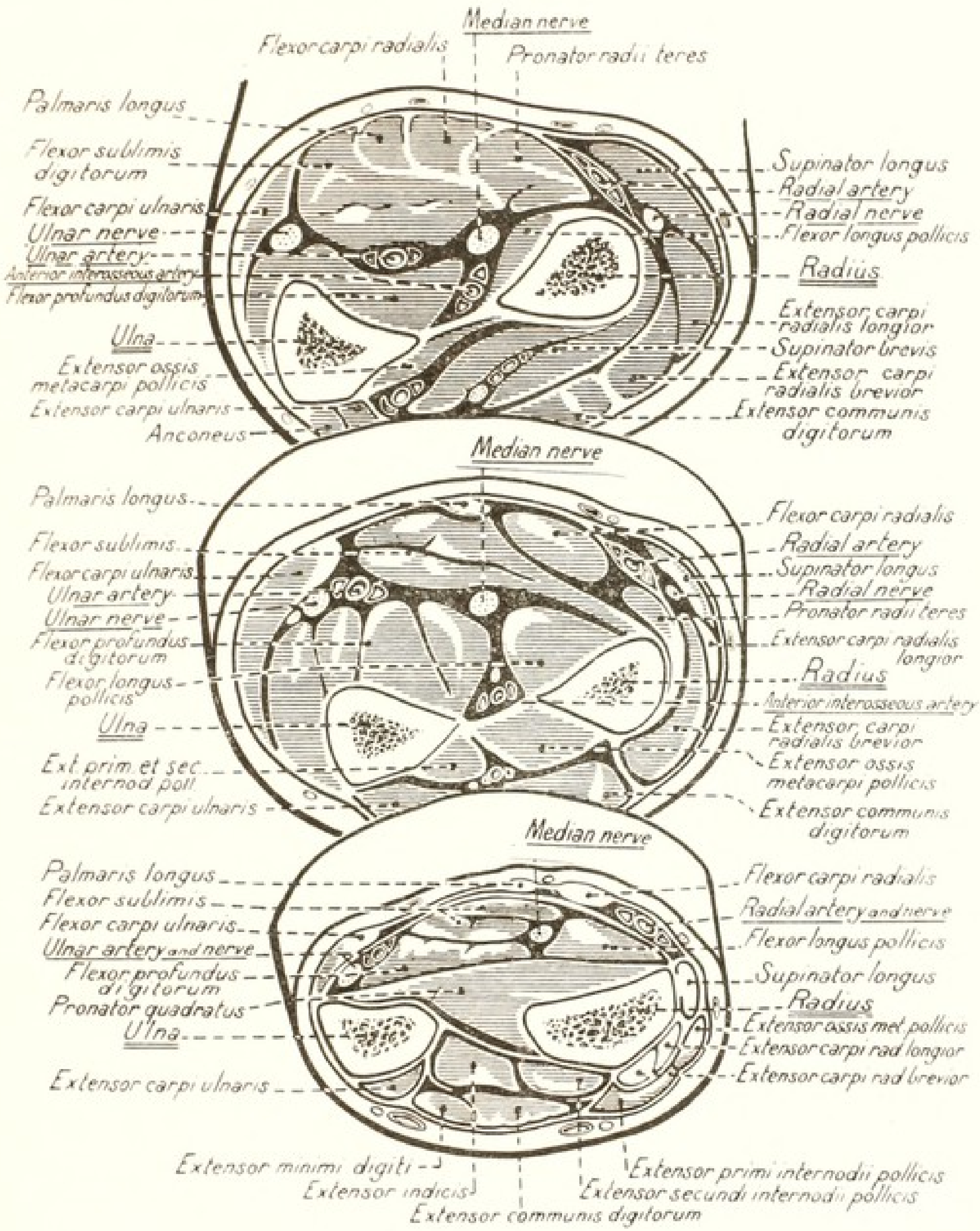
To mark the *mid-point* of the fold of the elbow, see p. 9 (*Fig.* 11).



Figs. 14 and 15.—Sections 4 inches above, and at the level of, the elbow, respectively.

The *pulse groove* is the hollow felt above the base of the styloid process of the radius between two superficial tendons, the supinator longus to the outer side and the flexor carpi radialis to the inner side.

The hollow is continued upwards as a depression which can readily be felt with the pulps of the four fingers applied longitudinally to the forearm. On the inner side this depression is bounded by two muscles arising from the internal epicondyle, the *pronator radii teres* above, the *flexor carpi radialis* below; to the outer side, along the whole length of the forearm lies the *prominent internal border of the supinator longus*, broad and muscular above, thin and tendinous below (see sections, *Figs.* 16 to 18).

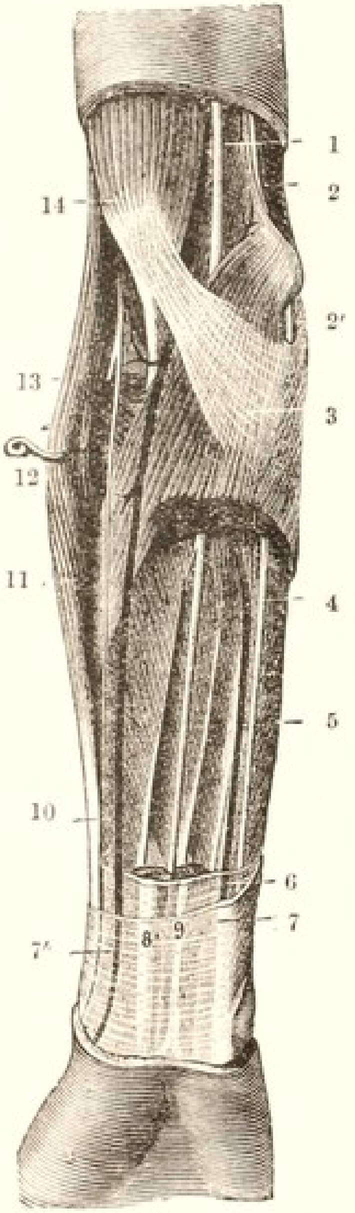


Figs. 16, 17 and 18.—Forearm: Sections from above downwards.

The artery is accompanied by *two veins*. The *radial nerve* runs alongside externally, but at some distance away, especially above, and is not in the same sheath; so that it ought not to appear in the field of operation.

Operation.—The assistant, standing on the inner side, presents the limb to the surgeon abducted at a right angle, the forearm extended and supinated. The operator stands on the outer side, and can operate therefore with the limb flat on the table.

1. Ligature in the Upper Third.—The *incision* should not reach higher than three finger-breadths below the bend of the elbow, so that it may still remain possible to tie the brachial artery at that level under good conditions.



1. *Median nerve* and *brachial artery* resting on the brachialis anticus muscle.

2 and 2′. *Ulnar nerve* lying, in the arm, behind the internal intermuscular septum, passing behind the internal epicondyle, and coming forwards between the two heads of origin of the flexor carpi ulnaris.

3. *Tendinous expansion of the biceps*, binding the muscles which originate from the internal epicondyle, and passing to the crest of the ulna. Below the expansion these muscles are shown divided (except the pronator radii teres), in order to exhibit the structures beneath.

4. The *ulnar artery* as it meets the nerve, which then passes downwards to its inner side.

5. *Median nerve.*

6. *Intermuscular aponeurosis*, covering the tendons of the flexor carpi radialis and palmaris longus (8) and (9), and the ulnar artery and nerve. These structures are also covered by

7. The *deep fascia*, which overlies also the tendon (divided) of the flexor carpi ulnaris (see below).

14. The *biceps* at the bend of the elbow, sending inwards from its radial tendon an expansion (3) through which it is inserted into the ulna also.

13. The *posterior interosseous nerve*, leaving the *musculospiral* to the outer side and behind, and piercing the supinator brevis muscle.

12. The *supinator longus*, retracted to show

11. The *radial nerve*, which follows to the outer side the course of

10. The *radial artery*, which lies above on the pronator radii teres, lower down on the flexor sublimis digitorum, and is covered below by

7′. The *deep fascia*, which ensheathes the tendons of the supinator longus and flexor carpi radialis (8) seen through it. It is separate from the fascial sheath of the flexor carpi radialis and palmaris longus, and passes directly from the supinator longus to the flexor carpi ulnaris.

Fig. 19.—Anatomy of the front of the forearm.

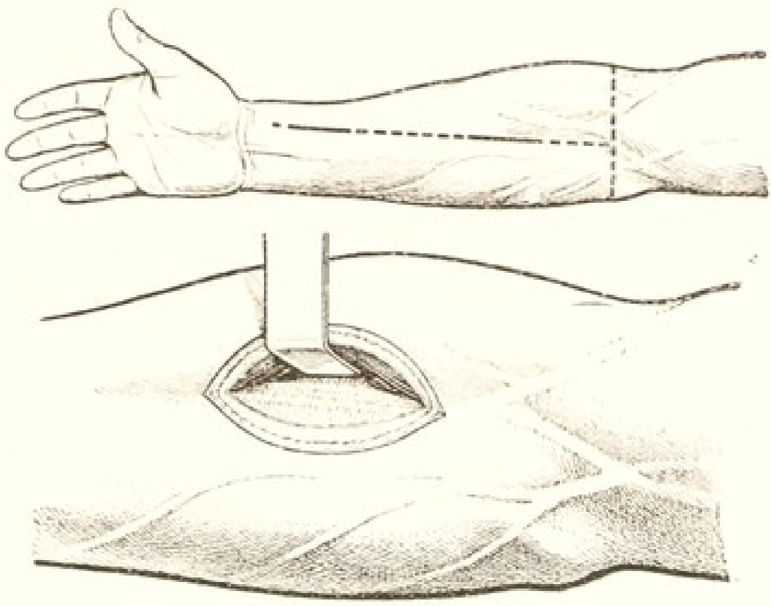
To ascertain whether one of the superficial veins passes over the field of operation, the operator is well advised to make the veins stand out by pressure from below upwards.

The incision should be about two inches long. Under the *deep fascia*, which should be well exposed, a white or yellowish line is often seen, marking the interspace at the *internal border of the supinator longus*. The fascia is divided with the point of a scalpel along this line, and the muscle is drawn outwards, after seeing its border, with the narrow end of a retractor (***Fig.* 21**).

The flexor carpi radialis is not seen, united as it is to the pronator radii teres by a *layer of fascia*, in which, exactly, lie the artery and veins. In the position previously occupied by the border of the supinator longus, the vessels are seen under this fascia, which must next be divided. This may be done by tearing it from end to end with a director; but a more experienced operator buttonholes the fascia, just as in opening an arterial sheath, thus making a window about half an inch long.

Clear the vessel. Pass the aneurysm needle from without inwards, although the nerve is some distance away.

2. Ligature in the Pulse Groove.—The *lower boundary* is the lower extremity of the radius. The assistant holds the wrist in extension, so stretching skin, fascia, and tendons. Make an incision in the *pulse groove* rather nearer the supinator longus than the flexor carpi radialis; the *incision* should be vertical, a little more than an inch in length.



Figs. 20 and 21.—Ligature of the radial artery.

Under the skin and subcutaneous tissue the *deep fascia* is reached, which must be defined carefully by light strokes with the point of the scalpel.

The artery lies just beneath this fascia, which is opened (if the operator is sure of himself) in a little buttonhole at the middle of the wound; otherwise he may pierce the fascia at the lower extremity of the wound with the director, and insinuate the latter horizontally upwards. Pass the finger over the director before cutting, because the artery is here very superficial and may well have been raised on the instrument.

Now direct the assistant to flex the wrist and so relax the tendons; retract each lip of the wound with the small end of a retractor; clear the vessel; and pass the aneurysm needle *indifferently* from one side or the other.

B. *In the Anatomical Snuff-box.*

Course.—To pass from the anterior surface of the forearm to the dorsal surface of the hand, the radial artery rounds the extremity of the styloid process of the radius and passes under the tendons bounding the anatomical snuff-box—the extensor ossis metacarpi pollicis and extensor primi internodii pollicis to the outer side, the extensor secundi internodii pollicis to the inner side.

The vessel passes obliquely downwards, backwards, and inwards, following a line from the tip of the styloid process of the radius to the upper limit of the first interosseous space. It is in contact deeply with the trapezium, so that it must be sought for in the lower part of the snuff-box.

Operation.—The assistant, standing at the end of the limb, presents the hand with the radial border uppermost. With one hand he pulls downwards the four fingers, with the other he raises the thumb and drags it towards him, the proximal phalanx flexed, so making the tendons of the snuff-box stand out, easy both to see and feel (*Fig.* 22).

Fig. 22.—Radial in the snuff-box.

The operator stands on the outer side of the limb.

The *incision* is made along a line, rather more than an inch long, passing *from the tip of the styloid process to the base of the first metacarpal bone*; it passes between the two tendinous margins and equi-distant from them, so *bisecting the snuff-box.*

Cut the *skin* lightly, so as to avoid the *cephalic vein* of the thumb, which nearly always follows the axis of the snuff-box in the subcutaneous plane: draw the point of the knife along one of its borders, and having thus got rid of it, divide the deep fascia. The small end of a retractor may now be placed on each tendinous cord; but it is nearly always useless. Take a director then, and scratch with its point the back of the trapezium in the lower part of the incision (above you might open the wrist-joint); this is done in two strokes, down and up, following carefully the obliquity of the artery, one above and the other below it. Thus the vessel is exposed, and without clearing it with a knife, the aneurysm needle is passed *indifferently* from either side, perpendicularly to the direction of the vessel.

4. LIGATURE OF THE ULNAR ARTERY.

Course.—From its origin at the bifurcation of the brachial, one inch below the middle of the fold of the elbow, the ulnar artery does not take a straight course, but changes in direction as it descends (*Fig.* 19).

1. *In the upper third of the forearm* it runs obliquely downwards and inwards, covered by the flexor sublimis digitorum in front, lying on the flexor profundus digitorum, until it reaches the *interspace between the outer border of flexor carpi ulnaris and the inner border of flexor sublimis digitorum.* From this point,

2. *In the lower two-thirds of the forearm*, it descends vertically, to the outer side of the ulnar nerve, for the whole length of the above interspace (which becomes intertendinous below).

The nerve descends vertically, direct from the bend of the elbow, and is therefore, in the upper part of the forearm, some distance from the artery to its inner side.

The *line of operation* should lie over *the interspace between flexor carpi ulnaris and flexor sublimis digitorum*, that is, along a line drawn from *the most prominent part of the internal epicondyle to the external border of the pisiform bone*. The common error (not to speak of mistakes with the lower landmark, the pisiform bone, which are inexcusable) is to draw the line from the front of the internal epicondyle along the anterior surface of the forearm. Now, although the line of the vessel becomes anterior at the wrist, higher up it should be placed definitely on the internal border of the limb.

Operation.—The assistant, placed to the outer side, presents the limb extended at the elbow and supinated, the arm abducted to a right angle and projecting beyond the edge of the table. The operator places himself to the inner side.

1. Ligature in the Upper Third.—The operator is seated before the inner border of the limb, which is held horizontally.

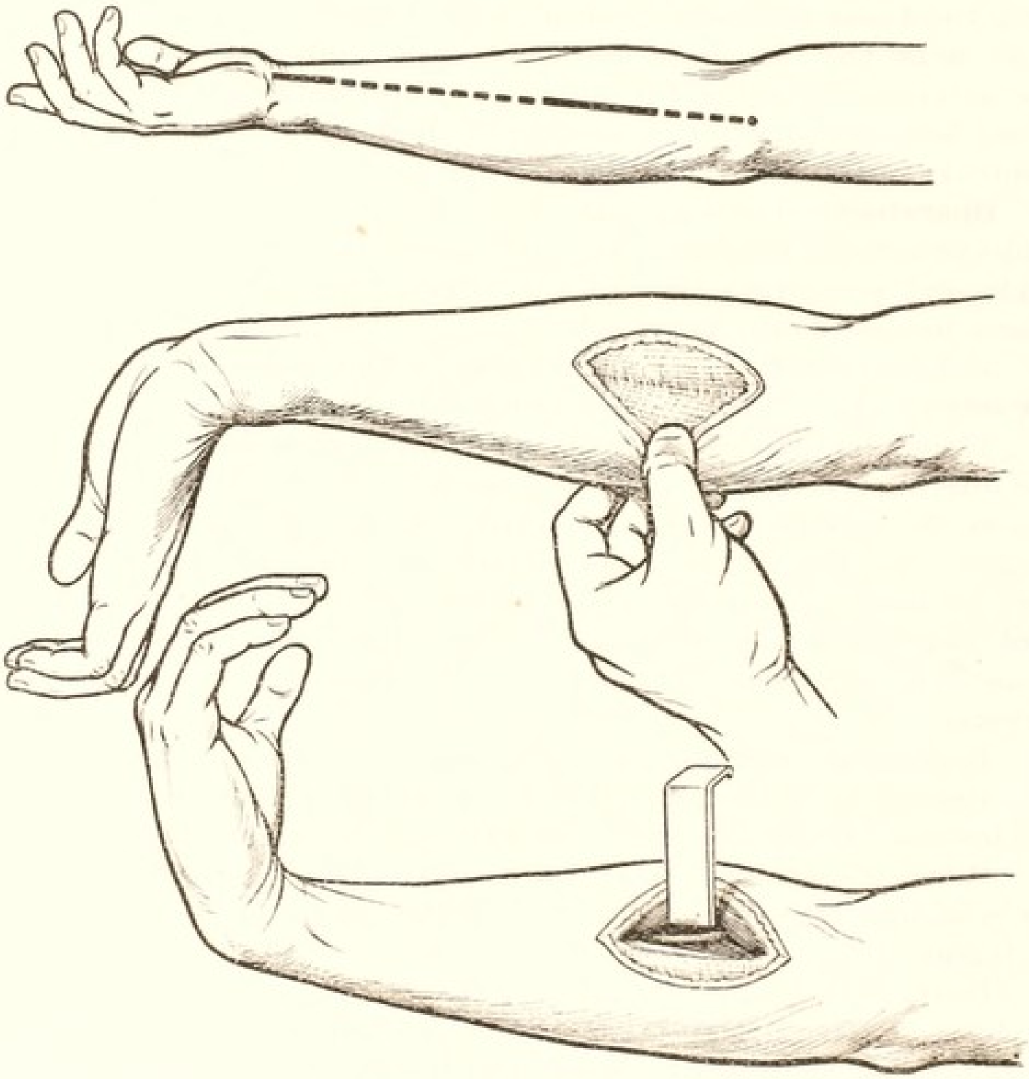
The upper limit of the *incision* should be *three finger-breadths* below the internal epicondyle, for two reasons: (*a*) The artery at its origin lies in the middle of the forearm, therefore far from the internal border; (*b*) The flexor carpi ulnaris and flexor sublimis digitorum muscles have a common origin from a tendinous intersection which runs downwards from the internal epicondyle; the interspace between them only commences, therefore, below the upper quarter of the forearm.

Beginners would do well to end their incision even three and a half finger-breadths below the internal epicondyle. From this upper limit the incision should extend downwards for two and a half inches.

When the skin has been incised, and the *deep fascia clearly exposed*, the muscular interspace, along which the fascia will be opened, must be found.

Instruct the assistant to *extend the wrist* so as to put muscles and tendons on the stretch, then drag with the left thumb the posterior lip of the incision towards the crest of the ulna, and look carefully into the wound. Nearly always a white strip will be seen *running downwards from the internal epicondyle*, getting thinner as it descends, and beyond it a whitish or yellowish line, into which the point of a director can be pressed. Give a glance to make sure that this corresponds to the pisiform-epicondylar line, and then divide the fascia, *with the point of a scalpel*, from end to end of the wound and from left to right, *over the white intersection*: to this the flexor carpi ulnaris adheres more firmly than the flexor sublimis digitorum, at any rate below.

A search for the interspace should now be made *in the lower part of the wound*, against that muscle which is not adherent to the fascia and therefore bulges into the slit—the flexor sublimis. A delicate fatty line is noticed; into this push the point of a director, somewhat obliquely downwards and inwards, because the border of the flexor carpi ulnaris sometimes overlaps the flexor sublimis. As soon as it is certain that the point of the director is in the interspace, *direct the assistant to relax the muscles by flexing the wrist* (*Fig.* 25), then thrust the director further in, up to an inch in depth, holding the instrument horizontally, but perpendicular to the axis of the limb, and free the muscle from below upwards. It must be done from below upwards because the fibres of the flexor sublimis form an angle, open below, with the fascia from



Figs. 23, 24, and 25.—Ligature of the ulnar artery above.

which they take origin. Slide the large end of a retractor under the loosened muscle, in place of the director, telling the assistant to draw it directly upwards (and not obliquely towards himself, as he nearly always does).

The first structure seen, near the fascia, is the *ulnar nerve*, which passes from end to end of the wound. The nerve must always be seen before continuing; if not visible, make sure, first of all, that it has not been retracted, and if this is not so, you must be passing through the fibres of the flexor sublimis, not working in the interspace.

Having seen the nerve, remember that the *artery lies outside it, towards the centre of the limb,* resting on the flexor profundus digitorum. Near the elbow the artery is well away from the nerve, but reaches its outer border in the lower part of the incision, and can be seen passing obliquely to this position. Pass the aneurysm needle from within outwards at the centre of the incision.

Anomaly.—If the artery is not where it should be, make sure first of all that it has not been retracted; if it is not under the retractor, it probably lies superficially, and will be found under the anterior lip of the divided fascia, between the fascia and the flexor sublimis digitorum.

2. Ligature in the Lower Third of the Forearm.—With the wrist extended, to render fascia and tendons tense, make a vertical *incision* one and a quarter inches long, above the pisiform bone, and a *few millimetres outside the flexor carpi ulnaris tendon.* The artery lies under the tendon, so this line is a little outside it; but when the skin retracts, the incision will lie along the outer border of the tendon. If the incision is exactly over the tendon, it will be exposed when retraction takes place, and the result is ugly.

Define the deep fascia carefully.

The artery is very near the surface, but is covered in this position by *two layers of fascia*: (i) *The deep fascia of the forearm,* which ensheathes the tendons of palmaris longus and flexor carpi ulnaris, and between these passes, like a bridge, over the tendons of flexor sublimis digitorum; (ii) *The intermuscular aponeurosis* which passes in a semicircle from radius to ulna, ensheathing all the flexor group of tendons with the exception of those named. Therefore:—

a. Open the deep fascia from end to end of the wound with the point of the knife, *under the inner lip of the incision,* against the tendon of flexor carpi ulnaris, kept on the stretch by extension of the wrist.

b. Have the wrist flexed, put the small end of a retractor on the *tendon of flexor carpi ulnaris, and draw it inwards.* Now open the aponeurosis, button-holing it by the direct method if you are sufficiently experienced, or else open it on a director passed from above downwards (pass the index finger along the groove of the instrument before cutting, lest the artery may have been raised with the fascia).

Clear the vessel, and pass the aneurysm needle from within outwards.

3. Superficial Palmar Arch.—The ulnar artery differs from the radial in that it remains on the anterior aspect of the forearm, and descends on to the front of the hand to form the superficial palmar arch.

It can be followed, therefore, to the outer side of the pisiform bone, at the base of the hypothenar eminence, and if the incision is prolonged so as to *bisect the angle between the upper and middle palmar folds,* you are following the line of the *superficial palmar arch,* which lies immediately under the palmar fascia.

Chapter III.

LIGATURE OF ARTERIES IN THE LOWER LIMB.

1. LIGATURE OF THE EXTERNAL ILIAC ARTERY.

Course.—The external iliac artery runs in the subperitoneal tissue along the brim of the true pelvis against the internal border of the psoas muscle. A large vein runs with it to the inner side and behind, but comes to lie exactly to the inner side at the crural ring, where the artery becomes continuous with the common femoral artery. It reaches from the sacro-iliac synchondrosis to the crural ring, and its *course* lies along a line *from the umbilicus to the middle of the fold of the groin* (*see Fig.* 27). It gives off no branches until just before reaching Poupart's ligament (deep epigastric inwards, deep circumflex iliac outwards).

Operation.—The subject is flat on his back ; the surgeon stands on the side to be operated upon, his assistant faces him.

The *line of incision* (three inches long) runs *parallel to, and one finger-breadth above Poupart's ligament*, with its centre over the artery at the mid-point of the fold of the groin (*Fig.* 27). The operation is made easier if the outer extremity of the incision is curved upwards, which renders possible a more extensive exploration of the iliac fossa.

Under the *skin and subcutaneous tissue*, the *aponeurosis of the external oblique* must be cleaned and then divided. The fibres of the *internal oblique and transversalis* muscles are now seen. An experienced operator will divide these with the full cutting blade of his scalpel in several strokes, and knows how to stop at the right moment in the subperitoneal tissue without opening the peritoneum ; a beginner should proceed carefully, and seek for the border of these muscles outside the inguinal canal, close to Poupart's ligament, with a director. The muscles are then freed from within outwards, scraping the upper surface of the ligament, the director pointed towards the thigh to avoid opening the peritoneum.

Similar precautions should be taken with the *transversalis fascia*, which is divided at the middle of the ligament, and quite close to it, for a distance of one inch. The large end of a retractor is now introduced, the handle towards the umbilicus, and the tissues are retracted from below upwards, the handle of the instrument being somewhat raised so as to strip back the peritoneum under which the end has been slipped. In this manner the subperitoneal plane of cleavage is opened in the iliac fossa, along the course of the artery, and the vessel is now seen. Clear as high as possible, and pass your aneurysm needle from within outwards.

2. LIGATURE OF THE FEMORAL ARTERY.

Course.—The *femoral artery*, which is a continuation of the external iliac, *enters the thigh anteriorly through the crural ring*, lying between Poupart's ligament in front, Gimbernat's ligament internally, the iliac fascia on the outer side, and the iliopectineal eminence posteriorly. It then descends almost vertically (for it is the femur, truly speaking, which winds round the artery), and crosses the inner border of the femur *four finger-breadths above the internal condyle*, passing at this point through the *opening in the adductor magnus* to the posterior aspect of the limb, where it becomes the popliteal artery.

This course corresponds to *a line* drawn from the *middle of the fold of the groin to the posterior surface of the internal condyle of the femur*, but which comes to an end four finger-breadths above the condyle.

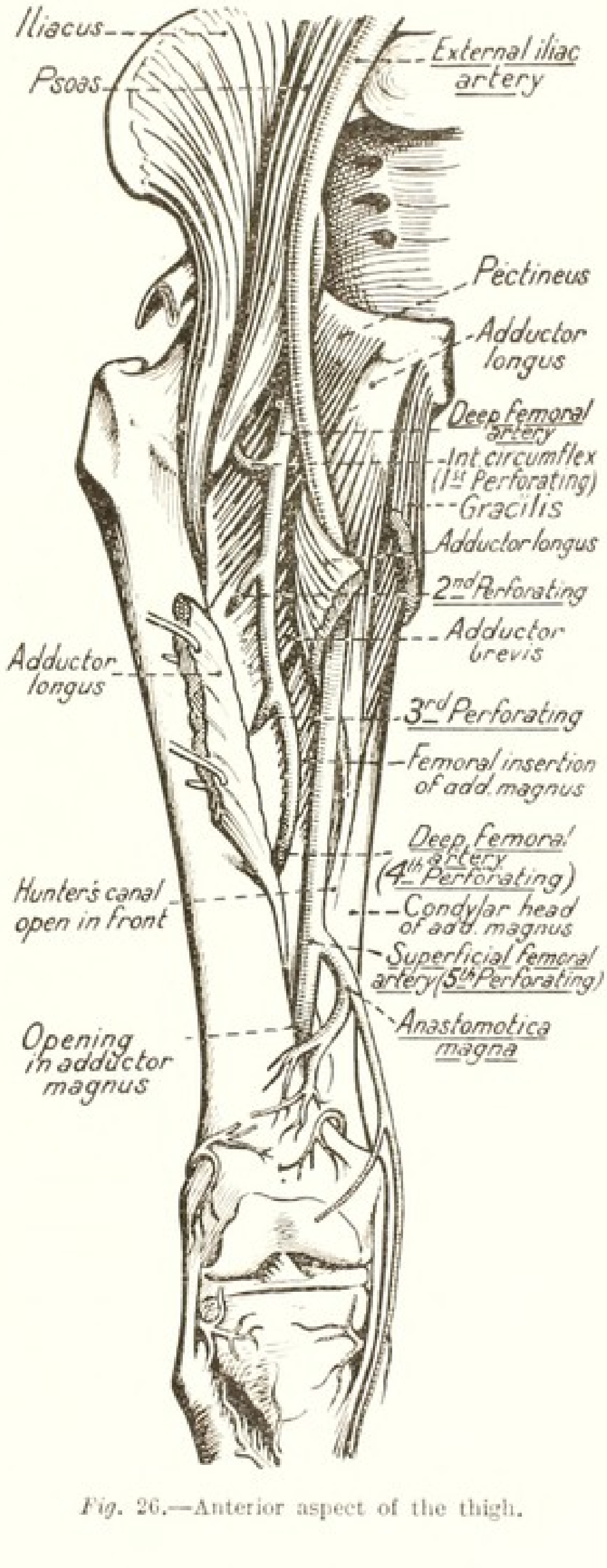


Fig. 26.—Anterior aspect of the thigh.

The *line of the fold of the groin runs from the anterior superior spine of the ilium* (always easily felt) *to the pubic spine*. To feel the pubic spine it must be approached from below upwards, not from above downwards. Pinch the mons veneris as low down as possible between the thumb and index finger, then, all the while keeping the tissues closely grasped so as to feel the bones, push the fingers upwards towards the abdomen. As the bones spread out, the fingers become separated until arrested under the pubic spines, which overhang, so to speak, the broadest part of the pubis at its junction with the pectineal ridge.

To mark the mid-point of the fold of the groin, place the thumb and middle finger, like the points of a pair of compasses, on pubic spine and anterior superior spine of the ilium, and mark the mid-point between them with the index finger. The artery is a little inside this point; its pulsations can be felt in the living, for it rests posteriorly on bony structures (edge of acetabulum or head of femur), a fact which allows it readily to be compressed at this level.

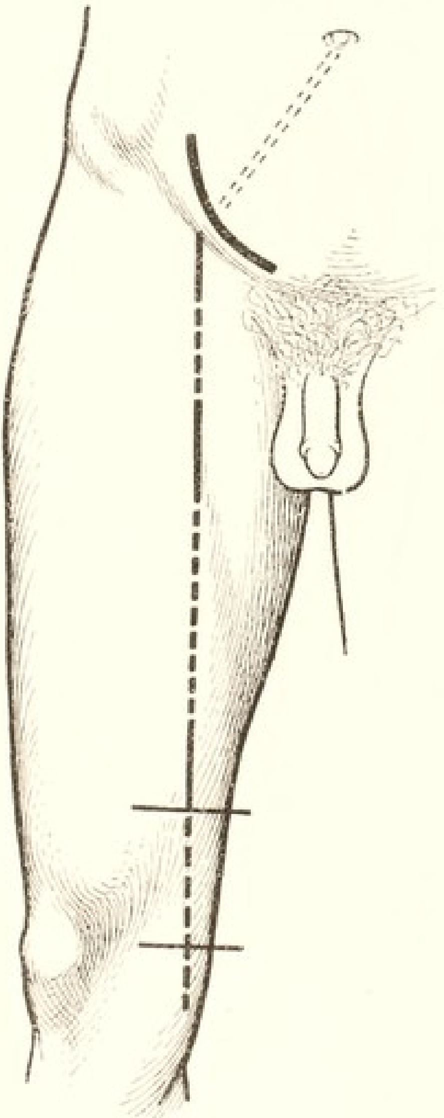


Fig. 27.—Line of the femoral artery.

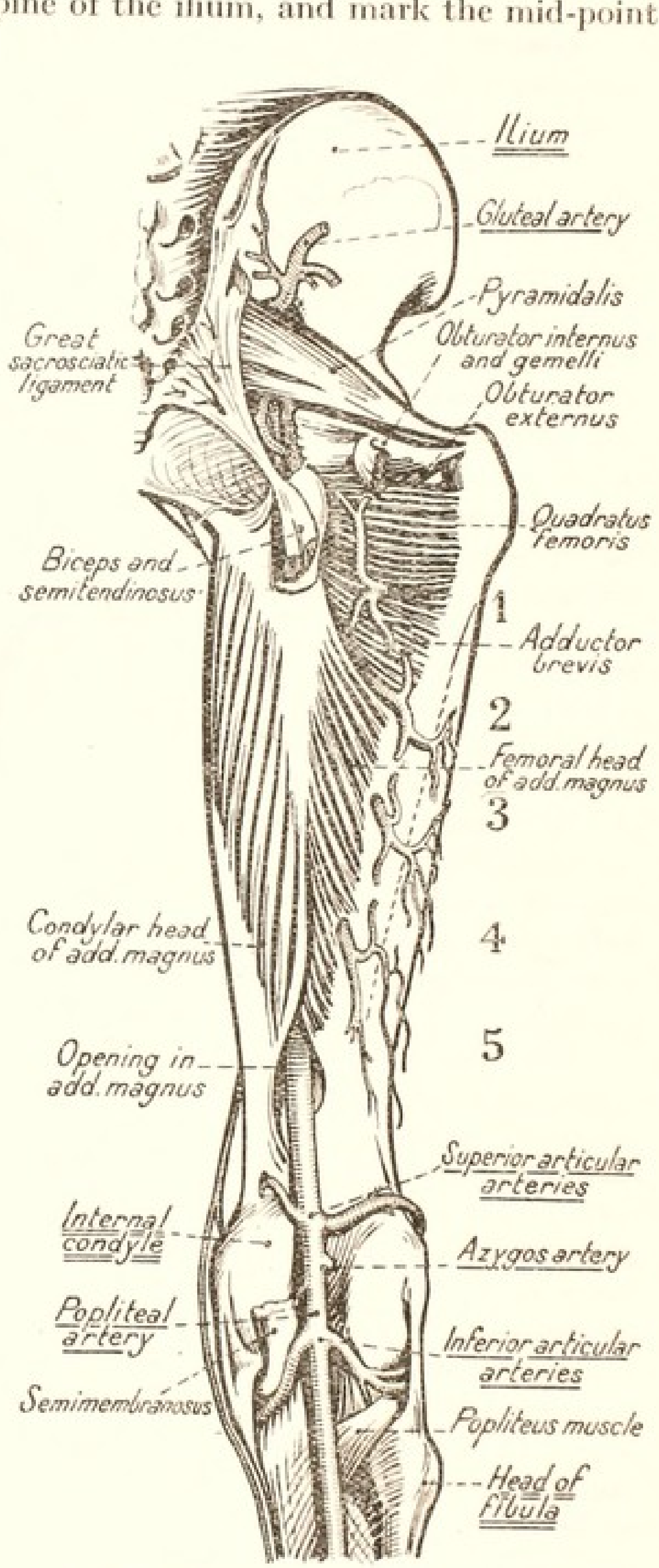


Fig. 28.—Posterior aspect of the thigh.

The lower landmark should also be marked, *behind the internal condyle of the femur*—in the popliteal space therefore.

The line corresponds in the deeper tissues to *the bed of the artery* in the angle between two muscular planes: (1) the peri-femoral muscular sheath (vastus internus); (2) the adductor group descending fan-wise from the ischiopubic region of the pelvis to the linea aspera of the femur and the internal condylar ridge below. The position of the bed can be verified by palpation with the pulps of the fingers.

The muscle *most related to the vessel* is the *sartorius*, which runs from the anterior superior spine to behind the internal condyle, thus lying first outside the artery and some distance away from it, then in front (from this point only is it used as a landmark) in the middle third of the thigh, lastly to the inner side and behind (*Fig.* 29).

Lying in the psoas sheath, the *anterior crural nerve* is separated from the femoral artery by the iliac fascia. Emerging from the sheath it terminates in a spray of branches, one of which, *the long saphenous nerve*, enters the sheath of the vessels in front of the artery.

The *femoral vein*, a single one, lies to the inner side of the artery at its commencement; it gradually passes posteriorly until, in the popliteal space, it comes to lie definitely behind the artery.

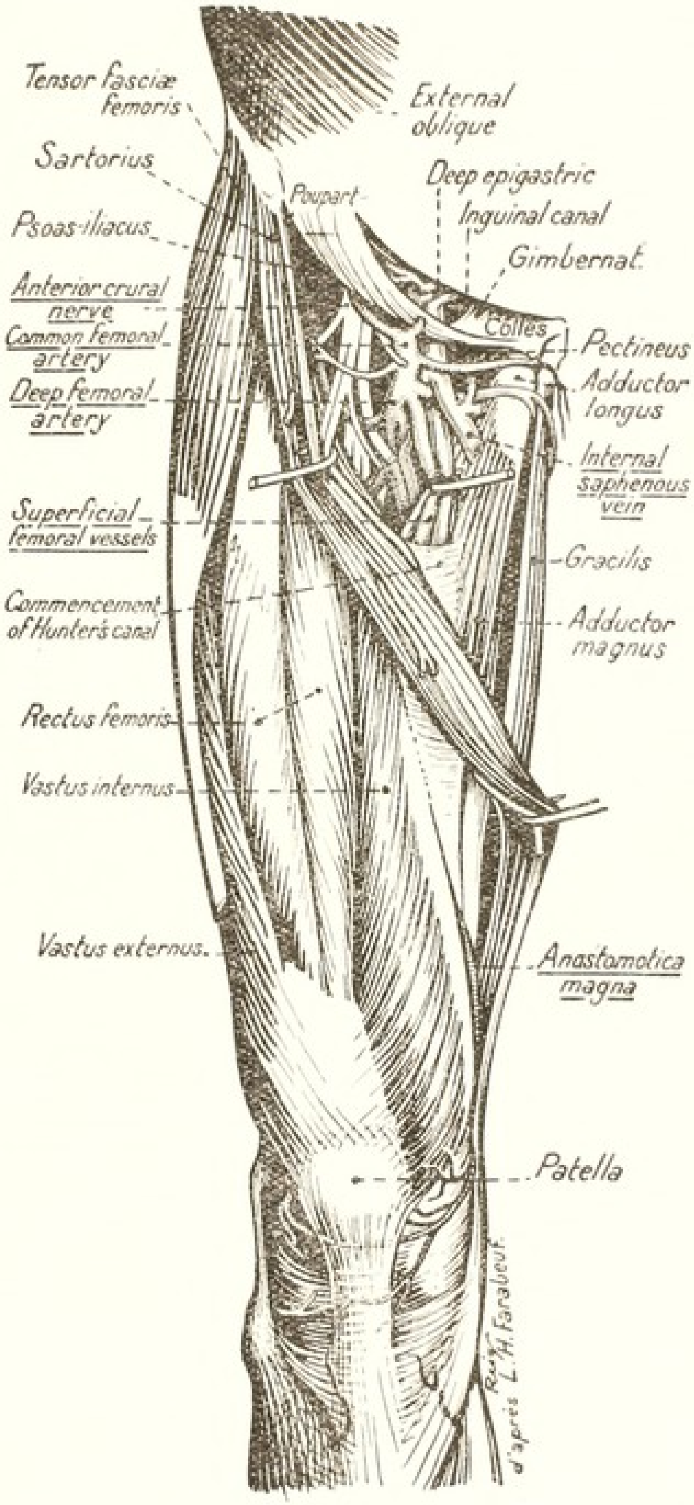


Fig. 29.—The sartorius muscle and the femoral artery.

The anatomy and distribution of the arteries of the thigh may be studied in detail in *Figs.* 26 and 28, and the means by which collateral circulation is established after ligature may thus be understood. This takes place through the system of perforating arteries.

Below Poupart's ligament, sometimes very close to it, the *deep femoral artery* takes origin, forming with the superficial femoral a ∧ which sits astride the upper border of adductor longus, so that the deeper artery descends between adductor longus and adductors brevis and magnus, close to the inner surface of the femur. From the postero-internal aspect of this vessel a series of perforating arteries arise and pass through tendinous and muscular interspaces to the posterior aspect of the thigh, behind adductor magnus, where they divide into ascending and descending branches which anastomose freely with one another. In this way a posterior collateral arterial route is formed, and is ready to dilate if necessary. There are two, or sometimes three, perforating arteries, properly so-called; but *higher up*, the *internal circumflex artery*, passing above pectineus and appearing behind between quadratus femoris and adductor brevis, constitutes the first link in the chain, and communicates through its ascending branch with the terminal branch of the sciatic artery coming from the internal iliac. Below the third perforating artery the termination of the trunk of the deep femoral forms a fourth perforating artery. Finally, the passage of the superficial femoral through the adductor magnus gives us a fifth perforating vessel, the popliteal artery, with which the posterior collateral route is connected by various peri-articular anastomoses. *Figs.* 26 and 28 show the departure from in front and the arrival posteriorly of these perforating arteries, 1, 2, 3, 4, 5.

Operation.—*The three classical sites of ligature* are: (1) *At the base of Scarpa's triangle* (ligature of the common femoral artery); (2) *At the apex of the triangle*; (3) *In Hunter's canal.*

The surgeon always stands outside the limb, which is stretched flat on the table; his assistant faces him.

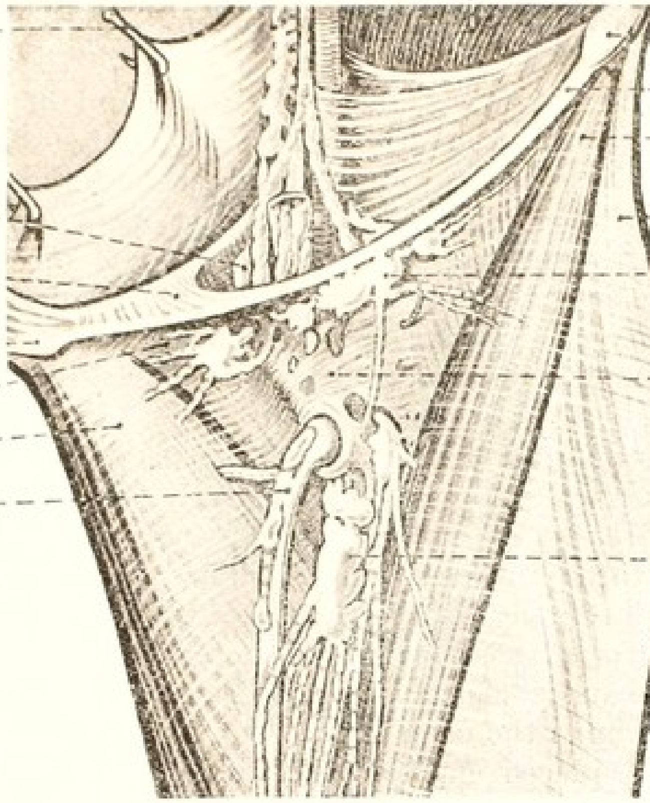
1. Ligature at the Base of Scarpa's Triangle.—This triangle is bounded above by Poupart's ligament, to its outer and inner sides by the sartorius and adductor longus muscles respectively. The artery rests on the angle formed by the meeting of the psoas iliacus muscle externally and the pectineus internally. It is covered by *superficial fascia* and by the deep fascia, *fascia cribriformis*, stretching like a bridge between sartorius and adductor longus. Between these two layers runs the internal saphenous vein, which turns backwards above, like a shepherd's crook, to pierce the fascia cribriformis and end in the femoral vein. A number of lymphatic glands may trouble the operator, though for the most part they lie in front of the vein. In order to avoid these, as well as the internal saphenous and femoral veins, the incision is made at the mid-point of Poupart's ligament, over the outer border of the artery (*see* p. 5).

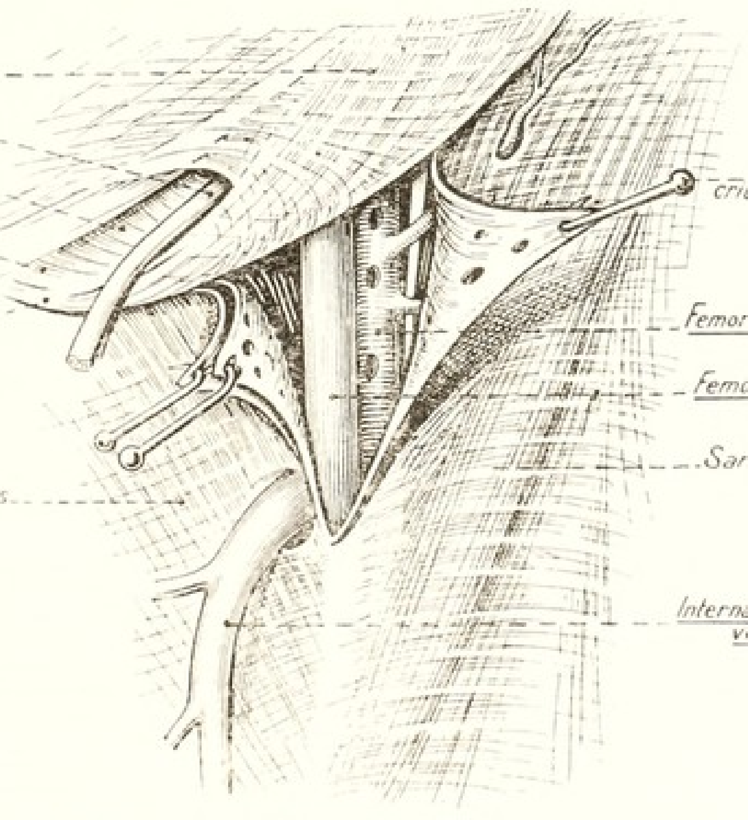
The vessel must be tied *as close as possible to Poupart's ligament* to ensure that the thread is passed above the origin of the deep femoral artery, which usually arises one inch to an inch and a half below the ligament, but sometimes at a much higher level.

The *skin incision* should be placed vertically, two inches long, at the middle of the fold of the groin, extending for half an inch on to the abdominal wall above the fold.

Poupart's ligament must be used as a rallying point, so the subcutaneous tissue is divided in the upper half inch of the wound until the white fibres of the external oblique and the rounded tendon in which they end are seen and have been well cleaned.

Having seen Poupart's ligament, divide *the superficial and deep fascia on a director*, making a little hole with the instrument just below the ligament, and passing it from above downwards (*see* p. 4). Prick





Figs. 30 and 31.—The bend of the groin.

carefully, so as not to transfix the artery, and if necessary divide the layers successively in two or three steps, passing the finger each time along the groove of the director before cutting. The vascular bundle is now reached, without having seen the anterior crural nerve (*see Figs.* 29 and 31).

After dividing the fascia, place the small end of a retractor on each lip, and approach the artery from the outer side, bearing in mind that the vein sometimes overspreads its anterior surface. Free the outer border of the vein, and have it drawn inwards by the corresponding retractor; clear the artery, *close to Poupart's ligament*, and pass the aneurysm needle from within outwards.

2. Ligature at the Apex of Scarpa's Triangle.—At the middle third of the thigh the sartorius muscle reaches the outer side of the artery, and then passes in front of it. It is contained in a fascial sheath formed by a splitting of the deep fascia of the thigh, and the posterior wall of this sheath, which is continuous with the coverings of the adductor longus and vastus internus, roofs in the angle between these muscles, thus forming a curvilinear triangle, bounded antero-internally by the sheath of the sartorius (*see Fig.* 32). To reach the artery, therefore, it is necessary, after dividing the skin, to open the superficial layer of the sartorius sheath, retract this muscle, and then open the deep layer.

The limb is placed flat on the table, slightly abducted and externally rotated.

Along the line described (*see Fig.* 27), make an *incision* three inches long; beware of the internal saphenous vein in the subcutaneous tissue.

Clean *the deep fascia* with care, then divide it, from end to end of the wound, on to the muscle. The sartorius is recognized by the direction of its fibres, running obliquely downwards, inwards, and a little backwards. Having made sure of this landmark, seize the inner lip of the fascial opening, draw it a little inwards, and, close to it, loosen the inner border of the muscle with a director (or with a scalpel if sufficiently skilful). *Have the muscle drawn outwards* with the small end of a retractor; put a second retractor on the internal lip, and the *deep layer of the muscle sheath* will then be seen, through which the vascular bundle is visible. This layer may be opened from end to end on a director, or better, if you are clever enough, by buttonholing it so as to make a window two-thirds of an inch in length.

Next seize in the forceps each lip of the opening in succession, free it with a longitudinal stroke of the director, and have it retracted. Between the two retractors the femoral artery and vein will be seen; free the outer border of the vein with a director, and have it drawn inwards under the retractor; clear the artery, and pass an aneurysm needle from within outwards.

3. Ligature in Hunter's Canal.—Truly speaking, Hunter's canal begins at the apex of Scarpa's triangle, where the deep layer of the sheath of sartorius blends with the sheaths of vastus internus and adductor longus. But below the point where the sartorius has become

internal after crossing the anterior surface of the vessels, this *fascial union between vastus internus and adductor longus or magnus* becomes very thick (*Fig.* 33): *a canal is thus formed with a strong anterior wall*, bounded to the outer side by vastus internus, to the inner side by the

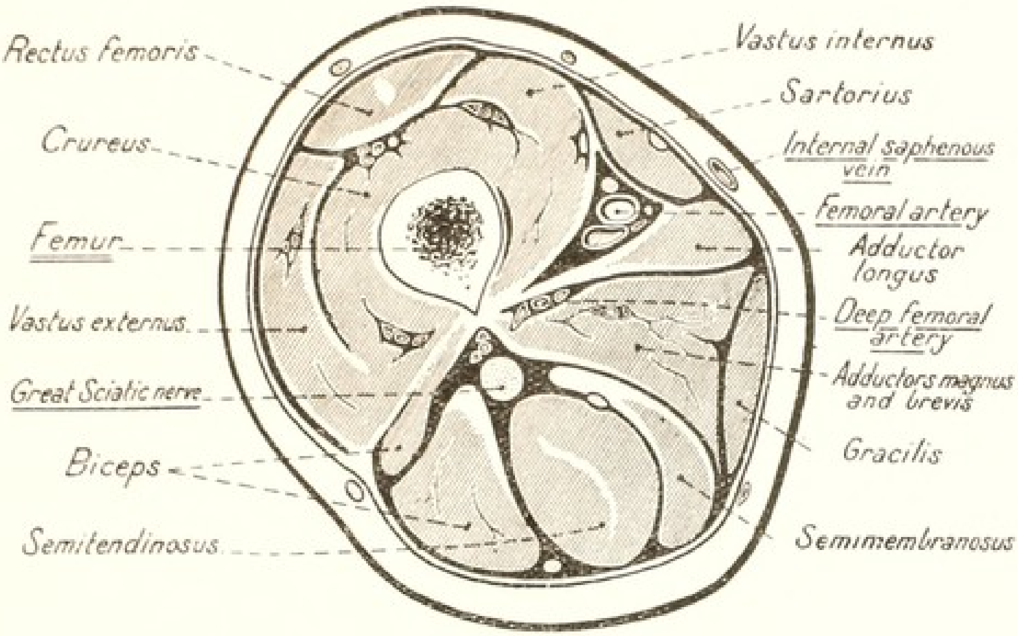


Fig. 32.—Section at the middle of the right thigh.

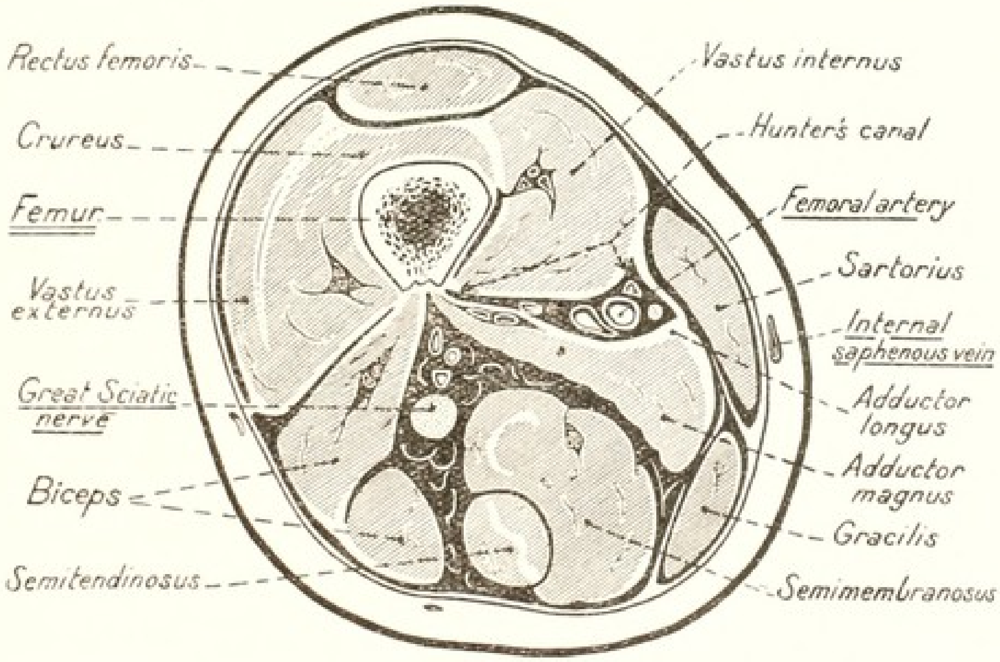


Fig. 33.—Section through the right thigh at the level of Hunter's canal.

strong, tendinous, condylar head of adductor magnus, behind by the flattened tendon of adductor longus as it passes to be inserted into the linea aspera, and below this tendon by the adductor magnus muscle. Between the two heads of adductor magnus against the internal border of the femur, *four finger-breadths above the internal condyle*, is the *opening through which* the artery passes backwards to become the popliteal artery.

After dividing the anterior fibrous wall of the canal (junction between the condylar tendon of adductor magnus, and vastus internus), the artery is reached, with its accompanying vein to the inner side and behind ; there is often also a collateral vein anteriorly. In front of the artery descends the long saphenous nerve, which perforates the anterior wall of the canal, at its lower extremity, to become subcutaneous. Together with the nerve, or a little above it, a branch of the femoral artery also passes out, the anastomotica magna.

For this ligature it is very necessary *to mark carefully, behind the internal condyle, the lower end of the line of operation*, otherwise you

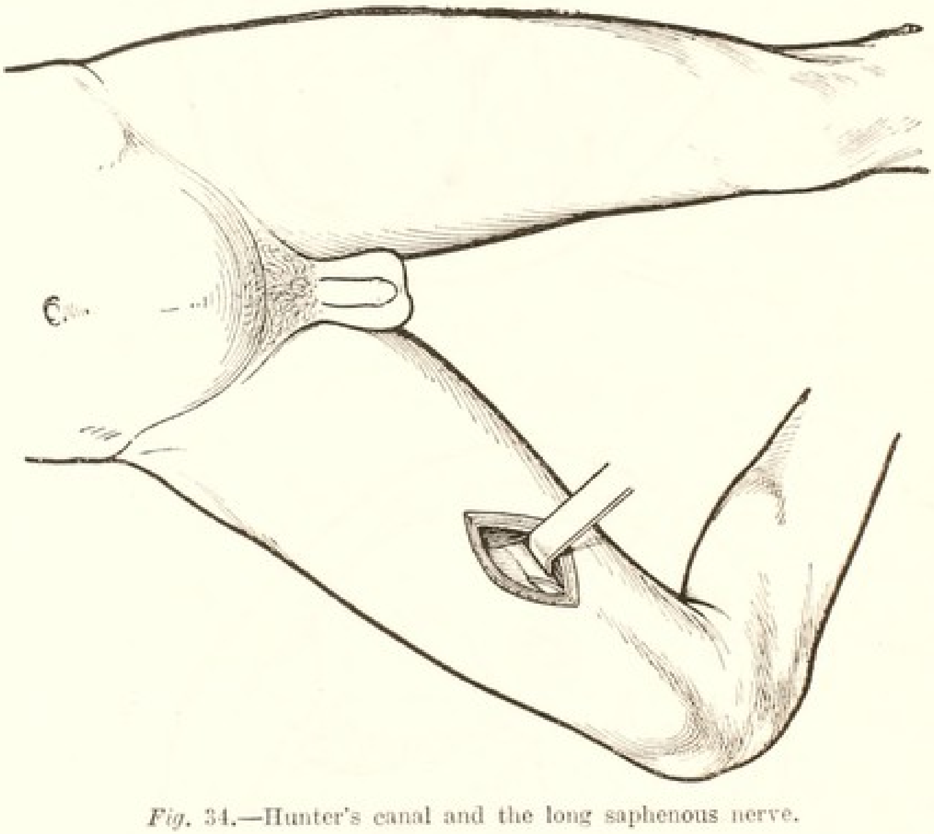


Fig. 34.—Hunter's canal and the long saphenous nerve.

may pass in front of and outside the canal, and penetrate the fibres of the vastus internus.

With the limb extended and rotated outwards, make an *incision*, three and a half inches in length, along the line described, *ending four finger-breadths above the internal condyle* ; remember that there may be superficial veins in the subcutaneous tissue which should be spared. Clean the deep fascia with care.

Next, *open the sheath of the sartorius*, and see this muscle (first rallying point). The usual tendency of beginners is to divide the fascia with the knife blade directed towards them, as when incising the skin, and they then find themselves in the vastus internus, recognized by the direction of its fibres downwards and outwards.

The blade must be *directed nearly vertically, under the inner lip of the incision* ; by so doing the knife is passed *on the flat under the external surface of the sartorius*, which muscle, at this level, is placed almost exactly against the internal surface of the thigh. In this way the muscle is freed, after it has been recognized, from its long parallel fibres running obliquely downwards, inwards, and backwards (the work may be completed by a stroke of the director). The loosened muscle now falls backwards, dragged by its own weight, and must not be retracted further or freed more extensively for the moment, a common mistake, which might lead the operator behind the adductor magnus tendon into the popliteal space.

Having dealt with the sartorius, *the position of the limb must be altered*. It is now placed *sideways, in abduction, and flexed at the knee*, with two objects in view : (*a*) To stretch the tendon of adductor magnus ; (*b*) To expose *the anterior wall of Hunter's canal* (*Fig.* 34).

This wall must now be divided, quite close to the adductor tendon (second rallying point), just outside and parallel to it, for the whole length of the wound. A beginner should not hesitate to feel the stretched tendon with his index finger, then to search to its outer side and below for a little depression (rather like that felt on pressing the tip of the nose), which denotes the point of exit of the *long saphenous nerve* (third rallying point). A practised operator, however, cleans the fibrous surface with a director, notes the adductor tendon and the transverse fibres of the anterior wall of the canal, then looks lower down and frees the long saphenous nerve directly. Pass the director from below upwards through this opening, run the finger along its groove, and divide the canal from end to end of the incision. Be careful to keep close to the tendon, in order to keep clear of the vastus internus.

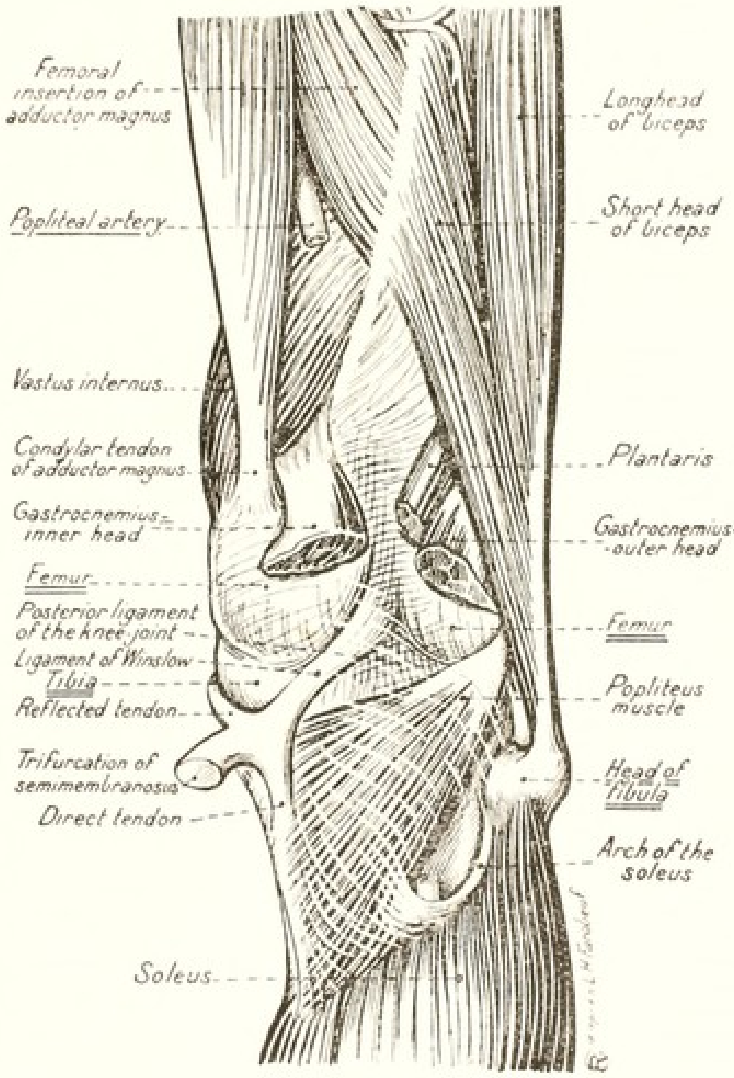


Fig. 35.—Floor of the popliteal space.

To *isolate the vessels*, pick up each fascial lip in turn, loosen it with a longitudinal stroke of the director (point directed towards the wall of the canal), and have it drawn aside with the broad end of a retractor : a manipulation easily done, as there is a well-marked plane of cleavage between the vessels and the aponeurotic wall. The vessels now lie between the two retractors ; isolate the artery, bearing in mind the possibility of an anterior collateral vein, and pass the needle from within outwards.

3. LIGATURE OF THE POPLITEAL ARTERY.

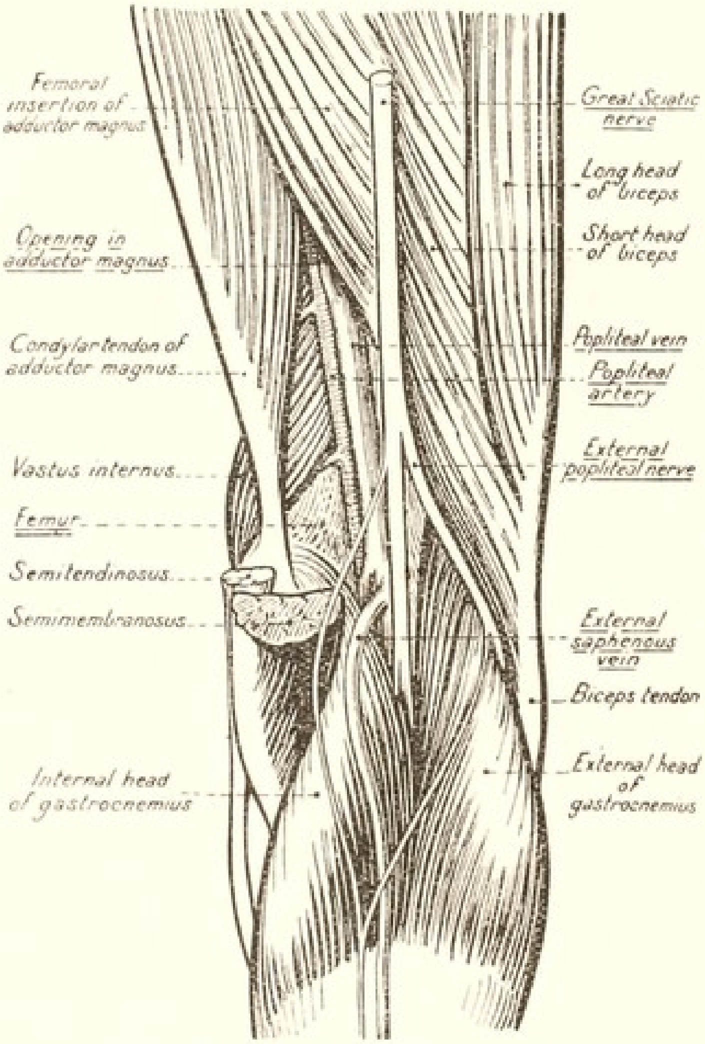


Fig. 36.—The popliteal space.

Course.—The popliteal artery commences above at the *opening in adductor magnus*, between the femoral and condylar insertions of this muscle, and is a continuation of the superficial femoral artery from the point where this trunk passes to the posterior aspect of the limb. It is bounded below by the *arch of the soleus* (a tendinous arcade passing from the head of the fibula to the oblique line of the tibia), and ends by dividing into anterior and posterior tibial arteries (*see Fig.* 37). Running at first somewhat obliquely downwards and outwards, it then descends vertically, first in the mid-line of the ham, next between the condyles of the femur, and finally in the leg.

In other words, it descends in the '*popliteal space*,' a space formed by the junction of two muscular triangles (*Fig.* 35) :—

1. A *femoral triangle*, elongated, and formed by the diverging hamstring muscles, the biceps externally, the semimembranosus and semitendinosus internally—tendons easily felt and seen.

2. A *gastrocnemial triangle*, shorter, and formed by the coalescing heads of the gastrocnemius.

These two triangles are roofed by the *deep fascia of the limb*, and the hollow within them is filled by fatty tissue (with lymphatic glands), in which lie the vessels and nerves.

A little to the outer side of the median line the *great sciatic nerve* descends, and after its bifurcation the internal popliteal nerve continues in the same direction as the main trunk. The external popliteal nerve does not concern us here ; it lies underneath and close to the deep fascia.

The vessels are to the inner side and in front of the nerve—some distance away, because they lie *close to the bones* (femur, posterior ligament of the knee-joint, tibia covered by the popliteus muscle —*see Fig.* 35).

They are reached at the level of the femur, on the smooth surface below the linea aspera, between the condylar ridges. The artery is separated from the bone by a little connective tissue only, the vein lies in close contact with the artery, behind and to the outer side. The artery presents to the inner side, therefore, a surface uncovered by vein. Remember that this vein has thick walls, and appears to the eye, and sometimes even to the finger, like an artery.

Operation.—The subject is placed flat on the abdomen, and the surgeon stands outside, the assistant inside, the limb.

The *line of operation* is the *mid-line of the ham*, and it must be performed *in the femoral triangle, above the fold of the ham* : this fold forms a transverse line, which is marked by bending the knee over a director, as described on p. 9 in the case of the elbow.

Make an *incision four inches long*, dividing the *skin* ; then, without hesitation, the *subcutaneous tissue* ; and then the *deep fascia* by the direct method. Put the large end of a retractor on each lip of the wound. Underneath the external lip, close to it, a tense cord, the *great sciatic nerve*, is seen. Free the inner border of this, and retract it outwards. Continue to pass into the depths of the wound, strictly in the middle line, palpating the artery as it lies against the bone if not very experienced. The vascular bundle is reached between the two retractors thrust deeply in.

The structure first seen is the *vein*, to the inner side of which the artery projects. It is necessary, therefore, to free the *inner border*, then *the anterior surface of the vein*, with longitudinal strokes of the director. Have it retracted outwards when freed. Clear the artery, and pass the aneurysm needle from without inwards.

4. LIGATURE OF THE POSTERIOR TIBIAL AND PERONEAL ARTERIES.

Course.—On reaching the arch of the soleus, the *popliteal artery divides* into the *posterior tibial*, which continues under the soleus in the same direction as the main trunk, and the *anterior tibial* which passes forwards, at right angles, over the interosseous ligament (*Fig* 37).

The *posterior tibial artery*, after a course of about an inch and a half, gives off a large branch, the peroneal artery ; the two vessels then pass to each side of the interosseous space, and run vertically downwards along its borders. They are placed nearly symmetrically on either side of the *posterior tibial nerve*, which descends in the mid-line of the calf, continuing the direction of the internal popliteal nerve. Below the upper half of the calf this nerve runs obliquely inwards, to take up a position against the postero-internal border of the posterior tibial artery, in company with which it passes behind the internal malleolus. Below the malleolus, vessels and nerves bend forwards to follow the *groove in the os calcis*, and there *divide into the plantar vessels and nerves*. The *peroneal artery* usually disappears into the flexor longus hallucis; its anomalies are of interest to us when tying the dorsalis pedis artery (*see* pp. 40 and 43).

In the calf these vessels lie under the deep surface of the soleus muscle, a thick muscular sheet which arises, along a line running obliquely downwards and inwards, from the upper end of the fibula, the oblique line of the tibia, and the internal border of the tibia. They are buried in a *thin layer of fascia* which, passing across from tibia to fibula, covers the three muscles which fill the interosseous space: tibialis posticus in the

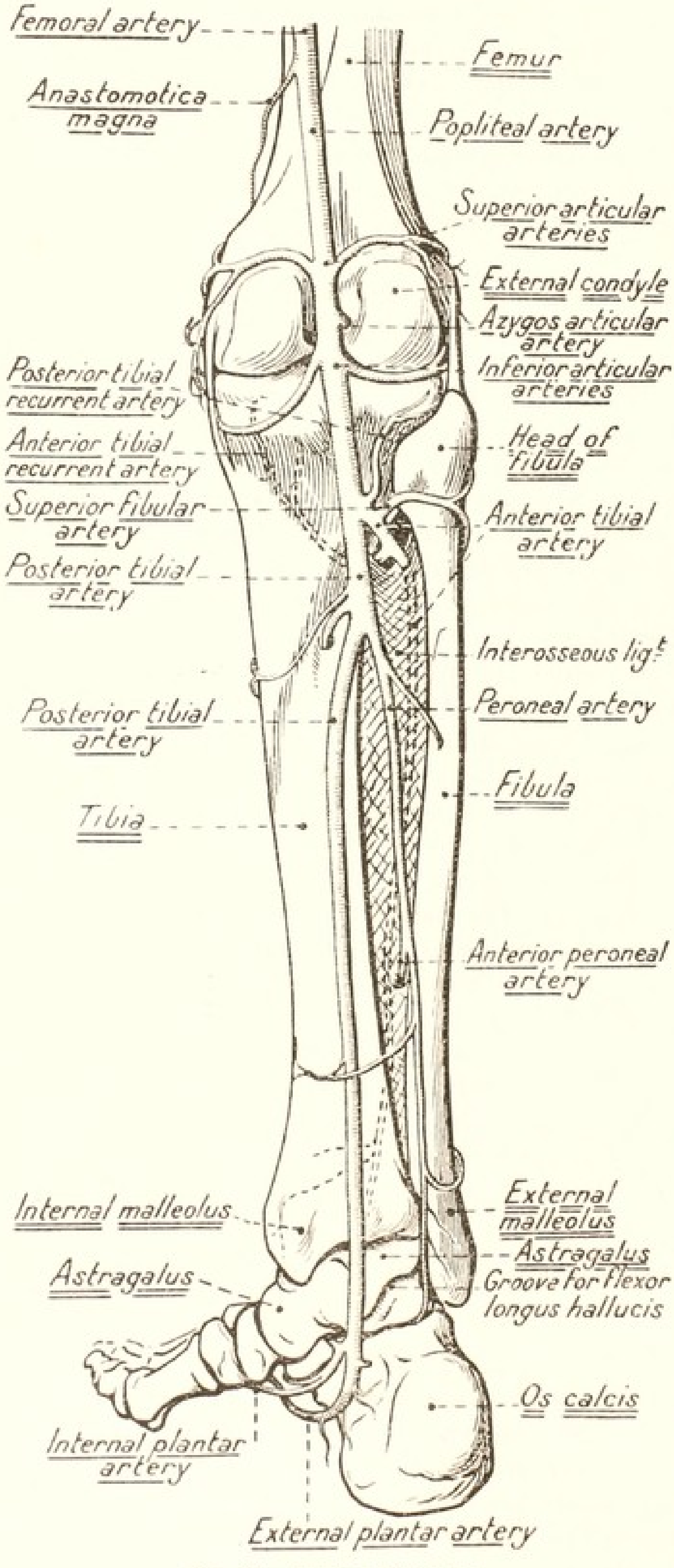


Fig. 37.—Arteries of the leg.

middle, flexor longus digitorum on the inner side, and flexor longus hallucis on the outer side (*Figs.* 38, 39).

This layer of fascia becomes thicker as it nears the malleoli. At the level of the ankle-joint, *behind the internal malleolus*, it is very thick, and provides two strong *sheaths for the tendons*, and between these a rather *weaker sheath* for the *posterior tibial vessels and nerve*. The tibialis posticus and flexor longus digitorum tendons lie in front and to the inner side; the flexor longus hallucis tendon, which passes over and grooves the posterior border of the astragalus, lies to the outer side. Behind these sheaths the deep fascia passes across to the external malleolus, ensheathing as it goes the tendo Achillis (*Fig.* 40). I confine myself for the moment to the above general anatomical description, reserving certain details for description with the separate operations.

Operation.—There is, then, in the upper part of the leg, under the 'thick' of the calf, a complicated system of arteries with many and large branches, and if hæmorrhage takes place in this region, it is impossible to diagnose the exact source whence it comes; frequently, also, several vessels are injured at the same time. The best operative procedure in such a case is that of Arnott: divide the calf in the mid-line, make the posterior tibial nerve the rallying point, and then search for the bleeding vessel on the deep surface of the soleus. But in the dissecting room the typical ligature of the posterior tibial, or the peroneal, is performed above, through a lateral incision. I will not describe the ligature of the peroneal artery, because that of the posterior tibial through the inner border of the calf is exactly similar.

The *posterior tibial artery* may be tied at any point of its course. The classical operations are performed in the upper part and behind the internal malleolus.

A. ***Ligature in the Upper Part of the Leg.***—The subject is placed on his back, the knee is placed sideways, flexed, and moderately abducted; the surgeon stands on the outer side, the assistant faces him.

First make the veins prominent by pressure from below upwards, and note their course, then make an *incision, four inches in length*, along *a vertical line running downwards* from the 'garter region,' and *a thumb-breadth inside the postero-internal border of the tibia*. By the 'garter region' is meant the narrow part of the leg about the level of the head of the fibula, between the popliteal space and the prominence of the calf; it is in this position that ladies formerly wore their garters, and it is there that the band of knickerbockers is fastened.

The skin is divided, the subcutaneous tissue, and the deep fascia, and the *first rallying point* is then reached, *the internal border of the inner head of gastrocnemius*. Thrust your director under this border, for a distance of one inch, to free it from the soleus, to which it is not adherent at this level, and place the large ends of two retractors above and below, perpendicular to the muscle. Give the retractors to an assistant, and tell him to pull towards the table, in order to retract the

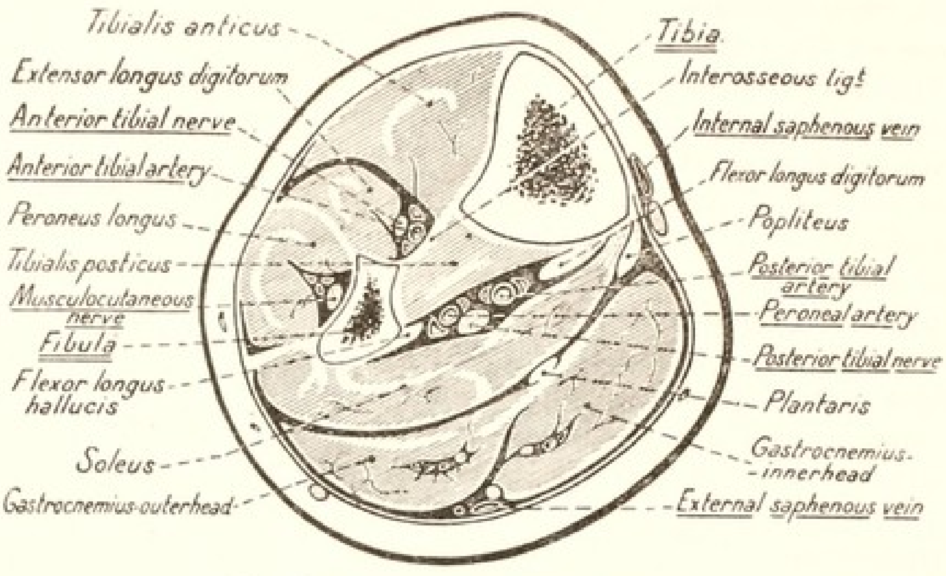


Fig. 38.—Section through the right calf.

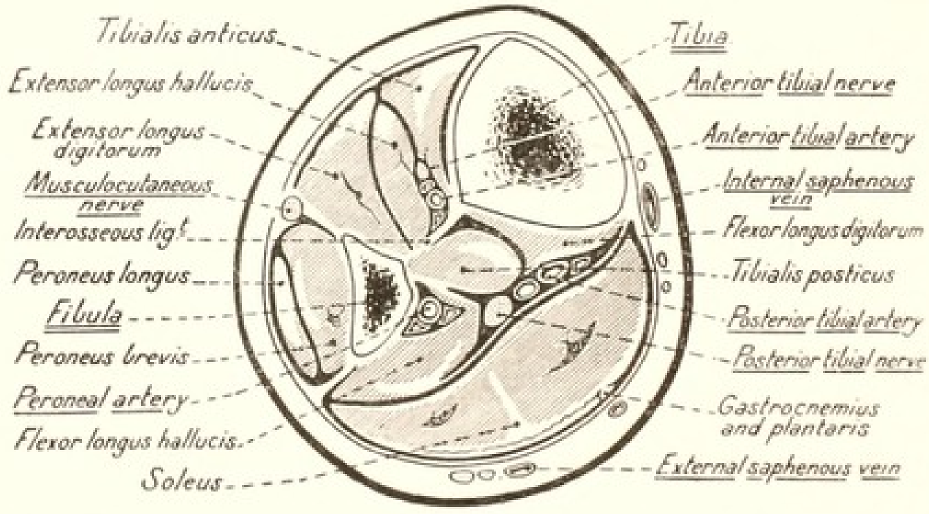


Fig. 39.—Section through the right leg at the junction of the middle and lower thirds.

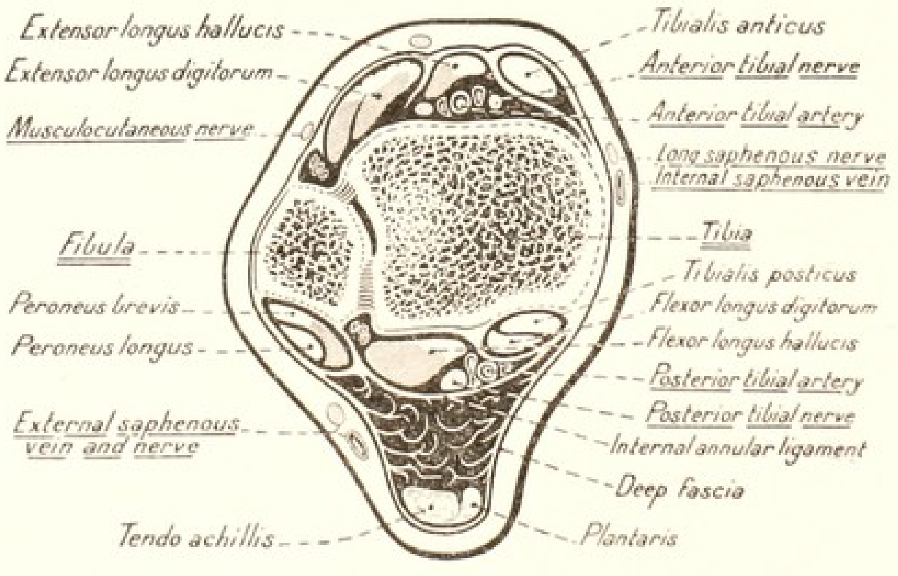
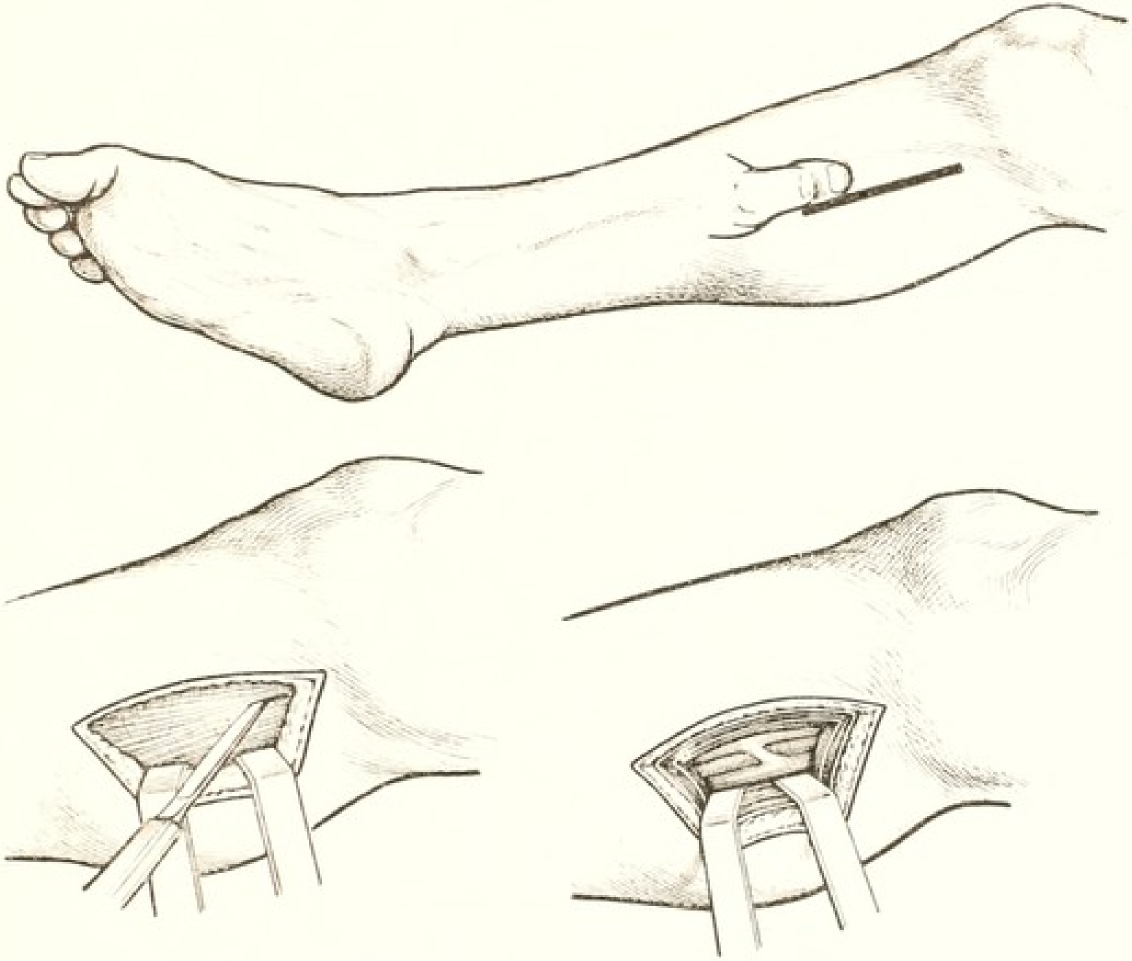


Fig. 40.—Section through the right leg at the level of the malleoli.

gastrocnemius without stripping it from soleus, as will happen if he pulls on them with the handles raised. There should be an interval of one and a half inches between the tibia and the edge of gastrocnemius.

In this space appears the soleus, tendinous above, red and muscular below; this *muscle must be divided* in order to reach the artery, which lies beneath it. Lean forwards to see what you are doing, and make the incision about *one and a quarter inches inside the tibia, with the scalpel held horizontally* (*Fig.* 42). The muscle should be divided by several strokes of the knife from *end to end* of the wound and from left to right: at the end of each stroke depress the



Figs. 41, 42, and 43.—Ligature of the posterior tibial above.

inner lip of the muscular opening with the flat of the blade, while the assistant reinserts the retractor, above when the lower end is reached, and at the lower end when a start is again made from above (or inversely according to the side operated upon). This continues until *the second rallying point* is reached, the *intramuscular tendon of the soleus*—a bad name, for it is not always intramuscular: here a knowledge of anatomy is essential.

The soleus arises at the tibio-fibular line from between two tendinous sheets which run vertically and transversely like a Λ, one branch posterior, one anterior. The anterior branch, which extends very low down, often gives origin to muscular fibres in front (that is from its deep surface), but not always ; sometimes, therefore, it is in direct contact with the vessels, sometimes, on the other hand (and only then is it to be regarded as intramuscular), it is separated from them by a muscular pad of variable thickness.

The soleus must be divided then, as just stated, until a *white and resistant tendinous sheet* is seen, and this in turn must be divided *with the extreme point of the knife from end to end of the wound* (for it is not known whether there is a muscular pad on its anterior surface or not), holding the scalpel vertical to the plane of the tendon. Next place the retractors at each end of the inner lip of the divided tendon, and it will then be seen if there are muscle fibres under it or not ; if they are present, divide them just as before, but more carefully, for it is impossible to say how thick they are, and the division must stop as soon as the connective-tissue plane is reached over which the deep surface of the muscle glides. The surgeon places the retractors in position himself, close to the divided muscle (*Fig.* 43), so as to be certain not to include vessels and nerve, and has them drawn inwards ; not too forcibly, or the muscle may be loosened unnecessarily.

The *third rallying point* must now be seen, *the posterior tibial nerve*, and the tissues must not be separated beyond it. The *artery* indeed lies internally and is therefore nearer to the operator than the nerve.

The vessel is *difficult to clear* : (1) Because its *venæ comites* frequently make a network of anastomoses over the vessel, and these are often dilated and full of blood ; the director must be passed through one of the meshes of this vascular net ; (2) Because the artery is *often atheromatous* and therefore easily torn.

Pass the *aneurysm needle from without inwards*, for the nerve lies outside.

B. ***Ligature behind the Internal Malleolus.***—The limb is rotated outwards and placed flat on the table ; the surgeon places himself on the outer side ; the assistant, standing opposite to him, holds the foot at right angles to stretch the tendo Achillis.

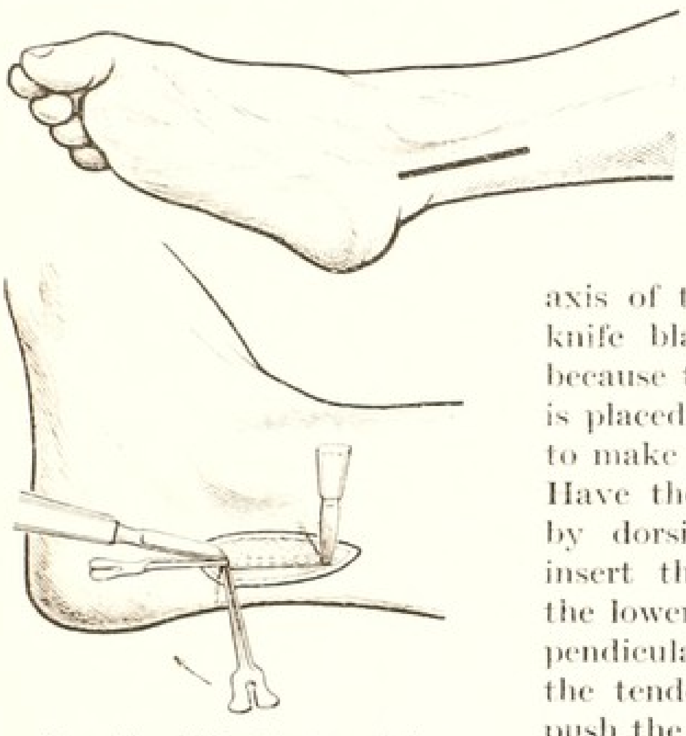
Along *a vertical line, equidistant from the inner border of the tendo Achillis and the posterior border of the internal malleolus*, make an *incision two and a half inches long*, having *its lower extremity opposite the tip of the malleolus* (*Fig.* 44). There is nothing to note *in the subcutaneous tissue*.

Two layers of fascia must then be divided in succession : (1) The deep fascia ; (2) The internal annular ligament, ensheathing the vessels, as described on p. 35 (*Fig.* 40).

1. *The deep fascia* passes from the posterior margin of the internal malleolus to the inner border of the tendo Achillis, which it ensheathes ; but in order to reach its insertion into the os calcis, this tendon leaves the deeper tissue plane, and becomes separated from it by fatty connective tissue. As the limb is presented to the surgeon, the foot at right angles, the outer border resting on the table, the fascia runs nearly horizontally from before backwards, and is best divided—

completely and from end to end of the wound—against the edge of the tendo Achillis, the blade flat to the deep surface of the tendon and cutting in a vertical direction, as if aiming to cut the table (*Fig.* 45). When the fascia is divided, the tendon retracts and exposes the subjacent fatty tissue.

2. The *internal annular ligament* lies against the posterior surface of the bone, separated from it only by the thickness of the tendons. It forms, therefore, if we consider the subject in the erect position, a partition extending vertically and transversely; or, for the operator, vertically and anteroposteriorly. Under it are three compartments, one immediately behind the internal malleolus for the tibialis posticus and flexor longus digitorum, one for the flexor longus hallucis as it passes obliquely downwards and inwards from the tibia over the tail of the astragalus, and an intermediate compartment for the vessels and nerve.



Figs. 44 and 45.—Ligature of the posterior tibial below.

A practised operator may *divide directly the sheath of the vasculo-nervous bundle* in the axis of the skin incision, with the knife blade directed horizontally, because the ligament to be divided is placed vertically; but it is wiser to make *use of a director* (*Fig.* 45). Have the tendo Achillis stretched by dorsiflexion of the ankle, and insert the director horizontally in the lower end of the wound, perpendicular to the tendon. Press the tendon backwards a little and push the instrument forwards until the ligament is perforated, exactly over the sheath of the vessels. Now rotate the director, bringing its handle towards the sole with the point under the ligament, then push it longitudinally from the foot towards the leg. Make sure, by feeling with the index finger, that only the fibrous tissue has been raised, and move the director about a little also, to make certain that the point is not held in a narrow aponeurotic tube (as it will be if a tendon sheath has been pierced by mistake); then divide the ligament. Next let the assistant extend the foot and so relax the vessels and nerve; free the nerve, which lies, as the operator stands, to the inner side and a little behind, and have it drawn inwards on the small end of a retractor. Clear the vessel, and pass the needle from without inwards.

5. LIGATURE OF THE ANTERIOR TIBIAL AND DORSALIS PEDIS ARTERIES.

Course.—The anterior tibial takes *origin on the posterior aspect of the leg* where the popliteal artery bifurcates, at the arch of the soleus: the other branch being the posterior tibial (*Fig.* 37). It runs straight forwards to *pass above the upper border of the interosseous ligament*, then *bends at right-angles*, and passes downwards in the anterior compartment of the leg. The part of the vessel on the front of the leg is the only one now to be considered; the posterior portion is annexed, surgically speaking, by the posterior tibial.

The anterior tibial artery first lies deeply against the interosseous ligament, a vein on either side; but it leaves the ligament little by little as it descends, and at the same time comes nearer to the tibia. Above, it is separated from this bone by the thick belly of the muscle most related to it, *the tibialis anticus*; in the lower quarter of the leg, however, the muscle has become a tendon, behind and outside which the artery lies directly against the anterior surface (which higher up is the outer surface) of the tibia.

To the *outer side* of the vessel lies the *extensor longus digitorum* above; lower down, first the fleshy body, then the tendon, of *extensor longus hallucis*.

Above the ankle the vessel is situated midway between the malleoli, and between two tendons, the tibialis anticus internally, the extensor longus hallucis externally; of which the former is very easily felt and seen.

From this point it passes under the anterior annular ligament, then under the extensor longus hallucis tendon, then, as the *dorsalis pedis* artery, it runs straight to the posterior extremity of the first interosseous space, through which it passes, to end on the sole of the foot. The dorsalis pedis artery lies between the bone and the inner border of extensor brevis digitorum, which overlaps it. It is not very exceptional, however, for the anterior tibial to terminate at the ankle, and for its place on the dorsum of the foot to be taken by the anterior peroneal, which, in this case, courses obliquely forwards and inwards, under the extensor brevis digitorum, to the posterior extremity of the first interspace.

In the leg, *the anterior tibial nerve* approaches the artery from the outer side, crosses it very obliquely in front, and reaches the inner side of the vessels at the level of the ankle-joint.

A. ***Ligature of the Anterior Tibial Artery.***—The *muscular interspace* at the bottom of which the artery lies is that between tibialis anticus and the extensors—extensor longus digitorum above and extensor longus hallucis below; it corresponds to a *line* drawn from the *anterior fibular depression to the mid-point of the ankle-joint in front*.

To mark *the anterior fibular depression*, semiflex the limb and apply the pulp of the thumb behind the head of the fibula in the popliteal space, its extremity above and to the outer side, then push the thumb from behind forwards, round the head of the fibula, pressing firmly all the time. Just in front of the head the thumb drops into a depression, which is marked with a stroke of the nail (*Fig.* 46).

To *mark the mid-point of the ankle*, take the base of the two malleoli between thumb and middle finger, and mark the mid-point between them with the index finger. It is a point easily verified, for it lies just at the outer border of the tibialis anticus tendon, which nearly always projects and has a little callosity over it; in any case

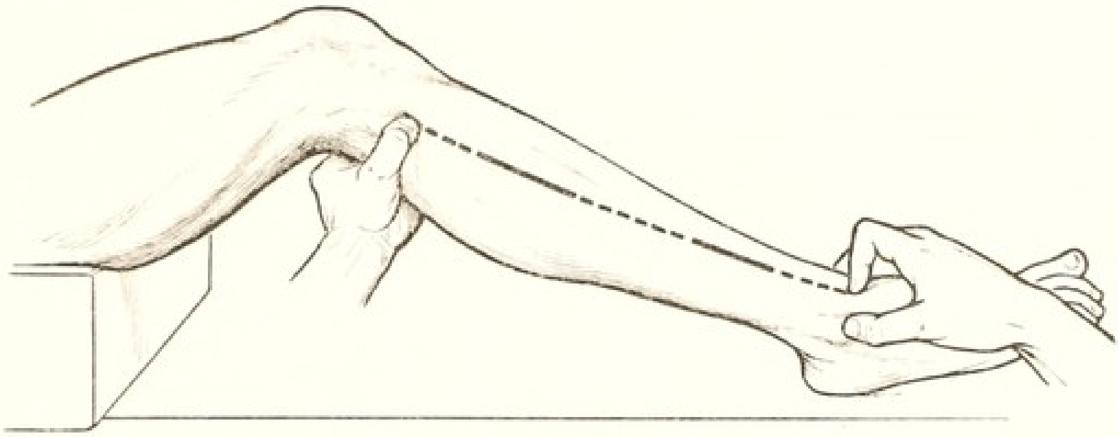


Fig. 46.—Line of the anterior tibial artery.

it may readily be made tense by placing the foot in a position of equino-varus.

Sometimes the muscular interspace can be palpated along the line described.

1. Ligature Above.—The leg is placed in the semiflexed position, a block under the thigh. The assistant, standing on the inner side, presents the limb to the operator slightly rotated inwards to expose the antero-external surface. The surgeon, standing on the outer side, makes an *incision* three and a quarter inches long, with its upper limit three finger-breadths below the line of the knee-joint (or even four finger-breadths below this point, because the lower the operation is performed, the easier it becomes).

Now divide *skin, subcutaneous tissue*, and *deep fascia*, after exposing it carefully, all the while *keeping the foot extended, to render tense the subjacent muscles*. Divide the deep fascia with the point of the knife lightly, so as not to injure the muscle.

The *muscular interval* between tibialis anticus and extensor longus digitorum must next be found, and for this it is necessary to know its exact anatomical position. Two points must be borne in mind:—

1. *In a longitudinal direction*, the interspace only exists below, for the muscles both take origin above from the same tendinous intersection. One should proceed, therefore, just as described on p. 18 when ligaturing the ulnar artery; then look for a greyish or yellowish line in the lower part of the wound, and thrusting into it the point of a director, free the muscles from below upwards. It is necessary,

however, to raise somewhat with the director the internal muscular lip of the incision, because—

2. *In a transverse direction*, the interspace is not flat, but concave inwards and backwards. In a transverse section of the limb, the tibialis anticus muscle, which is always very thick, is shaped like a comma, the tail of which covers the extensor longus digitorum to a greater or less extent : the tail, indeed, may nearly reach the septum dividing the extensor group of muscles from the peroneal group, a strong fibrous sheet attached to the border of the fibula by one edge and to the deep fascia by the other, and giving origin anteriorly to the extensor longus digitorum, posteriorly to the peronei muscles. If, therefore, the connective-tissue line of the interspace is not seen at once, seize the outer lip of the fascial opening in the forceps, and pass the point of a director transversely, first backwards, then forwards, bringing the handle of the instrument towards you, so as to pass under the edge of tibialis anticus and hook it forwards. There should now be seen a smooth, rounded, fleshy belly, which can be freed in a longitudinal direction without difficulty. The two margins of the interspace are smooth, and branches from the anterior tibial vessels can be seen entering them in series, perpendicular to the axis of the muscles—giving an appearance like the backbone of a fish.

To widen this interspace, it is best to introduce the large ends of two retractors, transversely and back to back, at the middle of the opening, then turn them at right-angles and pull one upwards and the other downwards. A rectangular space is thus formed, as broad above as below, and in the depths as on the surface of the wound.

In this space the nerve is first noticed, then the artery and its venæ comites. The artery is difficult to clear because of the depth of the wound.

To pass the aneurysm needle, introduce it longitudinally until the back touches the interosseous membrane between artery and nerve ; then lower the handle, rotating it a little, so as to pass the point under the artery, and bring it out obliquely.

2. Ligature Below.—The limb rests flat on the table, the surgeon is on the outer side, the assistant faces him.

Make an *incision* two and a half inches long, ending about two finger-breadths above the line of the ankle-joint. Divide the subcutaneous tissue, in which there is nothing to avoid, and clean the deep fascia. Then direct the assistant to *place the foot in a position of equino-varus, to render tense the tibialis anticus tendon*, and with a stroke of the knife-point *open the deep fascia* from end to end of the wound along the border of the tendon. Take in the forceps the inner lip of the opening thus made, and pass a director transversely under it, between it and the tibialis anticus tendon, which can be seen. When the director is arrested by the insertion of the fascia to the crest of the tibia, draw it towards you, pressing on the point, until it rounds the prominence of the tendon and drops into the hollow between it and the extensor longus hallucis. Now have the muscles relaxed by dorsiflexion of the foot, and with a longitudinal stroke of the director make room for the small end of two retractors, one on each lip. Between the two lies the artery, resting on the bone; the nerve is in front and to the inner side. Pass the needle from within outwards.

If the artery is not seen at once, make sure that two tendons have not been passed over to the outer side of the tibial crest instead of one, with the result that the extensor longus hallucis has been retracted with the tibialis anticus.

B. ***Ligature of the Dorsalis Pedis Artery.***—*The line of operation runs from the mid-point of the ankle, outside the tendon of tibialis anticus, to the posterior extremity of the first interosseous space.*

The limb rests in extension, flat on the table, the assistant stands on the inner side; the surgeon, who faces him, makes an *incision* one and a half inches long, ending at the posterior extremity of the first interosseous space. The incision lies about the third of an inch outside the tendon of extensor longus hallucis, which should not be seen during the operation. After passing through the subcutaneous tissue, where superficial veins and nerves should be seen and spared, the thin *deep fascia* is reached, under which the *inner border of extensor brevis digitorum* can be seen. The fascia is divided with a stroke of the point of the knife over this border, from end to end of the wound, the muscle is then loosened by a director passed on the flat beneath it, and drawn aside on the small end of a retractor. The artery is seen, accompanied by its venæ comites, in the position previously occupied by the edge of the muscle, and the needle may be passed *indifferently* from either side.

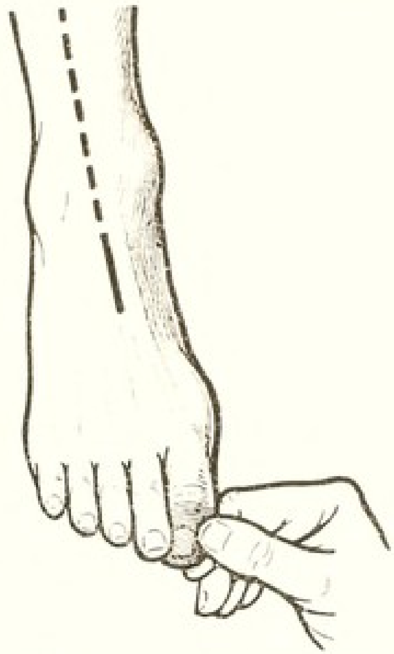


Fig. 47.—Line of the dorsalis pedis.

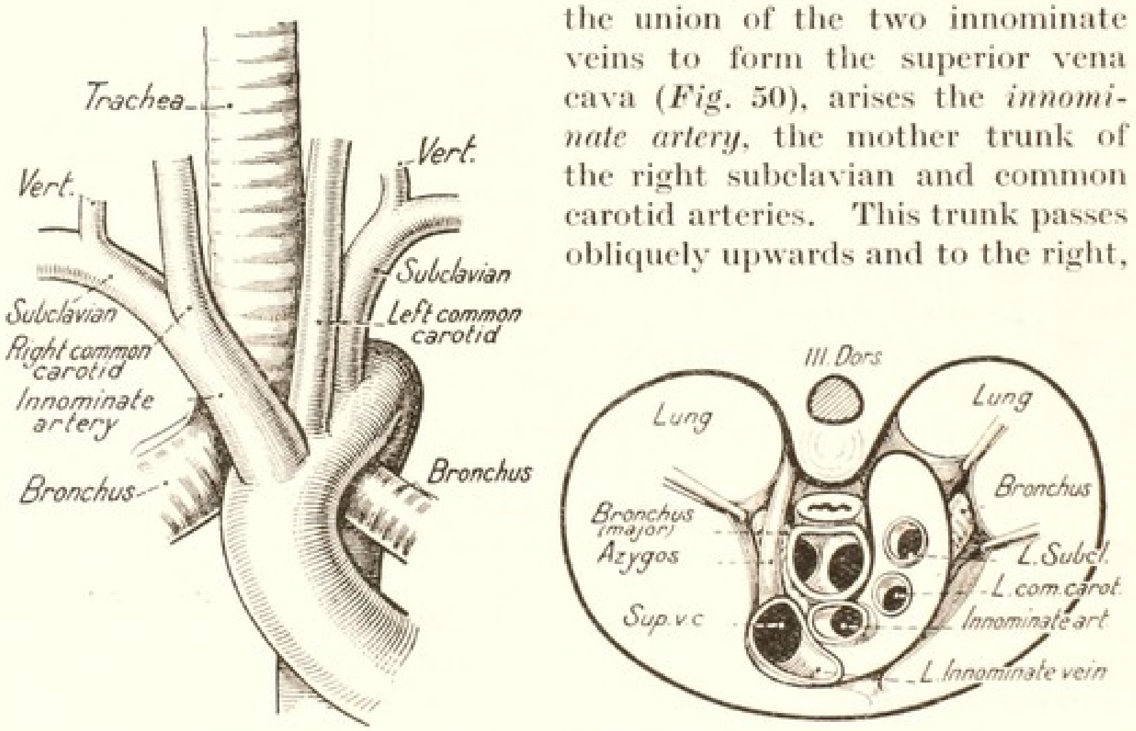
If the artery is missing from its accustomed place, it is because the anterior peroneal has supplanted it, and this will be found at the posterior extremity of the first interosseous space.

Chapter IV.

LIGATURE OF ARTERIES IN THE NECK.

The Origin of the Arteries at the Base of the Neck.—The innominate, left carotid, and left subclavian arteries take origin in the thorax from the upper surface of the aortic arch in a manner which must be known exactly in order to understand the arrangement of the structures at the base of the neck. In this connection *Fig.* 48 may be studied with advantage.

The horizontal portion of the arch of the aorta runs obliquely backwards and to the left, riding on the angle between the trachea and left bronchus. In front and to the right, behind the manubrium sterni, but separated from it by the union of the two innominate veins to form the superior vena cava (*Fig.* 50), arises the *innominate artery*, the mother trunk of the right subclavian and common carotid arteries. This trunk passes obliquely upwards and to the right,



Figs. 48 and 49.—Aortic origin of the arterial trunks.

crossing the right tracheo-bronchial angle, and continues in the direction of the right subclavian, which forms a curve, with concavity downwards, over the apex of the right pleura. From the innominate trunk as it lies in contact with the trachea, the right common carotid arises, and ascends vertically, lying in the neck for the whole of its course.

The *left common carotid*, on the other hand, arises direct from the aortic arch, behind and to the left of the innominate artery, and ascends first of all in the thorax, in front of the left border of the trachea, the anterior surface of which can be seen between the diverging vessels.

Further back still, near the third dorsal vertebra and close to the œsophagus (*Fig.* 49), the *left subclavian* artery arises, and after ascending at first nearly vertically, curves outwards, like its fellow on the other side, over the apex of the lung, to become horizontal. At the point where the subclavian arteries become horizontal, their first branch arises, the vertebral artery ; the vessels then pass between the scalene muscles.

We must now consider in order : (1) The *clavo-axillary trunk* at the *base of the neck* ; (2) The *carotids* in the *lateral regions of the neck*.

1. THE CLAVO-AXILLARY TRUNK.

Course.—It is more convenient, for the purposes of operation, to consider together the ligatures above and below the clavicle of this

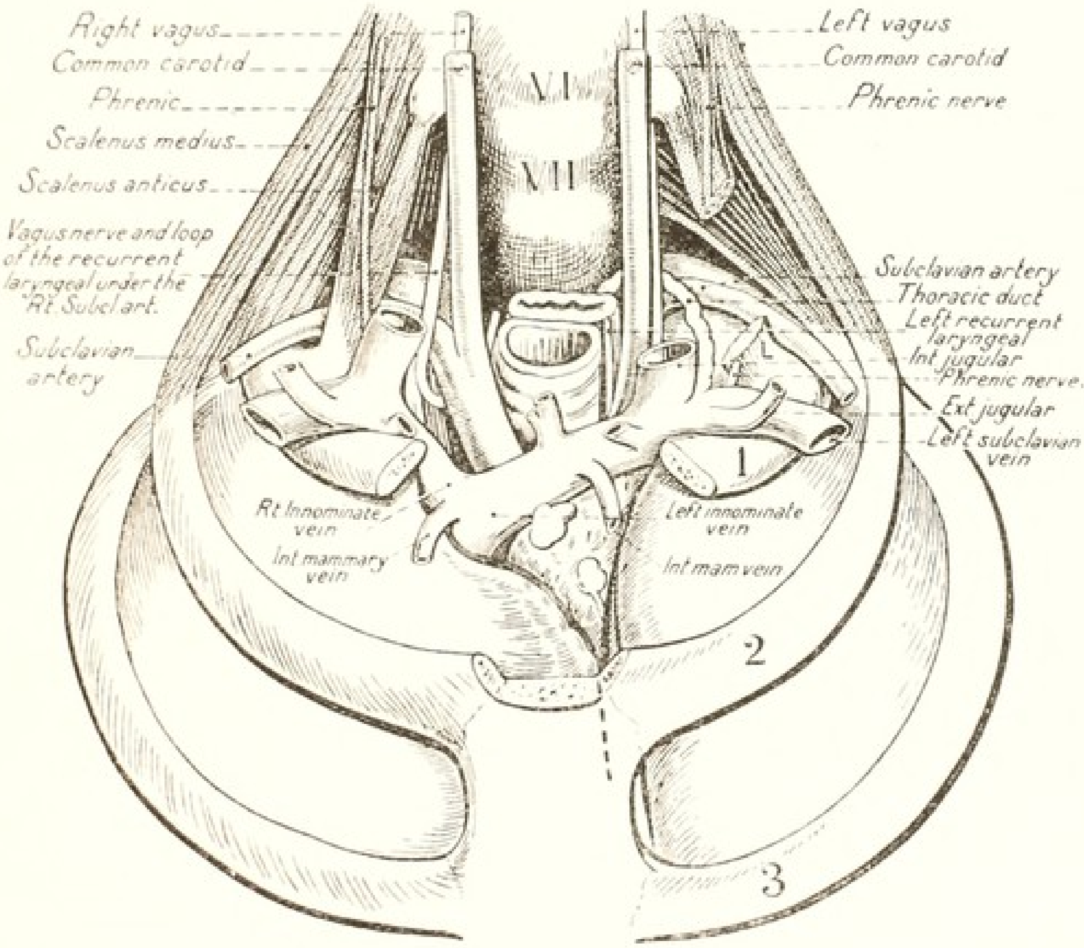
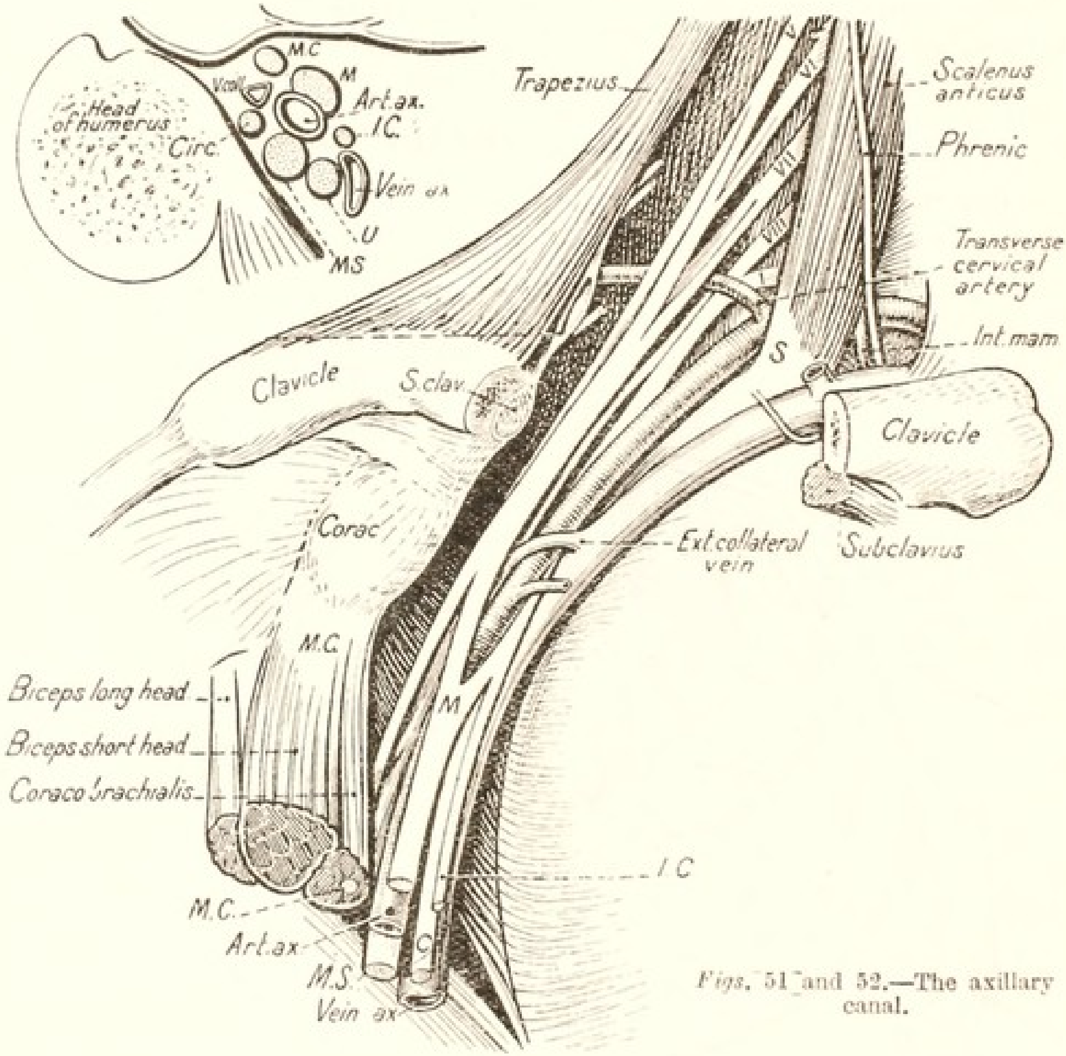


Fig. 50.—The base of the neck.

great vascular trunk, which, after leaving the thorax, crosses the first rib, and passes behind the clavicle into the axilla, along the border of the coracobrachialis muscle, where it becomes continuous with the axillo-brachial trunk already described.

This trunk, then, the intrathoracic portion of which does not concern us here, enters the supraclavicular fossa at the base of the neck, resting on the first rib, between the scalenus anticus and scalenus medius muscles. At this level, therefore, it lies behind the firm rounded tendon by means of which the scalenus anticus is inserted into the *scalene tubercle* on the upper surface of the first rib. Under the artery the broad first rib lies nearly horizontally, and is hollowed out somewhat to form a shallow groove in which the vessel rests (*Fig.* 54).



Figs. 51 and 52.—The axillary canal.

From this point the arterial trunk courses outwards and downwards under the mid-point of the clavicle, which is here padded by the subclavius muscle, and reaches the inner surface of the shoulder-joint close to the anterior wall of the axilla, crossing diagonally the first intercostal space. The position of the supra- and infraclavicular portions of the vessel is such that their relative length varies as the shoulder is raised or lowered.

The *corresponding vein* is situated at first to the inner side and in front of the artery, separated from it at the base of the neck by the thickness of the scalenus anticus, in front of which it crosses the first rib. About two finger-breadths below the clavicle, at the middle of the anterior wall of the axilla, it reaches the artery on its inner side. It is voluminous, and frequently overspreads the anterior surface of the artery.

The *nerves of the brachial plexus* lie above the artery in successive rungs which unite between the first rib and clavicle into a bundle of nearly parallel cords running obliquely downwards and outwards like the artery. Behind the clavicle, and immediately below it, they lie against the outer border of the vessel; but the latter, at the level of the coracobrachialis, passes into their midst between the two heads of the median nerve; and so we reach the axillo-brachial trunk (*Figs.* 52 and 54).

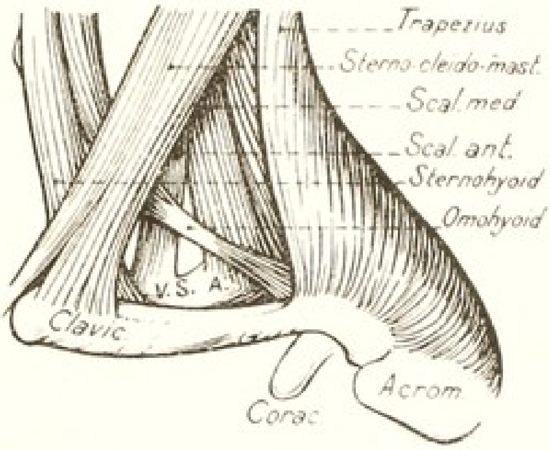


Fig. 53.—Supraclavicular fossa.

These vascular and nervous trunks are covered, beneath skin and subcutaneous tissue, by *two musculo-aponeurotic layers*, above and below the clavicle: (1) Sterno-mastoid, trapezius, and deep fascia above, pectoralis major below; (2) Omohyoid and a deep layer of cervical fascia above, and costo-coracoid membrane below.

Further anatomical details will be given in describing the ligature of the vessel above and below the clavicle.

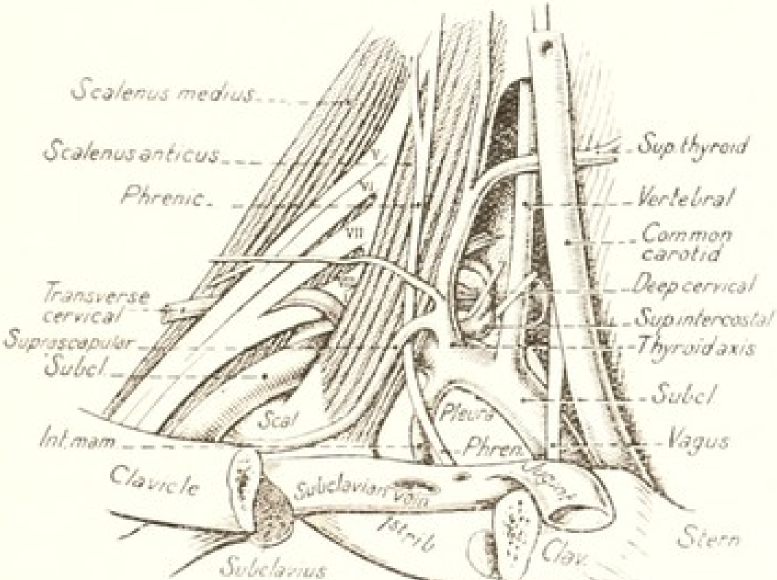


Fig. 54.—The subclavian artery

The *bony landmarks* are the same for both ligatures. The anterior border of the clavicle must be felt, and the line of the joints at each end of the bone, acromial and sternal, marked with a stroke of the nail; the mid-point between these is then marked with the index finger, while thumb and middle finger are placed at each end. The sternal end is very easily found, for the bony head of the clavicle projects at the root of the neck; but mistakes are possible in marking the acromial end. To find this, the finger is made to follow outwards the anterior border of the clavicle, concave forwards at this point, until it is arrested at the level of the shoulder by the acromion process, the point of which reaches in front of the corresponding surface of the clavicle.

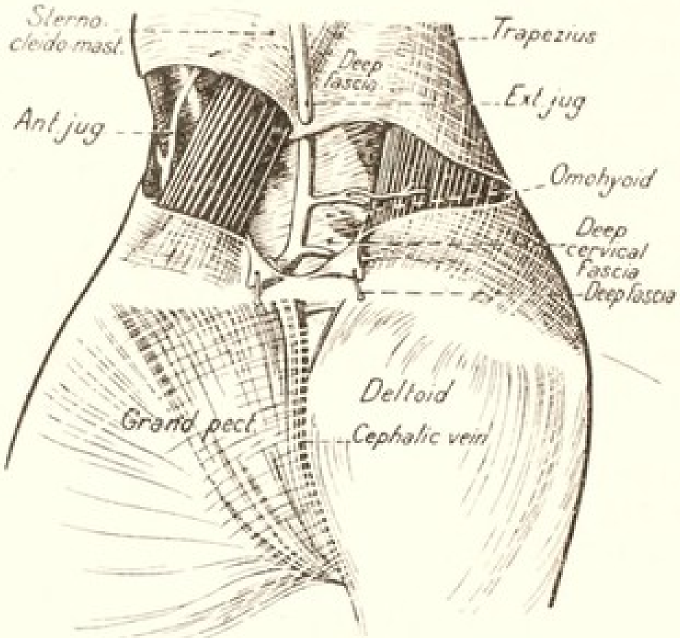


Fig. 55.—Superficial structures in the supraclavicular fossa.

The mid-point of the clavicle corresponds on the surface with the point where the artery passes under the bone; but the vessel runs obliquely downwards and outwards; it reaches the clavicle half an

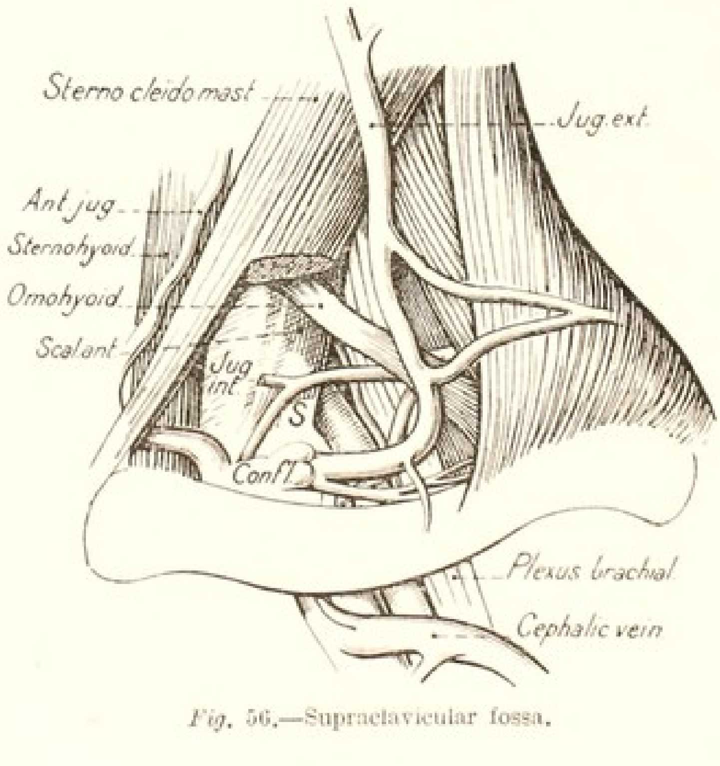


Fig. 56.—Supraclavicular fossa.

inch inside the mid-point (end of the subclavian artery), and leaves it about half an inch outside the mid-point (beginning of the axillary artery).

Operation.—For these two ligatures the *surgeon* stands on the outer side of the shoulder, facing the clavicle; his *assistant* stands opposite to him, at the narrow end of the table, behind the shoulder. The *subject* is placed quite at the edge of the table, and tilted a little, the nape of the neck and the upper part of the back resting on a block placed longitudinally so that the concavity lies under the scapula, and this bone, lying free posteriorly, can be raised or lowered with the shoulder and clavicle at will.

Be careful always to ascertain as far as possible the course of the superficial veins (external jugular, cephalic, and a possible anastomosis between the two), which can be done if they are filled and made to swell by pressure from below upwards.

1. Ligature above the Clavicle (*third part of subclavian artery*).—The supraclavicular fossa, where lies the accessible part of the artery, is made as wide as possible *by carrying the shoulder downwards, forwards, and inwards*, and by placing the forearm, flexed at right angles, transversely across the abdomen of the subject.

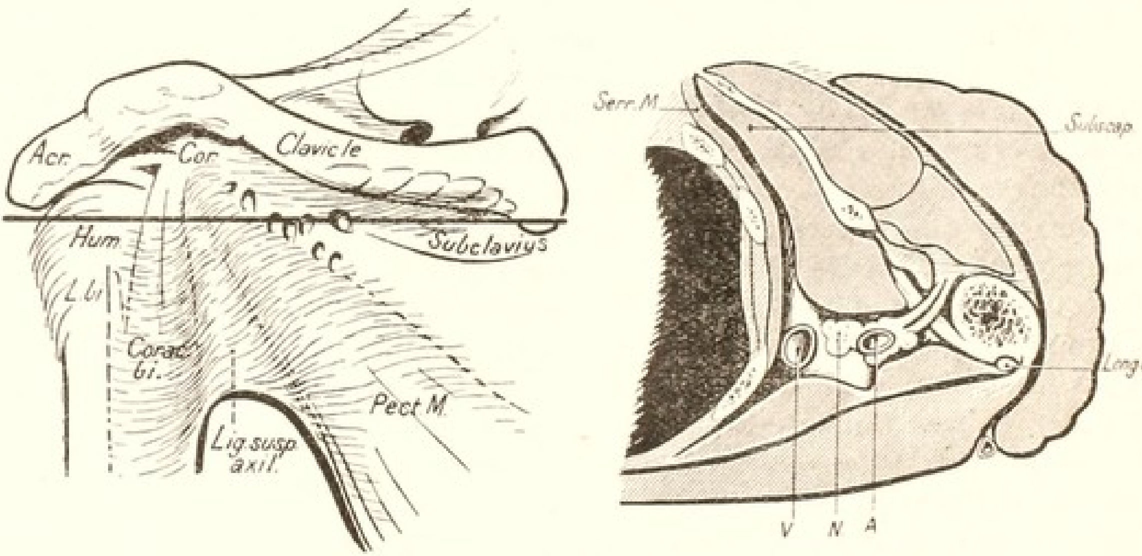
The *cutaneous incision*, three and a quarter inches long, begins *two finger-breadths outside the sternoclavicular articulation*, along a line *parallel with the upper border of the clavicle and half an inch above it*. *Skin*, *subcutaneous tissue*, and *platysma* are divided without danger, and the *deep fascia* is reached, which may be divided by the direct method, as the external jugular vein has already passed deeply in this position. Make the incision free enough inwards, and do not hesitate *partly to divide the sternomastoid muscle* if its clavicular head is broad and encroaches on the incision, which must be quite open at its inner end. This is the point at which the operator must work in order to *free the external jugular vein* and *divide* (*below omohyoid*) the *deep layer of the cervical fascia*, which is attached behind the clavicle at the point where the jugulars and the subclavian vein unite. Half an inch above the clavicle is still some distance from the great venous trunk which runs transversely, but the external jugular will be met with in the outer half of the wound, for it descends vertically and then turns inwards, forming a concavity directed forwards and inwards, to follow more or less the border of the subclavian vein until it reaches the junction of the subclavian with the internal jugular (*Figs.* 55 and 56).

The *deep layer of cervical fascia*, then, *must next be divided* at the inner angle of the incision, working with a director towards the sternomastoid and close to that muscle. A retractor is placed in the little funnel thus made, and the tissues are drawn transversely outwards, including the *curve of the external jugular*, over the concavity of which the instrument has been placed. It is easy to retract the vein outwards, for it receives no tributaries from the inner side, while on the outer side it is fixed by the scapular veins.

To gain a better view, put in a second retractor and draw it inwards, also transversely, so as to displace the sternomastoid muscle. The assistant should pass his hand behind the head of the subject to hold this retractor properly; and he should be directed also to press the elbow of his other arm against the side of the occipital region, and push it towards the side not being operated upon ; this stretches the *tendon of the scalenus anticus*, the next rallying point.

To practise finding this cord, begin by *seeking for it with the left index finger*. Thrust the finger deeply in over the middle of the clavicle, the pulp towards you, and it will reach the scalenus anticus muscle ; pass downwards towards the first rib, along the tendon, until the finger is arrested by bone, and the projecting *scalene tubercle* will be felt between pulp and nail. Now, without leaving the bone, draw the finger towards you, maintaining a steady pressure ; the arterial trunk as it lies on the bone is felt to escape from under the finger.

A practised operator will not use his finger in this way, but relies on the director, with a few longitudinal strokes of which he exposes the scalene tendon, easy enough to do if the muscle is kept tense. Behind the tendon, in contact with the rib, lies the artery.



Figs. 57 and 58.—Subclavicular region.

To *isolate the artery*, work *on the rib* and perpendicular to it, but parallel to the course of the vessel—that is, obliquely forwards and outwards—without leaving the bone ; this gives a space about half an inch long to operate in. If the bone is left, there is a risk of perforating the apex of the pleura behind or the vein in front.

Clean the vessel, and pass the aneurysm needle from within outwards. Before tying the ligature, make certain that it is really the vessel—lying in contact with the rib and scalenus anticus—that is secured, and not a nerve trunk, which may be recognized as a white and rounded cord.

2. Ligature below the Clavicle (*first part of axillary artery*).—Increase the extent of the subclavicular hollow by carrying the shoulder upwards and backwards, which happens readily if a block is placed under the back, as described on p. 49, the arm resting on the table, slightly separated from the body, the elbow pushed towards the head.

Palpate the anterior border of the clavicle and the coracoid process, then make an *incision*, three and a quarter inches long, *parallel to the clavicle but half an inch below it, reaching from the coracoid process to one and a quarter inches outside the sternoclavicular joint.*

In the subcutaneous tissue be on the look out for a *possible preclavicular anastomosis between the cephalic and external jugular veins*; if it exists, free it on the inner side, and have it drawn outwards. The *pectoralis major* muscle next comes into view. With the left thumb on the clavicle, draw the inner lip of the skin incision towards the neck, and with a full blade *divide the muscle* close to the bone. There is no reason to fear penetrating the posterior surface of the muscle, for it is separated by connective tissue from the *costocoracoid membrane* (*Fig.* 57). The latter, which is continuous with the deep cervical fascia, forms above, just under the clavicle, a sheath for the subclavius muscle, and below, a sheath for the pectoralis minor ; so that between

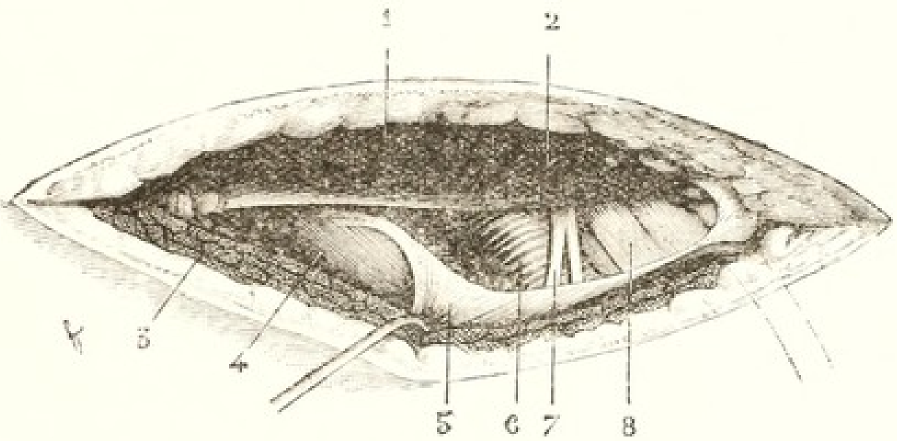


Fig. 59.—Ligature of the first part of the left axillary artery. The wound is shown dissected.

1. Clavicular origin of pectoralis major.
2. Subclavius muscle.
3. Divided clavicular head of pectoralis major, retracted downwards.
4. Axillary vein.
5. Aponeurotic sheet, which ensheathed the subclavius, drawn downwards, so hiding the termination of the cephalic vein, and all the acromiothoracic vessels.
6. Axillary artery.
7. External anterior thoracic nerve.
8. Trunks of the brachial plexus.

these two muscles a triangular space is left, with an upper border running horizontally (subclavius), and a lower border running obliquely upwards and outwards (pectoralis minor) to the apex externally (coracoid process). This aponeurosis is cribriform ; it is pierced by the cephalic vein, which curves in front of the artery, against the sheath of the subclavius, to join the axillary vein ; also by the acromiothoracic axis' artery and its branches, and by the external anterior thoracic nerve (*Fig.* 59).

In order to open the aponeurosis without injury to these structures, the knife must pass above it, through the *sheath of the subclavius muscle.* Prick this, with five or six millimetres of the knife point, on the flat, under the clavicle, and divide it from end to end; the muscle-pad protects the veins from injury. If the left index finger is now placed in the wound, and an endeavour made to hook and depress the lower lip of the aponeurotic opening, a sharp resistant edge will be felt, because the membrane is thick on its outer side, at its coracoid insertion. Keeping the membrane thus stretched with the pulp of the index finger (an unnecessary manœuvre for an expert operator), make a cut downwards and towards you, with the point of the knife, against the coracoid process, for a distance of three to four millimetres; immediately the fibrous edge can be drawn downwards on the broad end of a retractor, and with it the cephalic vein.

The artery (which can be felt to roll under the left index finger passed from within outwards over the thoracic wall), is crossed in front by the *external anterior thoracic nerve*. This nerve, a branch of the brachial plexus, perforates the membrane under the subclavius muscle, curving slightly, with the concavity forwards and inwards, and enters the deep surface of the pectoralis major. It descends nearly vertically, so that in order to see it the operator must work in this direction, at right angles to the clavicle, and half an inch outside its mid-point. Having found this landmark, take it on a retractor and have it drawn outwards and a little downwards. The *artery* now appears in place of the nerve; and as it lies internal to the brachial plexus, there is no risk of tying one of the nerve trunks by mistake. The *vein* lies to the inner side and in front; it is thin-walled, easily penetrated therefore, and is frequently of large size, spreading over the artery. Search carefully for its outer border, and free it by a few strokes of the director in an oblique direction downwards and outwards, half an inch outside the mid-point of the clavicle. Put a retractor on the outer border of the vein and draw it inwards. Clear the artery close to the clavicle, and pass the aneurysm needle from within outwards.

2. LIGATURE OF THE CAROTID ARTERIES.

Course.—The *common carotid* artery enters the neck deep to the projecting sternoclavicular joint; it passes almost vertically upwards, but a little obliquely outwards and backwards, as it is directed towards the carotid canal at the base of the skull. Between the upper border of the thyroid cartilage and the great cornu of the hyoid bone it bifurcates into the *external and internal carotids*. The internal carotid (which likewise gives off no branches in the neck) may be considered as the continuation of the common carotid artery, and the external carotid as a large branch arising from this trunk on its antero-internal aspect, to supply the upper part of the neck and the face. The main arterial trunk, as we regard it, then passes from the base of the neck to the base of the skull, flanking (on either side) the pharyngo-œsophageal tube, and resting posteriorly on the prevertebral muscles, internal to the anterior tubercles of the transverse processes of the vertebræ. It is accompanied to the outer side by the *internal* *jugular vein*, a large, thin-walled, and flaccid vessel, which often spreads over the front surface of the artery, especially in the lower part of the neck; in the angle between the two vessels, posteriorly, the *vagus nerve* descends. These three structures have a common connective-tissue sheath; the sympathetic cord is behind the artery, in front of the vertebral column, but lies outside the sheath.

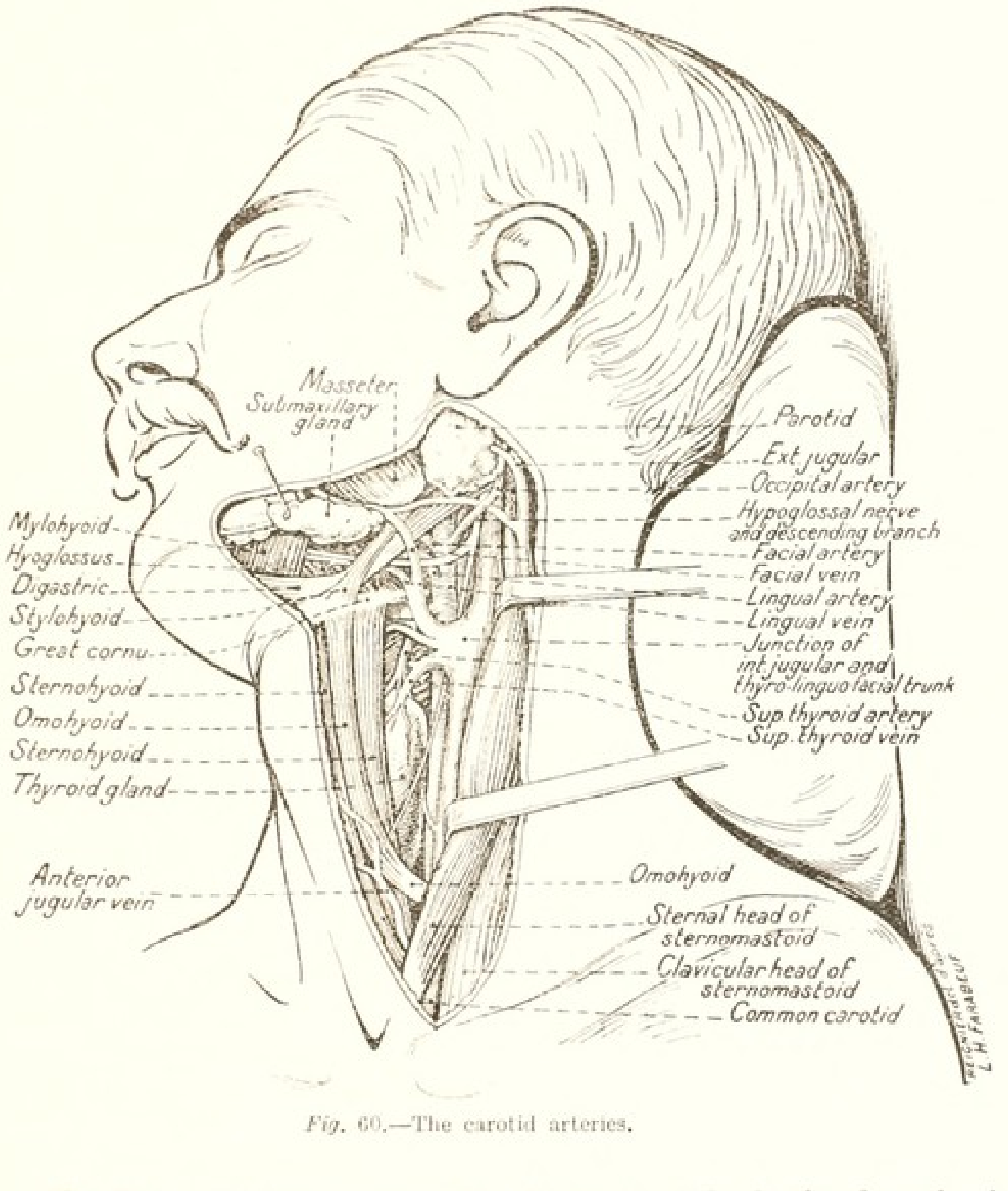


Fig. 60.—The carotid arteries.

The first covering, common to all the carotids, is the deep fascia, which ensheathes laterally the *muscle most related to the artery, the sternomastoid.*

This muscle can be seen passing upwards, backwards, and outwards from the sternoclavicular region below to the occipitomastoid region above; the anterior border is prominent, and a groove exists, which can easily be followed with the fingers, between it and the trachea. This groove corresponds to *the line of the artery*, and runs *from the sternoclavicular articulation to the parotid depression behind* *the angle of the jaw.* But it must be noted that the lines are not exactly parallel, for the arteries pass upwards nearly vertically, while the muscles diverge as they ascend, leaving a fascial space between them, which is equal above to the whole breadth of the face. The parallelism is more marked before the muscle is freed by dissection, because its anterior border is held close to the angle of the jaw by the continuity of the fascia over it with the fascial septum between the parotid and submaxillary glands. At its lower extremity, just above the sternum, the anterior border of the muscle extends over the inner side of the artery, which lies behind the interval between the sternal and clavicular heads ; in the middle of the neck the muscle lies alongside the artery ; above, it passes away from it somewhat, to the outer side and behind.

The deep tissue planes, which differ above and below, will be studied with regard to (1) the common carotid, and (2) the external carotid.

In addition to the prominence of the sternomastoid, *the cutaneous landmarks* to note before operating are :—

a. The anterior portion of the cricoid cartilage. This is felt from below upwards in the middle line of the neck (level of the transverse process of the sixth cervical vertebra).

b. The upper border of the thyroid cartilage (the upper limit of the common carotid).

c. The body and great corner of the hyoid bone, felt, like the thyroid cartilage, by pinching the neck transversely between the thumb and index finger.

d. The course of the superficial veins, making them stand out by pressure from above downwards.

1. Ligature of the Common Carotid Artery.—The artery is covered below by *two musculo-aponeurotic layers* :—

a. The deep fascia and the sternomastoid muscle.

b. The deep layer of cervical fascia (pretracheal fascia), and the omohyoid, sternohyoid, and sternothyroid muscles. This fascia forms a triangle, with its apex at the hyoid bone, and bounded postero-externally by the border of the omohyoid muscles.

The vessel may be tied at any part of its course ; the place of election is at the level of the tubercle of the transverse process of the sixth cervical vertebra (Chassaignac's tubercle), that is, at the level of the cricoid cartilage, and above the upper border of the omo-hyoid muscle. It is not necessary in this operation to divide the second layer of fascia.

The subject is placed on his back, a block under the nape of the neck, the shoulders resting on the table ; the surgeon stands on the side to be operated on, with the assistant facing him.

The *incision*, along the line indicated above, should be two and a half to three inches in length, *reaching upwards as far as the upper border of the thyroid cartilage.* Before incising, stretch the skin and sternomastoid by turning the face to the other side. Under the skin, which is thickened by the platysma muscle, be on the look out for the external jugular vein, and, to the inner side, for a branch of the anterior jugular which is sometimes present. Have these vessels retracted, the one outwards, the other inwards, and divide the deep fascia directly, for the whole length of the wound, over the anterior border of *the sternomastoid muscle* (or better still, a little outside the border, so as to be certain of the muscle). *Never proceed without seeing this landmark.* Seize with forceps the inner lip of the aponeurotic opening, and with the point of the knife on the flat under the muscle (directed therefore somewhat towards the operator), free the latter and retract it outwards, after relaxing it by putting the head straight again. The broad end of a retractor is now placed on the larynx, and drawn inwards; the surgeon will then have before him the *deep layer of the sheath of the sternomastoid*, which separates him from the vasculo-nervous bundle. A beginner would act wisely now to explore the wound at the level of the cricoid cartilage with the left index finger perpendicular to the vertebral column, on which he feels Chassaignac's tubercle (a projection on the transverse process of the sixth cervical vertebra, overhanging the seventh transverse process); then, drawing the finger towards himself, pressing firmly the while, the artery will be felt to roll under the pulp of the finger.

The sheath is divided, according to the experience of the operator, either by buttonholing it directly, or by the use of a director. On the anterior surface of the artery the descendens hypoglossi nerve should be avoided if it is seen; to the outer side, the inner border of the vein, often spreading over the artery anteriorly, is sought for, freed carefully with a director, and drawn outwards on the same retractor as the sternomastoid. The vessel should be cleared on its posterior aspect with especial care, in order to avoid tying the vagus nerve with the artery (make quite sure of this point before tying the knot). The aneurysm needle is passed from without inwards.

2. Ligature of the External Carotid.—The positions of the surgeon, his assistant, and the subject, are the same as for ligature of the common carotid.

The classical method is to incise the skin along the anterior border of the sternomastoid from the angle of the jaw to the superior border of the thyroid cartilage. I think it more convenient (see the anatomical *résumé* on p. 52) to make *an almost vertical incision*, about two and a quarter inches long, from a point on the horizontal ramus of the mandible one finger-breadth in front of the angle, reaching to the upper border of the thyroid cartilage. Its mid-point corresponds very nearly to the great cornu of the hyoid bone, a landmark to be noted with care; it can easily be made to project if the assistant pushes the bone from his side.

Under the platysma, be careful of the external jugular vein and its anastomosis with the facial, then divide the *deep fascia* directly. If a vertical incision has been made, it is in the lower part of the wound only that *the anterior border of the sternomastoid* will be seen, freed, and retracted outwards (as in the case of the common carotid); *this border must always be seen* (first rallying point). A retractor is put on the inner side of the wound, care being taken not to hook with it the great cornu of the hyoid bone.

Now have the head straightened, and whereas hitherto the blade of the knife has been held vertically, from this moment *work with scalpel and director horizontal*. In this manner the larynx and the *great cornu* of the hyoid bone are approached (which the assistant makes prominent), removing on the way any lymphatic glands that may be inconvenient. A beginner would do well to take his bearings, several times if necessary, by feeling for the great cornu with the left index finger. Having then carefully felt the cornu, divide the deep tissues just above and in contact with it with a director (or the knife point if clever enough). In the depths of the incision will now be seen a venous trunk, the *thyro-linguo-facial vein*, running transversely to join the internal jugular: higher up lies the *hypoglossal nerve*. To hunt for these structures and isolate them, work with the director parallel to their direction, transversely that is, and not longitudinally as heretofore. The vein, the bluish track of which is recognized immediately, lies about a third of an inch below the great cornu; free its upper border and take it under the outer retractor. The nerve, which must be freed behind the lower pole of the parotid in order to be seen, lies a third of an inch above the great cornu; place it under the inner retractor and have it very gently retracted. Now, just at the place where it was lying, between it and the vein, at the level of the great cornu, lies a large vessel, the external carotid artery. Clear it in the usual way, and pass an aneurysm needle from without inwards.

A mistake is made sometimes by tying instead the common carotid below the bifurcation (a pardonable error if the bifurcation is abnormally high), or the internal carotid. This last mistake occurs because it is often forgotten that the *external* carotid (so called because it supplies the external parts of face and neck) lies at its origin a little internal to, and in front of, the internal carotid. But neither the common nor the internal carotid has branches. Therefore, before tying the knot, free with a director the anterior surface of the vessel round which the thread is passed, and *make sure that branches take origin from it*. The typical ligature should be tied between a vessel running obliquely downwards and forwards (the superior thyroid artery), and a vessel running transversely forwards (the lingual artery, or common linguo-facial trunk).

3. Branches of the External Carotid.—Practically speaking, the best way to tie the branches of the external carotid in the majority of cases is to take them at their origin—that is, to lay bare the parent trunk, and seek the desired artery at that level.

It is usual, however, to teach certain classical ligatures:—

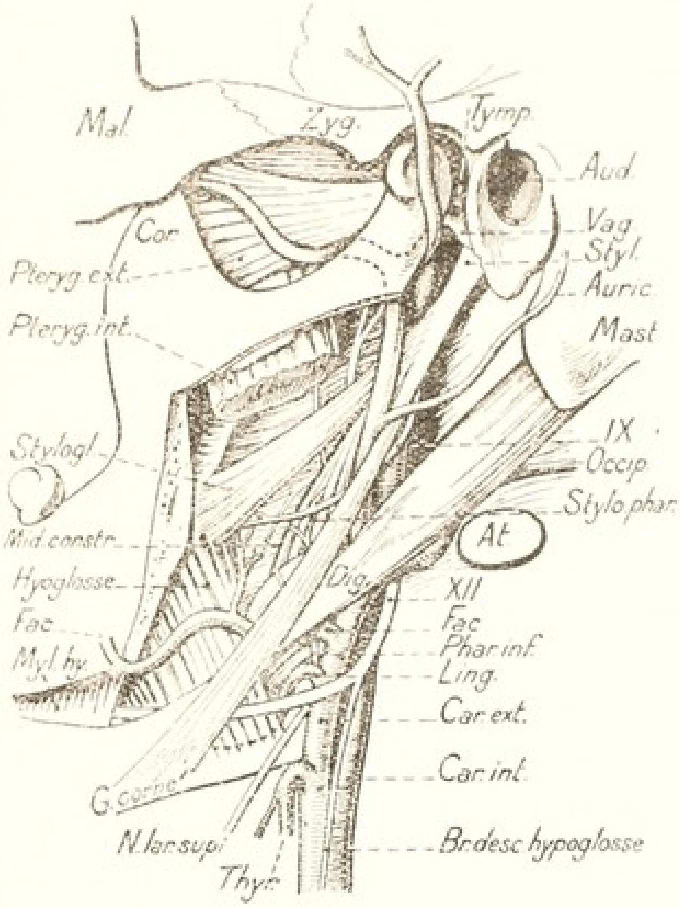
a. The Facial Artery, where it crosses the lower jaw in front of the border of the masseter muscle. An incision one inch long is made under the border of the jaw at this level; the artery lies against the bone.

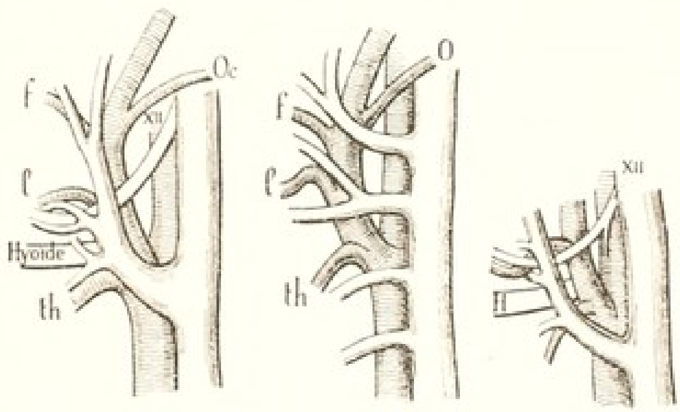
b. The Occipital Artery, under the mastoid process. It is found by a transverse incision, two inches long, ending in front at the tip of the process. Between this point and the transverse process of the atlas the artery is covered by the posterior portion of the sternomastoid, the splenius capitis, and the trachelomastoid muscles.

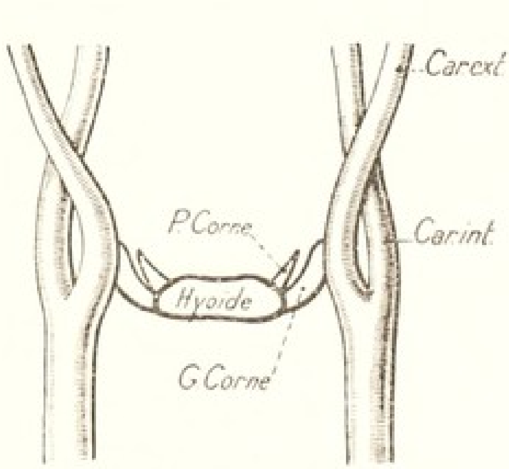
c. The Superficial Temporal Artery (terminal branch). This is reached by a vertical incision, one inch long, between the tragus and the condyle of the lower jaw, passing at its midpoint over the zygoma.

d. The Lingual Artery.—Starting from the anterior aspect of the external carotid, between the superior thyroid and facial arteries, the lingual artery first forms a loop with concavity downwards, the upper end of which rises above the hypoglossal nerve; it then comes to lie antero-posteriorly and transversely like the nerve. But whereas the nerve, accompanied by the lingual vein, lies on the outer surface of the hyoglossus muscle, the artery passes between the deep surface of the hyoglossus and the middle constrictor of the pharynx, about a third of an inch above the great cornu of the hyoid bone.

The deep structures in this region, as seen after removal of the more superficial structures, are arranged as follows: Above the great cornu of the hyoid bone the digastric muscle forms a loop, with the concavity upwards, its







Figs. 61, 62, and 63.

two red muscle bellies united by an intermediate tendon close to the anterior portion of the great cornu (at its junction with the body of the hyoid), to which it is attached by a fibrous band. From the great cornu, obliquely upwards, forwards, and inwards, runs the hyoglossus muscle; it is crossed behind by the posterior belly of the digastric, and in front by the mylohyoid running obliquely backwards and outwards. This surface of the hyoglossus is thus divided into two portions: one posterior, between the posterior belly of the digastric above and in front and the great cornu below (Béclard's triangle); one anterior, between the posterior belly and tendon of digastric behind and the mylohyoid in front (Pirogoff's triangle). The hypoglossal nerve, lying on the hyoglossus, passes between it and the digastric, and then disappears under the mylohyoid. The artery is deep to the hyoglossus, and at a slightly lower level than the nerve, the distance of which from the digastric tendon is somewhat variable.

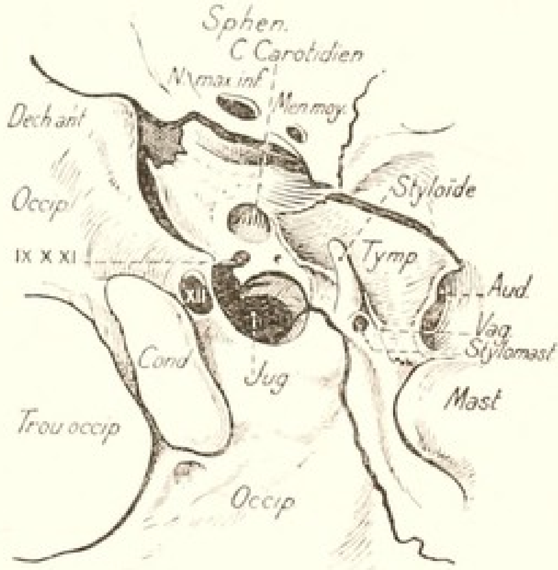


Fig. 61.

The whole of this region is covered by the submaxillary gland, which lies in a fibrous sheath formed from the cervical fascia.

The classical ligature of the dissecting room is in Pirogoff's triangle. If the artery is to be tied proximal to the origin of the dorsalis linguæ (which is most often necessary in practical surgery), it must be sought for behind the posterior belly of the digastric, in Béclard's triangle.

i. *Ligature in Front of the Digastric* (in Pirogoff's triangle).—The head is placed in extension, turned towards the sound side; the operator stands three-quarters facing the subject; the assistant is above the head and works over it.

Make *a horizontal incision*, two inches long (it will become a little convex downwards, as the skin retracts), *equidistant from the lower border of the mandible and the great cornu of the hyoid bone*, terminating one finger-breadth in front of the parotid hollow. Divide the skin and platysma (beware of the facial vein posteriorly); clean the *deep fascia*, then *divide it under the lower lip of the wound, dragged downwards for the purpose*. The fascial *sheath of the submaxillary gland is thus opened*, and the lower border of the gland (an indispensable landmark) must be freed, as it usually reaches below the digastric loop. Seize the lower lip of the aponeurotic opening in the forceps, loosen the lower border of the gland with a director, and pass the large end of a retractor, perpendicular to the horizontal ramus of the mandible, along the path thus made. Drag the retractor towards the face, keeping the handle well raised, and at once the gland is freed and drawn upwards beneath the jaw. The *digastric tendon*, with the ends of the two muscle bellies, now comes into view in place of the gland. The *nerve must next be found*; it often lies in

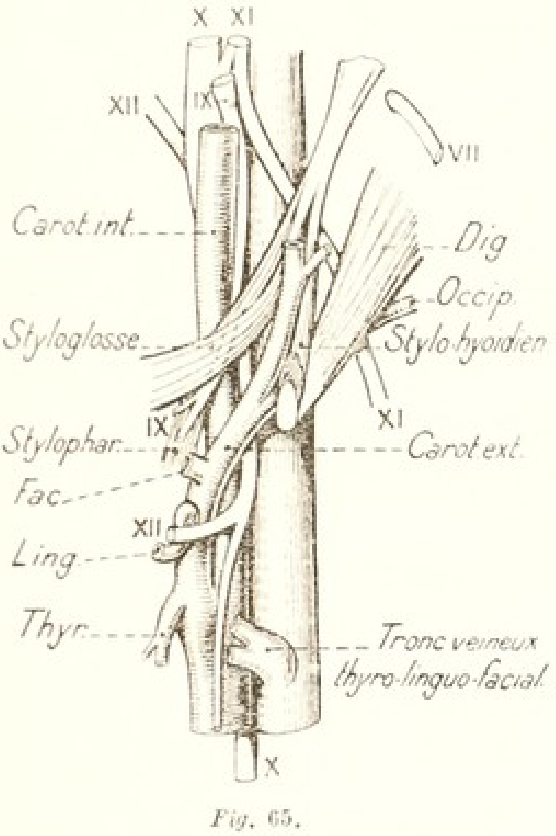


Fig. 65.

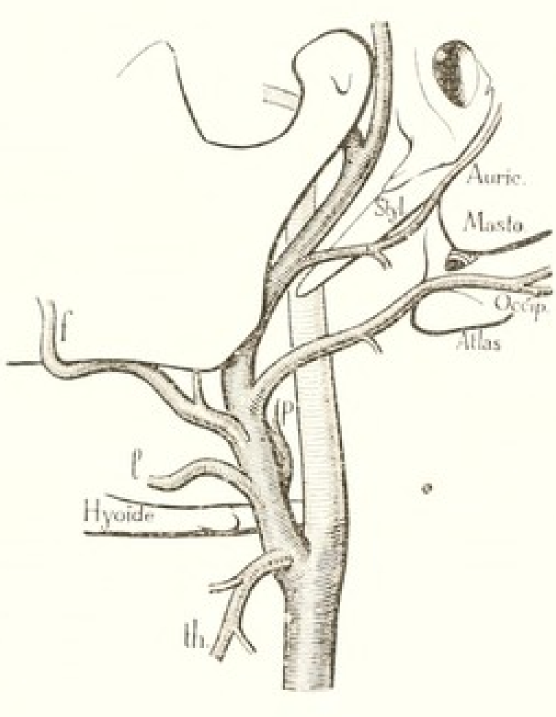


Fig. 66.

contact with the tendon (when the fibrous band is slack); the director must be used transversely therefore, parallel to the digastric tendon and close to it. In a few strokes the nerve is freed, and the area of *Pirogoff's triangle* is seen, between the nerve above, the digastric below, and the mylohyoid in front; in this area the fibres of hyoglossus are visible. At the centre of the space pinch up a transverse fold of this muscle with the forceps, and buttonhole the base of the fold in a direction parallel to the nerve. Enlarge the little opening thus made with a director (do it gently, or the middle constrictor of the pharynx may be perforated), and the artery is reached. To clear it, pinch the sheath of the vessel longitudinally with two pairs of forceps, the ends touching, so as to raise two transverse folds, and break it by separating them sharply.

ii. *Ligature Behind the Digastric* (in Béclard's triangle).—*The incision is a horizontal one*, an inch and three-quarters long, *parallel to the great cornu and a little above it*, reaching as far as the anterior border of the sternomastoid muscle.

Divide the skin, the platysma, the subcutaneous tissue (keeping a look out posteriorly for the anastomosis between the facial and external jugular veins), and then the deep fascia. If the submaxillary gland is low down, the posterior part of its sheath will thus be opened, but this is not essential ; whether the sheath is opened or not, the gland is drawn upwards, under the jaw, as described above, and search made for the great cornu of the hyoid bone, which the assistant makes prominent as previously described. The next landmark is the hypoglossal nerve, cleaned with one or two transverse strokes of the director, and the next the posterior border of the digastric muscle as it runs obliquely downwards, forwards, and inwards. Between these three structures (Béclard's triangle), buttonhole the hyoglossus muscle as above, clear the artery, and pass a ligature.

The linguo-facial veins, which pass downwards towards the internal jugular in the posterior part of the wound, should be protected by retracting them downwards and backwards.

Section II.

AMPUTATIONS AND DISARTICULATIONS.

Part 1.—GENERAL OBSERVATIONS.

Chapter V.

THE USE OF INSTRUMENTS AND SHAPING OF STUMPS.

Amputation consists in the removal of the whole or part of a limb. There are two kinds of amputations :—

1. *In continuity.* That is, removal by sawing the bone, an amputation in the true sense of the word.

2. *In contiguity.* That is, removal through a joint, more correctly called a disarticulation.

For division of the soft parts, the same rules apply to both.

1. INSTRUMENTS.

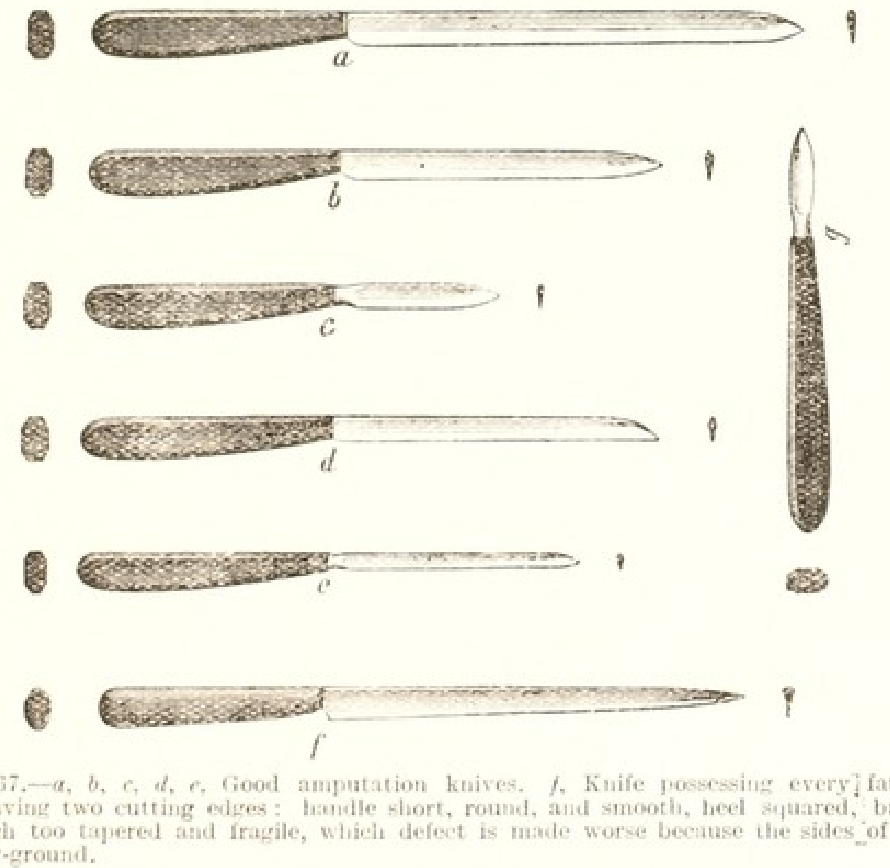


Fig. 67.—*a*, *b*, *c*, *d*, *e*, Good amputation knives. *f*, Knife possessing every fault except that of having two cutting edges : handle short, round, and smooth, heel squared, back thick, point much too tapered and fragile, which defect is made worse because the sides of the blade are hollow-ground.

a, With a blade of 8 to 10 inches for circular amputation, or by transfixion, through the thigh *b*, Blade 6 inches long, for arm, leg, etc. ; *c*, Syme's knife, blade 2½ inches long ; *d*, Lisfranc's knife, blade 6 inches long ; *e*, Finger knife, blade 4 inches long ; *g*, Small knife for operating on the small bones of the hand, with a long handle, which should be held like a pen ; blade 1½ inches long.

(The knives are represented with black wooden handles, as they were made at the time of the exhibition in 1878). [*Farabeuf.*]

Knives.—The handle, 4 to 5 inches long, is nearly always the same ; the sides should be flat.

There are three types of *blade* :—

a. The ordinary amputation knife, the point of which is lowered a little by a slight short convexity of the back of the blade. The usual lengths are 5, 6, 7, and 11 inches. The wrist knife is of the same type, but has a narrow blade 4 inches long.

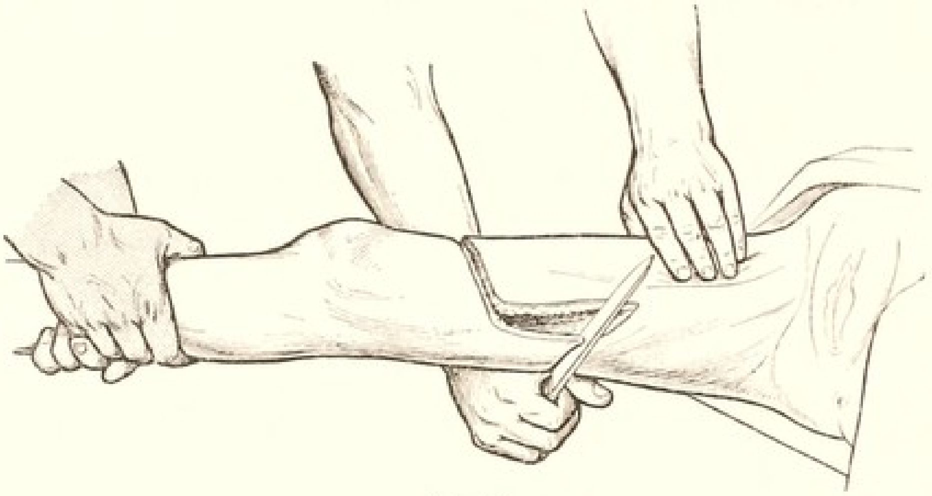


Fig. 68

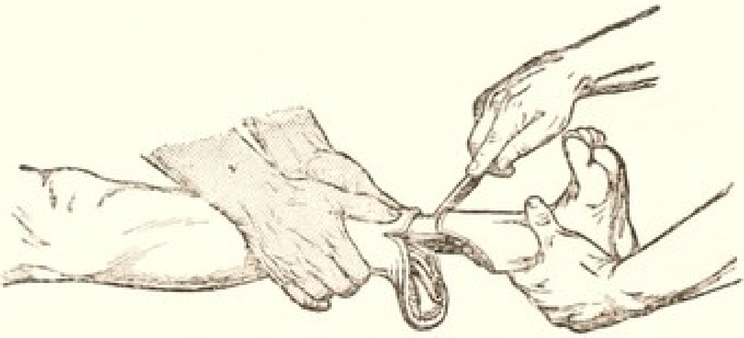


Fig. 69.

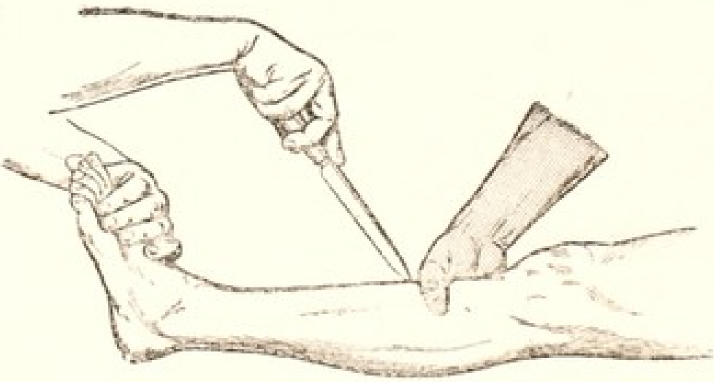


Fig. 70.

b. Syme's knife, for operations on the tarsus, has a short ($2\frac{1}{2}$-inch) blade, broad, and with the point in the axis of the blade, but the back blunt ; it may be likened in shape to a grain of corn.

In both these knives the cutting surface, ending in a sharp *point*, consists of two portions : the *cutting portion of the blade*, straight, and reaching from the heel to the *cutting portion of the point*, convex for a distance of about half an inch.

c. The special knife for Lisfranc's amputation, 6 inches long, $\frac{1}{3}$ inch wide, is characterized by the terminal convexity of the dorsum of the blade, so that the point is dropped, and the cutting surface is straight from one end to the other.

Manner of Holding the Knife.—An amputation knife is always grasped fully in the right hand.

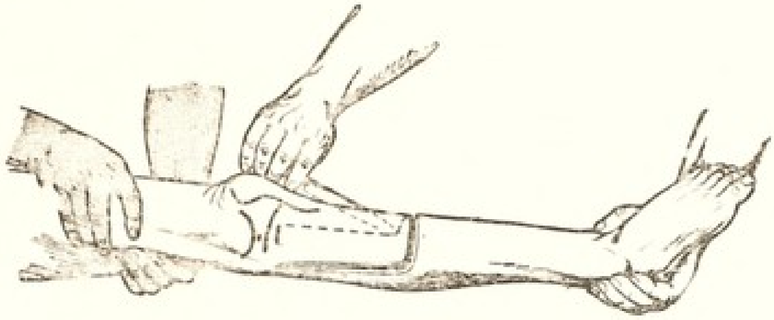


Fig. 71.—Knife held like a violin bow (reversing); view of the dorsum of the hand.

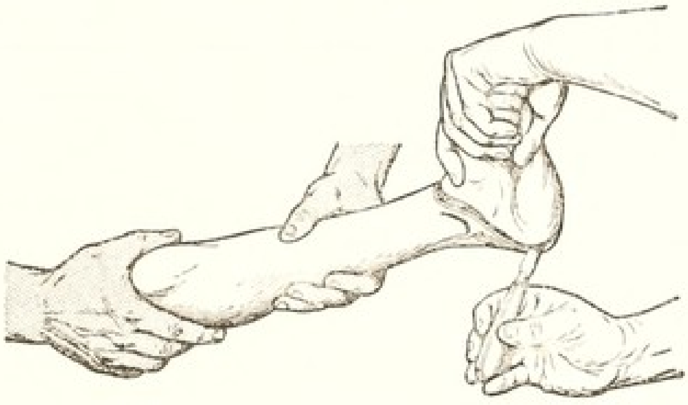


Fig. 72.—Knife held like a violin bow; view of the palmar surface of the hand, showing the handle.

Fig. 73. — A. Commencement of an incision with the point of the knife, index finger stretched along the back of the blade, handle uppermost. B. End of the incision at a corresponding point on the opposite side of the foot, knife held like a violin bow.

a. The typical hold is with the handle lying in the palm, gripped transversely by the four flexed fingers, the blade emerging between thumb and index finger in a direction perpendicular to the axis of the forearm (*Fig.* 68).

b. From this hold, little secondary movements of the fingers around the handle bring us to another common hold, in which the handle is held near the blade between the pulp of the thumb and the distal phalanx of the middle finger, and the index finger is stretched along the back of the blade ; the little and ring fingers are flexed on the handle, which is nearly parallel to the axis of the forearm, with its end resting in the hollow between the thenar and hypothenar eminences (*Figs.* 69 and 70).

c. By rotating the handle a little until it lies almost transversely between the thumb and middle finger, the knife comes to be held *like a violin bow*, the handle seized between the pulp of the thumb on one side and the pulp of the four fingers on the other (*Figs.* 71 and 72).

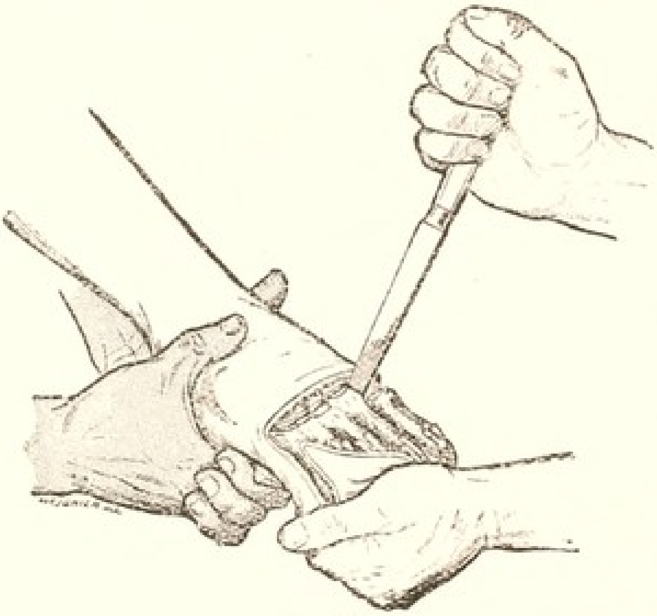


Fig. 74.

The student will not attain lightness and precision of touch unless he practises passing smoothly, without jerks, from one of these positions to the others (*Fig.* 73 A and B).

d. Sometimes the knife is held *like a dagger*, the inverse, that is, of the position just described ; all the fingers closed, the handle perpendicular to the axis of the forearm, the blade emerging between the flexed little finger and the hypothenar eminence (*Fig.* 74).

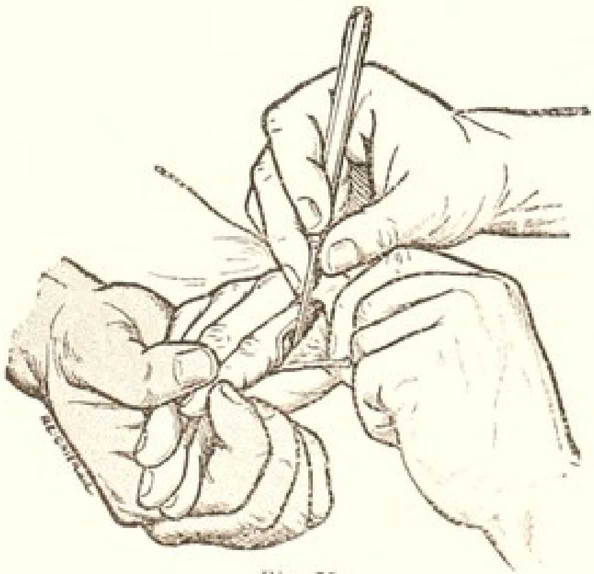


Fig. 75.

The student must practise passing from the first position to this one and back again, which is quite easy. Start with the hand in semipronation, the point of the knife upwards (first hold). Incline the knife forwards a little, pushing it with the thumb, and pass the index finger over it ; the handle is now held between the corresponding lateral surfaces of the terminal phalanx of the index finger and the head of the middle phalanx of the middle finger, both stretched along it as on a pen. By flexing these fingers the knife is rotated further, and then grasped again with the point downwards.

This change of hold is sometimes made in a single operative step, as when finishing a circular cut on the anterior aspect of the limb.

e. The amputation knife proper is never held *like a pen* (*Fig*. 75); but this hold is frequently used for a scalpel in operations on the small bones of the hand or foot, in freeing a flap, or in dividing accurately certain ligaments. In this hold, thumb and middle finger grasp the sides of the blade, limiting the serviceable portion of the edge, while the end of the ring finger is used as a support.

Fig. 76.

Manner of Handling the Knife.—With the point, the tissues are pierced. With the edge, they are cut: with the straight part of the edge when cutting in a straight line, with the terminal convex portion when turning a corner.

Fig. 77.

In an incision parallel to the axis of the limb, first *prick* with the point at the distal end of the incision, the wrist raised (*Fig*. 76); as soon as the thickness of the skin is pierced, drop the wrist and *draw* the knife directly towards you, without sawing, pressing with the index finger on the back of the blade, which is inclined at an angle of 45° to the axis of the limb (*Fig*. 77). In this way about an inch of the distal extremity of the edge is used. When the end of a stroke is reached and it is necessary to turn a corner, pivot a little on the point, raising the wrist at the same time, so as to cut with the convex part of the edge only (*Fig*. 78).

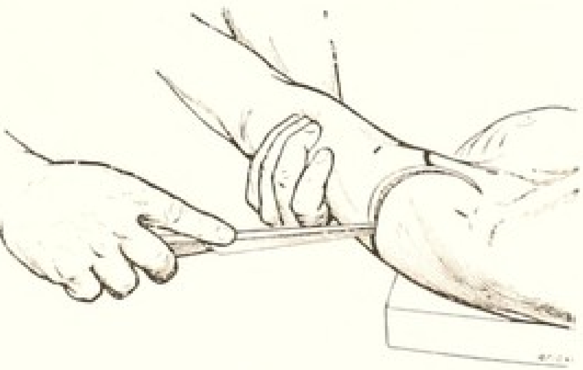


Fig. 78.

After turning a corner, it is often necessary to return along the limb by 'reversing' (*Fig*. 71), the wrist now being abducted and pronated, and the knife held like a violin bow.

The most precise and much the most frequently used movement is that in which the operator cuts from left to right and from a more distant point towards himself: this is called *drawing* the knife (*Fig.* 77). When the cut is made in a direction away from the operator, as often happens, it is called *reversing* (*Fig.* 71). It is only exceptionally, for certain special steps, that he cuts from right to left (*Fig.* 85).

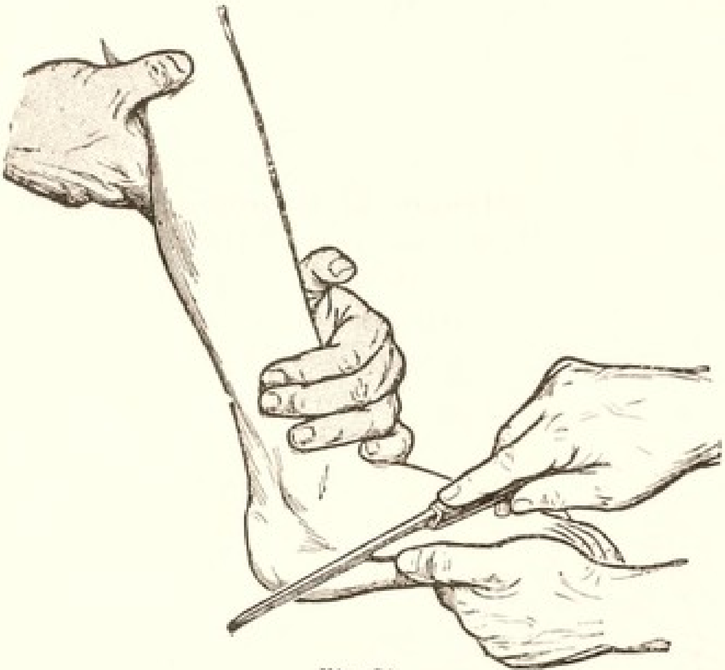


Fig. 79.

Fig. 80.

To cut the skin transversely in front of the operator, on the anterior surface of a limb, for instance, which is held with the extremity towards him, he applies the heel of the blade at the left extremity of the incision (*Fig.* 79), the point lowered, then cuts with the full edge, using the whole length of the blade, so as to end with the point at the extreme right (*Fig.* 80). The knife is now vertical, the handle downwards and held like a violin bow, and it is finally brought out, exactly at the extremity of the incision, by raising the handle to the right, so that the point emerges perpendicular to the skin.

When cutting the skin, the blade must always be perpendicular to it, so that the cut is clean, and not oblique, with a margin of tapered skin.

The skin should always be kept tense, either by the left hand of the operator, the hands of the assistant (*Figs.* 81–83), or the position of the limb (*Figs.* 84 and 85).

Figs. 81, 82, and 83 show a skin division similar to that of the preceding figures, but with the incision markedly curved. To perform this, start with the heel of the blade in the same way, the handle raised, and cut with the full edge as far as the apex of the curve, which is reached with the point. Now *turn*, which is done by raising and flexing the wrist, so that the blade becomes vertical, and at the same time the direction of the incision is altered to make it in shape like a circumflex accent. After turning, drop the wrist to the horizontal, carrying it a little to the left at the same time, to cut again with the full blade; and end with the knife held like a violin bow, the blade vertical, the wrist lowered.

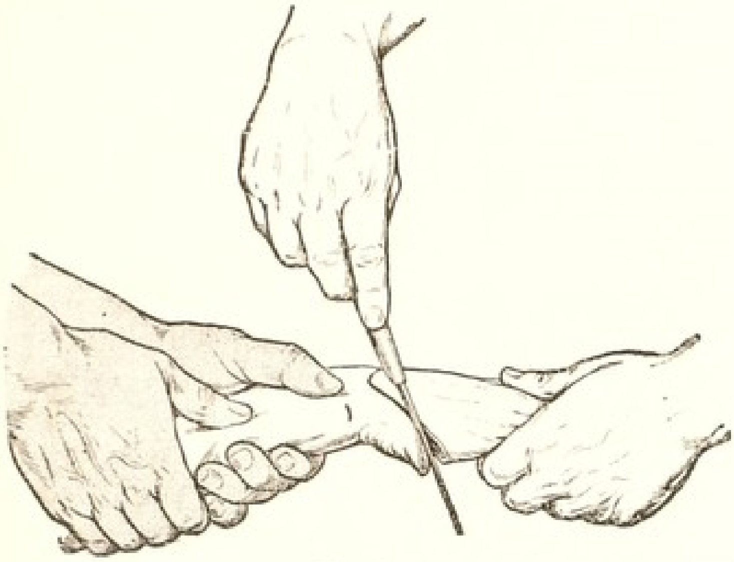


Fig. 81.

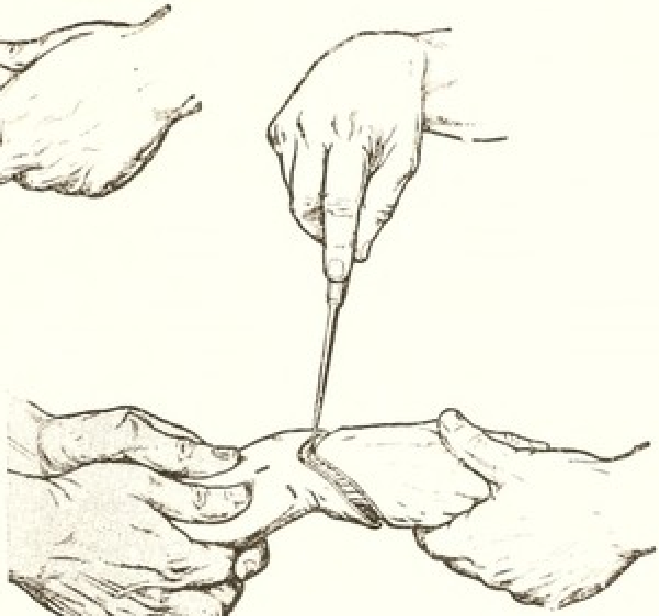


Fig. 82.

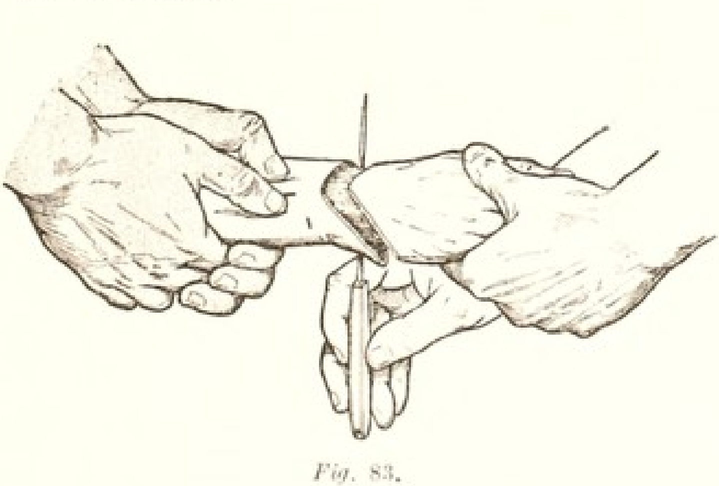


Fig. 83.

Fig. 84 shows how a digital commissure is divided by *reversing*, the operator standing at the end of the limb, the skin kept tense by the position of the finger, flexed, and separated from the remaining fingers, which are held by an assistant.

Fig. 84.

In *Fig.* 85 is shown a method of stretching the skin of the axilla, by abduction of the arm, without the necessity of an assistant. In this figure, also, it will be seen how, in order to make the cut as complete as possible, the stroke is finished from right to left, the back of the blade resting on the commissure of the thumb.

Certain parts of the skin which are tough and fibrous (palm of the hand and sole of the foot) must be divided with the point of the knife by little jerks of the wrist, the blade being held vertical (*Fig.* 86).

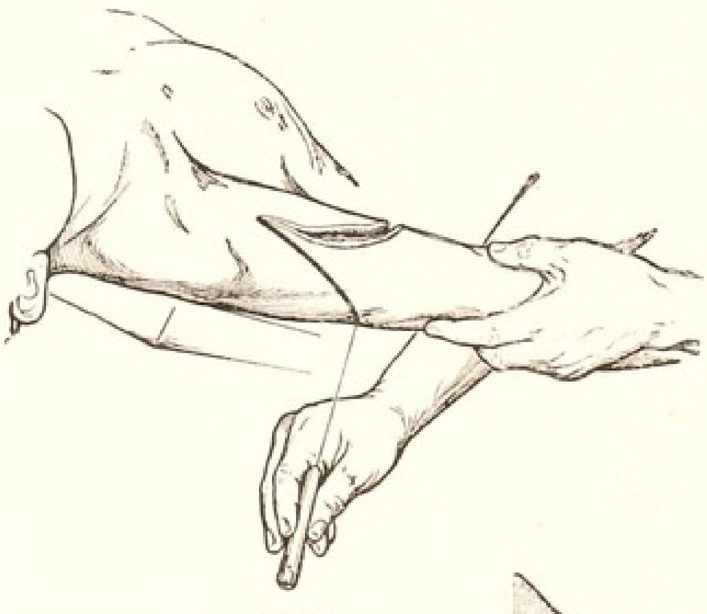


Fig. 85.

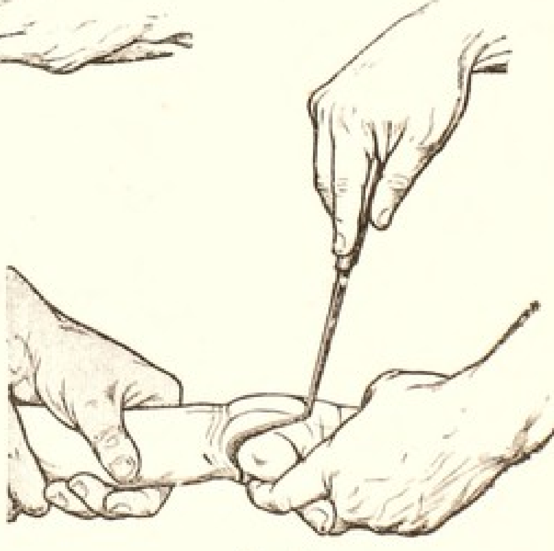


Fig. 86.

2. THE SHAPE OF STUMPS, AND HOW TO PLAN THEM.

A stump should be :—

1. *Well covered by Soft Tissues.*—If the soft parts are too short, the stump is said to be conical; the bone appears too long, is painful, and frequently adheres to the scar, which readily becomes ulcerated. The soft parts should therefore be as thick as possible, and long enough

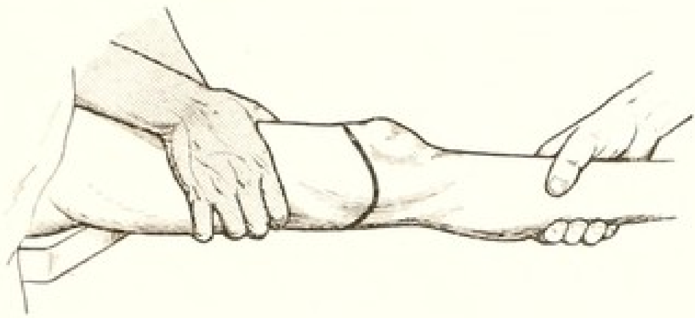


Fig. 87.—Skin outline for a circular amputation, marked obliquely to the axis of the limb; on account of the greater retraction of the skin on the inner side, the final result will be circular. The cicatrix will be terminal.

to cover *at least* the corresponding diameter of the limb. It must never be forgotten that after amputation the skin of a flap retracts for about a third of its length; and that it often retracts unequally at different points in the circumference of the limb.

Fig. 88.—A single anterior flap, the posterior incision uniting directly the two limbs of the U. *Fig.* 89 shows how a longer or shorter posterior flap may be cut. The angles of the flap are right-angles, but suitably rounded, and the flap must not taper. Its length should be greater than the corresponding half diameter of the limb. The cicatrix will be a transverse one and situated posteriorly.

2. *So Planned that the Cicatrix will not be pressed upon.*—Its position should be terminal therefore, if the artificial limb is to be supported by the periphery of the stump; lateral in other cases, or perhaps termino-lateral.

The best example of a terminal cicatrix is seen in a circular amputation (*Fig.* 87).

The best example of a lateral cicatrix is seen in amputation by a single flap (*Fig.* 88), a predominant flap (*Fig.* 89), or an ellipse (*Figs.* 90 and 91).

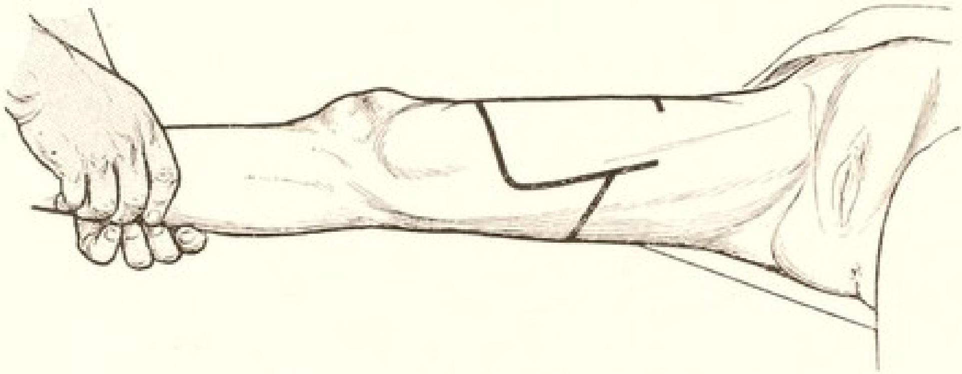


Fig. 89.—Long anterior, short posterior flaps.

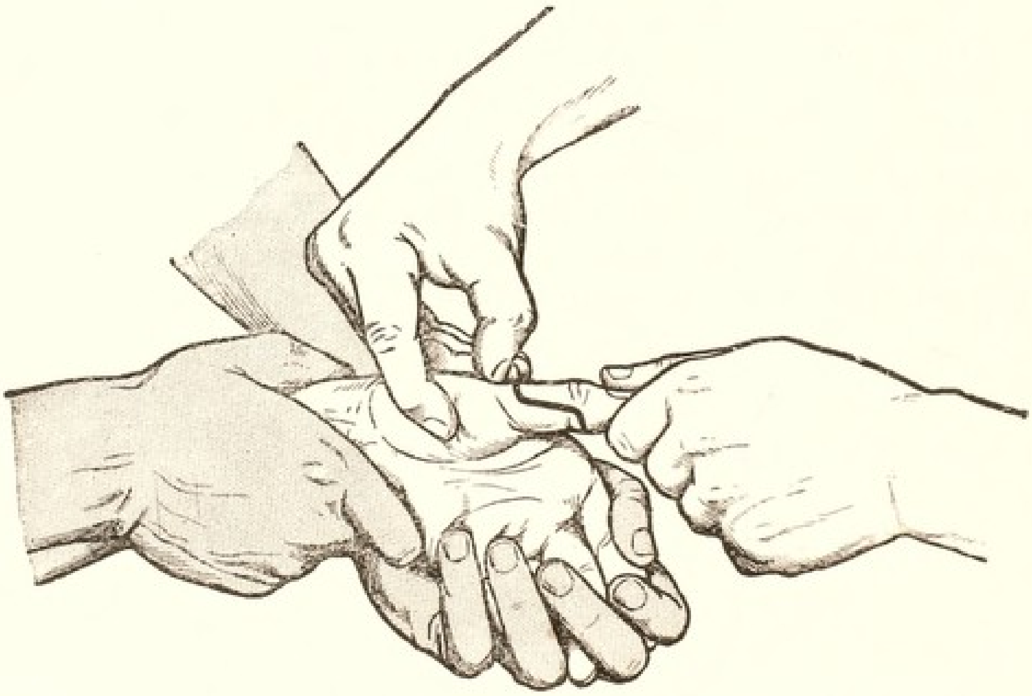


Fig. 90.—Elliptical division of skin, which results (*Fig.* 91) in a palmar flap with two lateral curtains hiding the extremity of the bone.

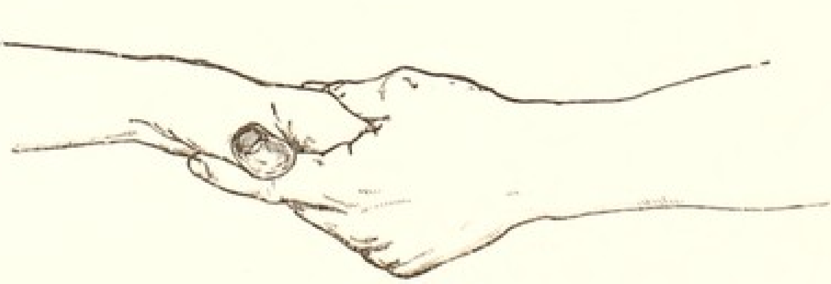


Fig. 91.

Termino-lateral cicatrices are seen after amputation by two equal flaps or by a racket incision (*Figs.* 92–4).

Fig. 92.

Fig. 92. — Modified circular incision, giving two little angular flaps. This, with the angles rounded to the quarter of a circle, makes the racket incision (*Fig.* 93). The racket consists of a handle and a ring; the typical form has a straight handle (of different lengths) and symmetrical ring. The principle remains the same when the end of the handle is bent back at right-angles (to facilitate certain disarticulations), and when the ring is made asymmetrical, so that a little flap can be turned back (*Fig.* 94). The scar of a racket is termino-lateral.

Fig. 93.

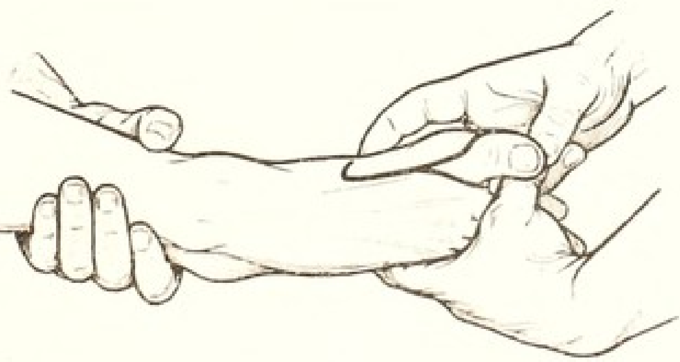


Fig. 94.

Chapter VI.

ON THE DIVISION OF THE SKIN.

1. CIRCULAR DIVISION.

The circular incision defines itself, although it has sometimes to be somewhat oblique originally, in order to be truly circular when the skin has retracted. It should be a quarter of the circumference of the limb below the level of section of the bone.

Practice the circular cut first of all *in two steps*, dividing first the posterior three-quarters of the circumference, and then the remaining quarter (*see Figs.* 95 and 96).

First Step: Division of Skin Posteriorly.—This is the best surgical exercise for teaching how to cut with the whole length of the blade, and how to turn the handle of the knife in the hand as the blade is carried round the limb.

Except in the case of the right thigh, when he stands outside the limb, the umbilicus to his left (*Fig.* 95), the operator always has to the left the portion of limb which is to be removed; and grasps in the left hand the skin on the anterior surface of this left portion of the limb between thumb and index finger, perpendicular to the axis of the limb and a little below the line of incision. An assistant, placed on the operator's right, grasps the limb between his hands, and, by drawing it towards the trunk, makes tense the skin which has been fixed below (*Fig.* 97).

Choose a knife about as long as the incision to be made at a single stroke, and grasp it fully in the right hand in the first position. Then, facing one side of the limb, which is held horizontally, pass the knife under it, and with wrist half pronated, blade vertical, the point upwards, apply the heel of the blade as far forwards as possible (above, as the operator stands) on the distal lateral surface.

Make the heel bite by pressure and by drawing it vertically downwards, bringing the handle towards you as it comes round the limb, making little sawing movements all the while, and nearing the point of the blade as the end of the incision is approached. After passing the mid-line posteriorly, rotate the handle between the middle and index fingers, until the surface of the limb near to you is reached with the knife again vertical, the handle uppermost; the point is now reached, and brought out in the usual way.

Second Step: Division of the Skin Anteriorly.—In this, the two ends of the first incision are united by a second. Expose the distal angle of the wound by rotating the limb towards you, and apply the heel of the blade at this angle, using the second hold, the index finger extended along the back of the blade (*see* p. 63). Now draw the

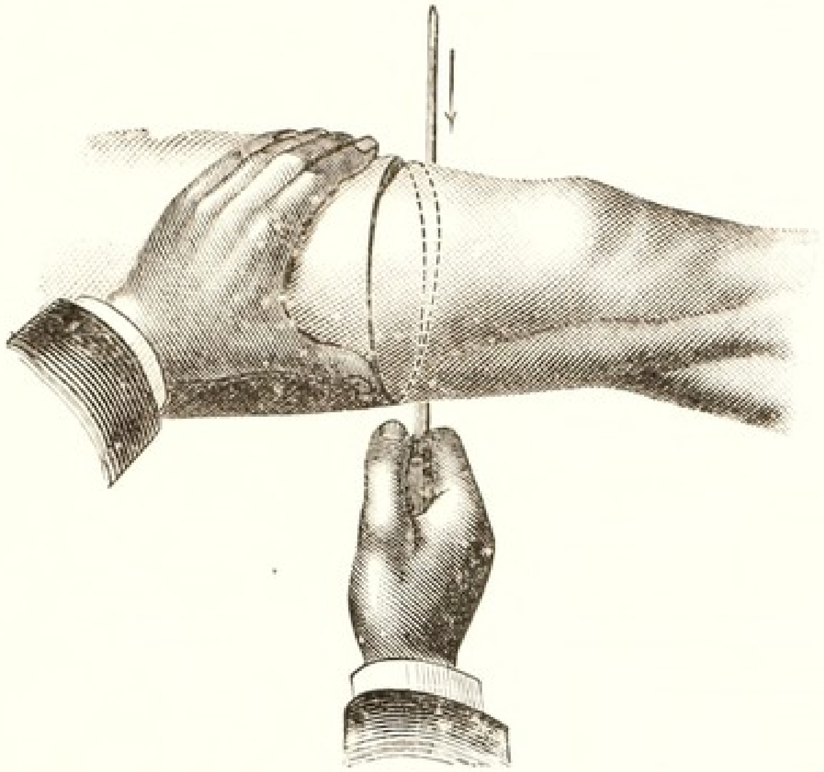


Fig. 95.—Circular cut—first step (Farabeuf).

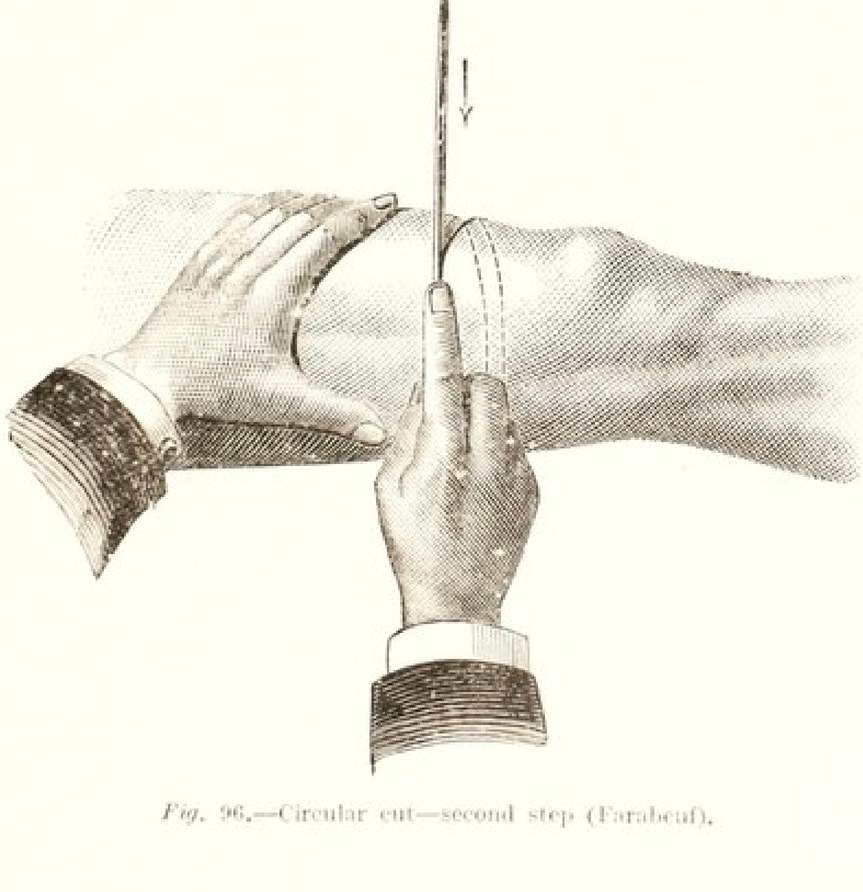


Fig. 96.—Circular cut—second step (Farabeuf).

knife towards you, sawing gently, and proportionately nearing its point as the end of the incision is approached. Drop the hand gradually, and rotate it little by little until the knife is held like a violin bow (*see* p. 64). End with the point in the nearer angle of the first incision, and bring out the knife in the usual way.

A practised operator makes the *circular cut in a single step* (*Figs.* 97 and 98). Pass the right hand, with the knife, round the limb from below, embracing it, so to speak, under the wrist, which is held in extreme flexion and pronation. This position makes it possible to apply the heel of the blade to the surface of the limb nearest the surgeon, the knife vertical, point downwards. Then carry it round the limb as described above.

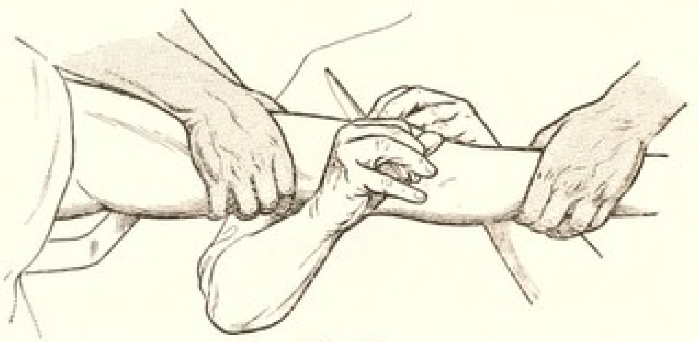


Fig. 97.

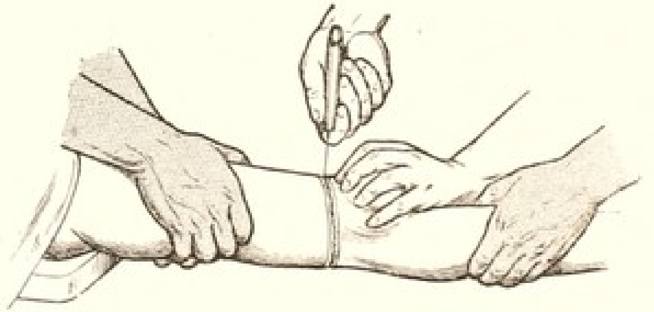


Fig. 98.

If the surgeon is skilful, the skin well stretched, the knife very sharp and sufficiently long, the cut may be made without or almost without sawing, by pressure and traction only.

If the incision is incomplete on the surface facing the operator, it may be completed by reversing over the same ground, allowing the end of the handle to pass between the thumb and index finger so that the knife is held near the blade, cutting surface downwards, rather like a dagger.

2. ELLIPTICAL DIVISION.

This is nearly always done in one step, the successive surfaces to be divided being exposed in turn by manipulating the limb, which is grasped in the left hand near its extremity. The typical movements necessary may be learnt in the disarticulation of the elbow, and may be followed in *Figs.* 99–101. Twist the limb to the right in order to see to the left, start with the heel of the blade of the knife at the apex of the incision, and draw it in a straight line, cutting with the full edge, to the other extremity of the ellipse; then untwist the limb, turning on the point of the knife at the same time, and cross the anterior surface with the arm in the normal position. Now twist the limb to the left, in order to expose its right side, and draw the knife again to the place from which the start was made, finishing the stroke with the point.

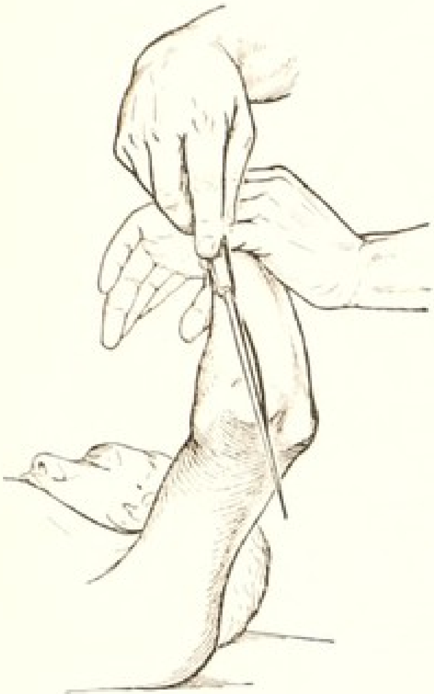


Fig. 99.

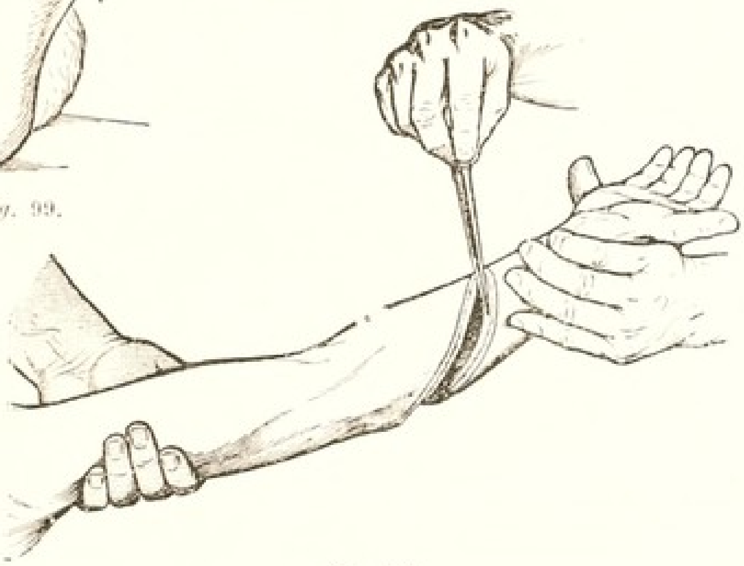


Fig. 100.

Fig. 101.

3. A CUTANEOUS FLAP.

A good flap should be U-shaped, that is, the same width at the free end as at the base, and rectangular, with the angles rounded to a quarter of a circle. The sides should be *at least* as long as half the diameter of the limb at the point where the bone is to be divided, and the two limbs of the U should end one finger-breadth below this level.

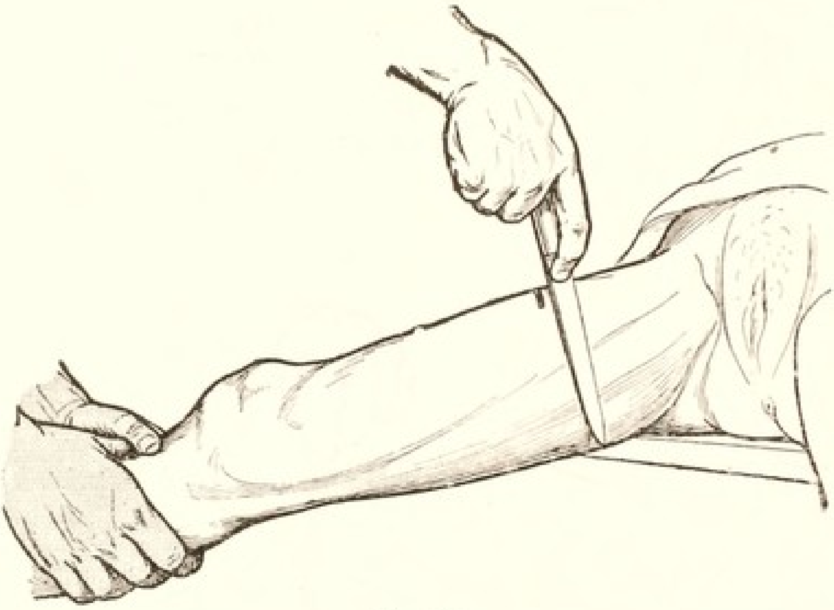


Fig. 102.

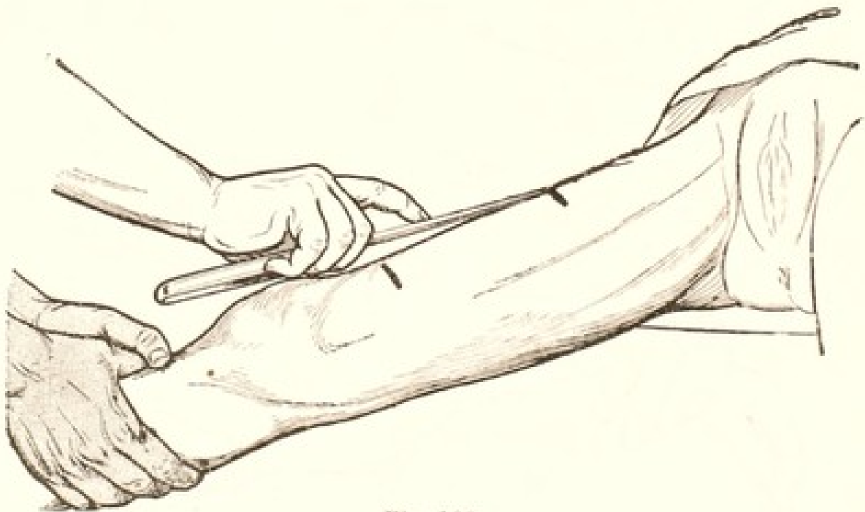


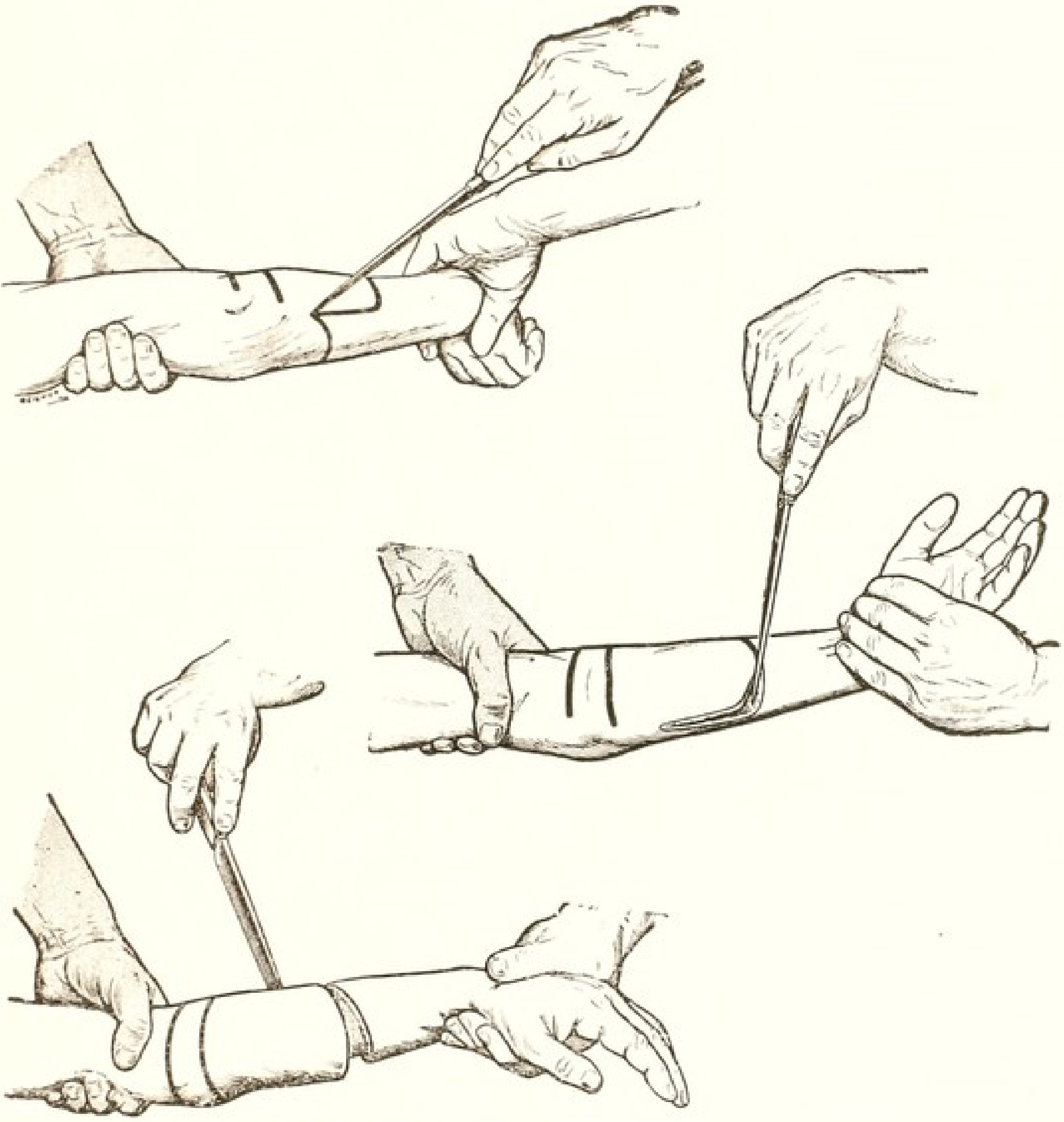
Fig. 103.

The diameter of a limb may be approximately determined by placing the knife flat on the limb, and perpendicular to it, so that the point just reaches to one surface, while the level of the other is marked with the index finger on the side of the blade. Maintaining the index finger in this position, measure off this length on the long axis of the limb below the point of section of the bone. A single flap should be equal to the diameter of the limb at the point of section of the bone, plus a third, to allow for retraction; if two flaps are made, the sum of their lengths should be the same.

Measure the anteroposterior diameter for an anterior or posterior flap, and the transverse diameter for a lateral flap.

1. To Cut an Anterior Flap.

A.—In the great majority of cases stand at the extremity of the limb, a little towards the right, and *grasp in your own left*

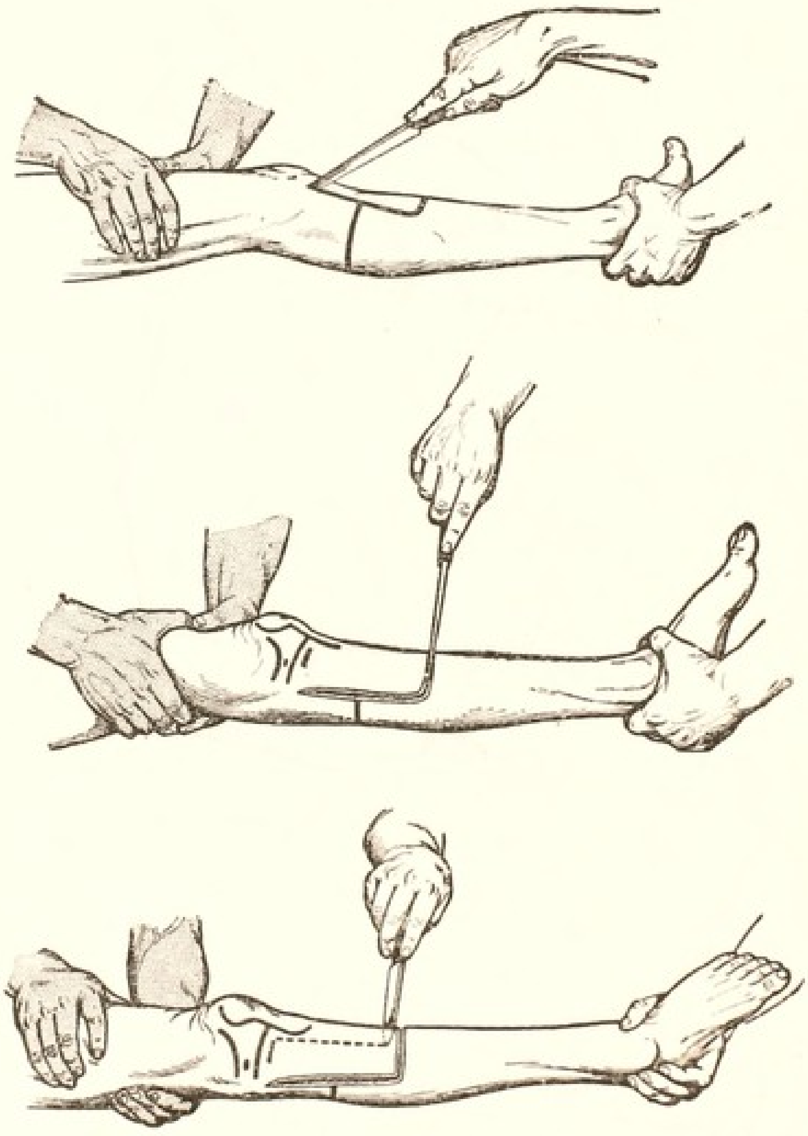


Figs. 104, 105, and 106.—Cutting an anterior flap in the forearm.

hand the part which is to be removed, below the corresponding articulation. Now with the left hand *twist and incline the limb towards the right*, so as to see its surface to the left.

With the index finger stretched along the back of the blade, commence at the appropriate extremity of the incision by *pricking* with the knife nearly perpendicular to the skin (*Fig.* 104). Then drop the handle to an angle of 45°, to make the terminal part of the edge bite, and *draw* the knife straight towards you (*Figs.* 76 and 77), without sawing if the edge is sharp, until the curve of the left angle of the flap is reached. Arrived there, *turn with the point*, by very slight sawing movements, raising the hand until the blade is nearly vertical (*Fig.* 105).

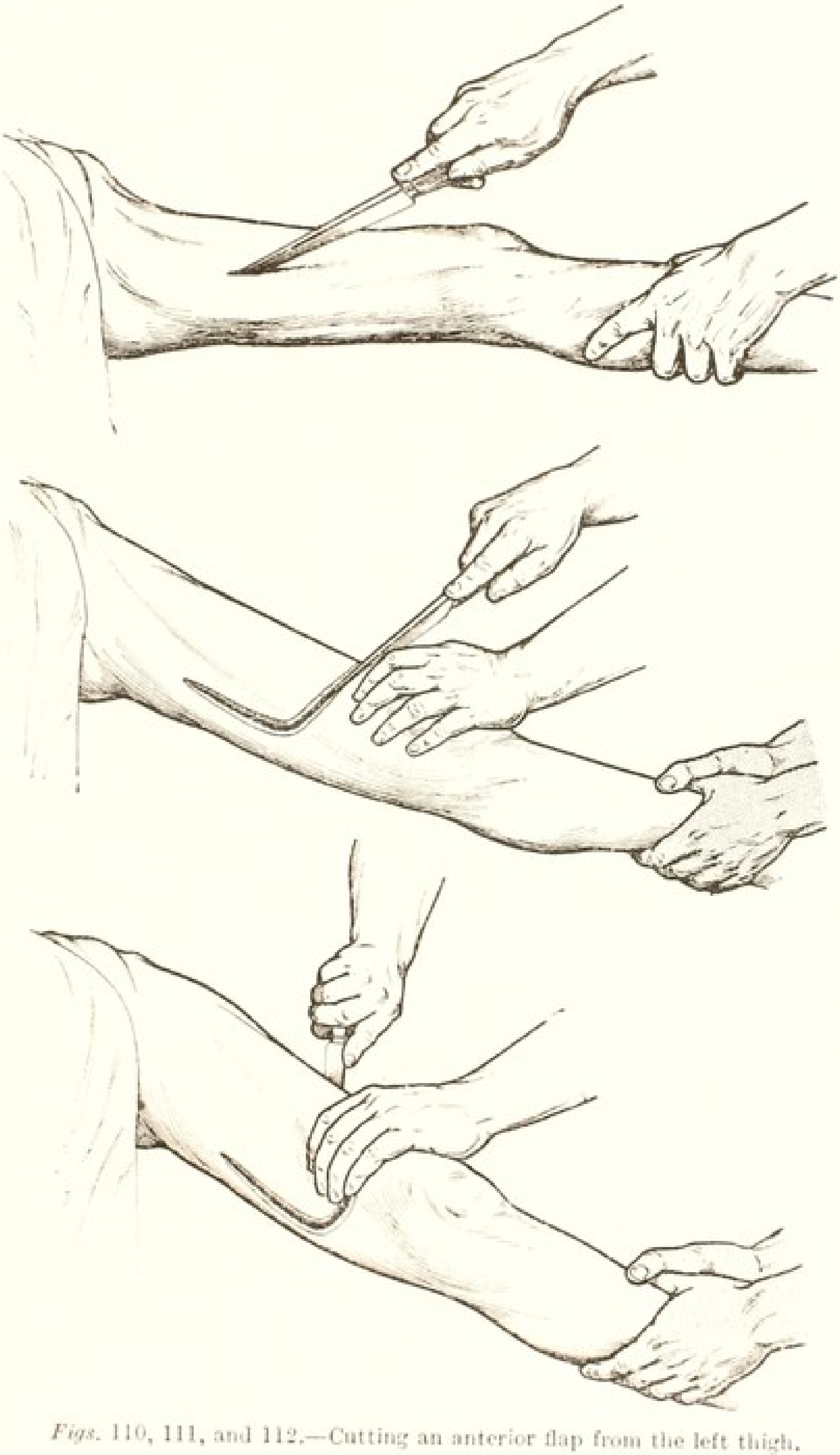
As your right hand begins to bear from left to right, *move the limb in the opposite direction with the left hand*, reversing the rotation to the right with which you started, until there is no rotation at all



Figs. 107, 108, and 109.—Cutting an anterior flap in the left leg.

when the anterior surface of the limb is crossed. If the limb is narrow, the transverse cut is made with the point; if broad, with the full cutting edge.

The same movements with the point are made to round the *right corner* of the flap, and now rotation and inclination of the limb to the left is begun; this, when completed (raising the limb at the same time), will expose to view the *right branch of the* U, along which the skin is divided by *reversing*, the hand turned away from the operator, the knife inclined at an angle of 45° to the limb, and held like a violin bow. Bring the handle towards you in order to make a neat upper angle to the wound, removing the knife with the point perpendicular to the skin (*Fig.* 106).



Figs. 110, 111, and 112.—Cutting an anterior flap from the left thigh.

If the right branch of the U is long, it may be difficult to reverse as far as the extreme end of the wound ; rotate, therefore, on the right foot when the corner is turned, so as to face the branch to be cut, and at the same time, with the left hand, incline the extremity of the limb strongly to the left. In this way the completion of the incision is made easy, however long it may be. The attitude advised is seen in *Fig.* 127, showing the cutting of an external flap for amputation of the leg; the position is the same in cutting an anterior flap in the left thigh; but is quite unnecessary in the case of the upper limb.

Figs. 107 to 109 show that the movements are the same, when cutting an anterior flap from the leg, on whichever side the operation.

In the thigh the conditions are different, for then the surgeon must always remain outside the limb. It is only in amputation of the *left* thigh that the part to be removed lies to the left (*Figs.* 110–112).

A practised operator can manipulate the limb in this case exactly as in the two preceding descriptions, and *Fig.* 110 shows the position at the start, the limb rotated outwards; it is easy to understand how the external branch of the flap may be exposed by rotation inwards and adduction of the thigh.

An operator who fears he may find it too tiring to support the whole weight of the limb, can have it supported by an assistant, and then, stretching the skin by pressure on the knee, he cuts the flap, facing the outer surface of the thigh from the commencement (*Figs.* 111 and 112).

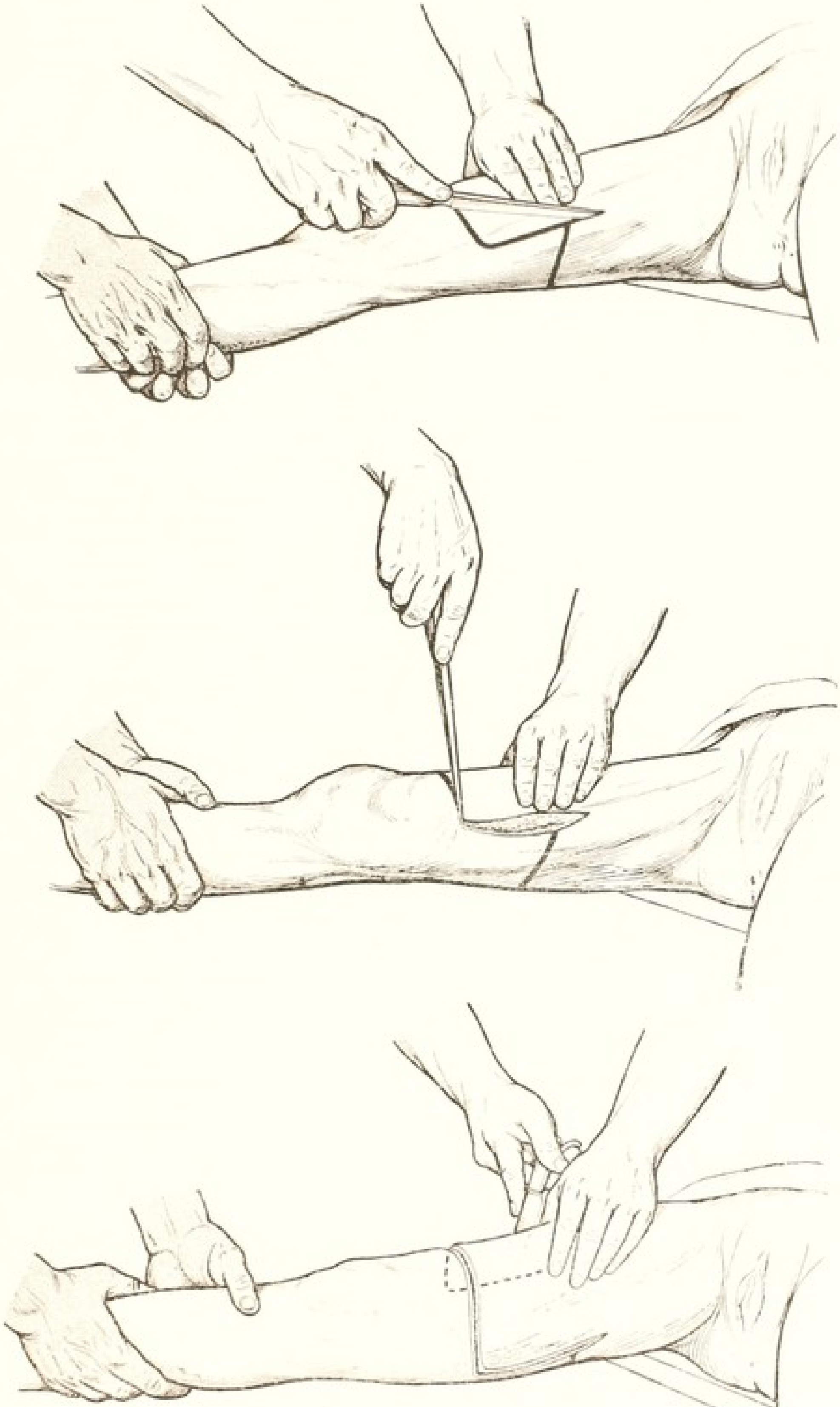
B. Sometimes—in amputation through the right thigh, for instance—*the root of the limb is to the left*, and an assistant must then support and manipulate the limb.

Grasp with the pronated left hand the flap that is to be made, and stretch the skin by approximating fingers and thumb; the general direction of the knife will be round this left hand, beginning at the angle farthest away and finishing at the angle nearest the operator. Thus, in order, prick the skin, draw the knife downwards, turn on the point, cross the limb, cutting with the full blade, turn again on the point, and reverse upwards to the proximal angle of the flap—or better still, rotate on the left foot so as gradually to face towards the extremity of the limb, and then finally draw the knife upwards.

While this is being done, the assistant holds the limb horizontally, without changing its position except to rotate it slightly in a direction opposite to that followed by the knife; that is to say, he starts with the limb in external rotation as the incision is begun, restores it to the normal position as the limb is crossed, and rotates it inwards at the finish, exactly as the surgeon would handle the limb himself to expose the successive surfaces to be divided (*see* p. 77).

When the anterior incision is completed, *divide the skin posteriorly* by a second stroke, passing the knife under the limb as for the circular cut; no attempt is made to round the angles. If the anterior flap is sufficiently long, the two ends of the U may be united directly by a slightly convex incision (*see Fig.* 104); but if the anterior flap is not long enough, the arms of the U are joined by an incision at a suitable level (*see Figs.* 107, 113).

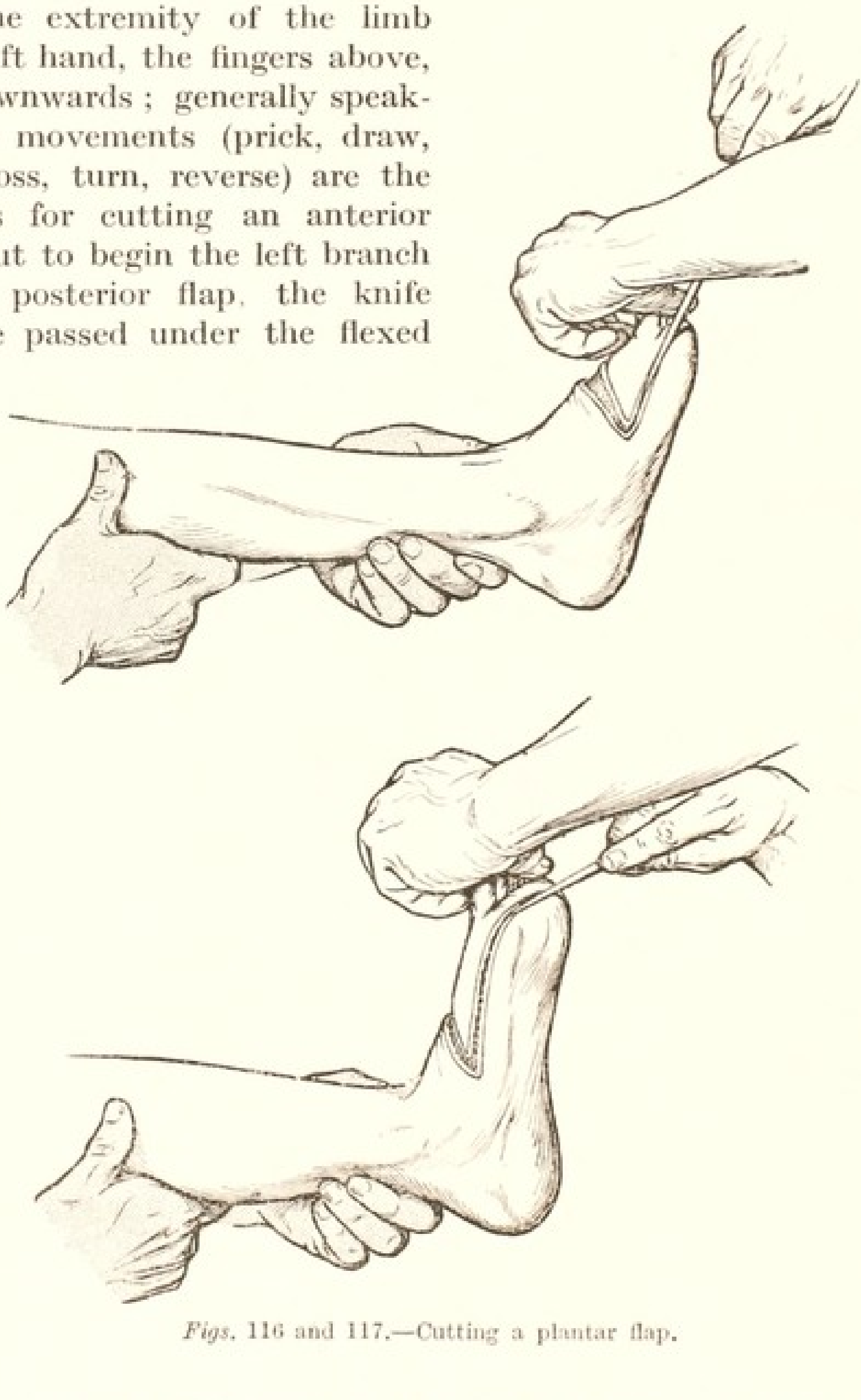
In either case care must be taken not to cut into the base of the anterior flap when commencing the second incision. To avoid this, it is useful to start with the heel of the blade on sound skin at some distance from the first incision, the point upwards: then, as the knife is brought towards the operator, when the point is seen to be



Figs. 113, 114, and 115.—Cutting an anterior flap from the right thigh.

opposite the first incision, raise the wrist again and move it away from the limb, so dividing with the knife-point the little bridge of skin which had been left. After this, the surgeon recommences the circular movement, bringing the handle towards him, and cutting with the whole blade from heel to point; then with the point, while the handle is raised, he rejoins the nearer arm of the U.

2. To Cut a Posterior Flap.—Take the extremity of the limb in the left hand, the fingers above, nails downwards; generally speaking, the movements (prick, draw, turn, cross, turn, reverse) are the same as for cutting an anterior flap; but to begin the left branch of the posterior flap, the knife must be passed under the flexed and pronated left hand. The rules for bending the limb, twisting and untwisting it, are the same as before; but when crossing the posterior surface, the limb is raised vertically upwards to expose fully the line of incision.



Figs. 116 and 117.—Cutting a plantar flap.

The rules for the right leg are the same as for the sole of the foot, and the operator finishes still standing on the outer side of the limb.

In the case of the left leg, however, he should be on the inner side of the limb at the finish of the incision, the umbilicus to his left: he starts, therefore, in a direction opposite to the one just described

Fig. 118.

(*Fig.* 119), and ends facing the dorsum of the foot, after turning to the right; this method, however, is much less important here than when amputating at a higher level. (It is unnecessary for an assistant to support the heel as shown in *Fig.* 120; it was done to steady the limb while the photograph was taken.)

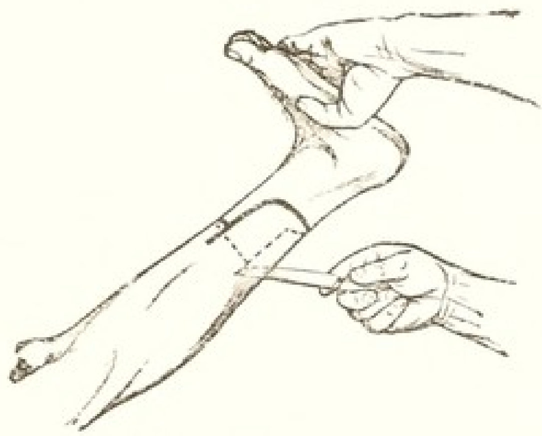


Fig. 119.

3. To Cut a Lateral Flap. — It matters little whether the flap to be cut is an external one (which is used almost exclusively), or an internal one; *mutatis mutandis*, the description of one applies to the other also.

In the position which the surgeon occupies to operate, parts external to the axis of the limb lie to his left in the case of the right limb, to his right in the case of the left limb.

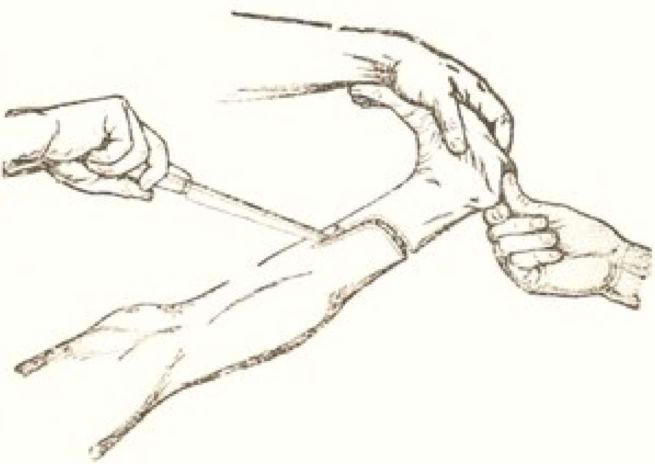


Fig. 120.

The general movements are always the same: begin by pricking with the knife at the anterior extremity of the U, then draw it at an angle of 45° along the corresponding branch, cross the external surface, cutting with the full blade, turn on the point, and reverse along the posterior branch, which is completely exposed by elevation of the limb.

The knife being always held in the right hand, however, there are certain essential differences in the manipulations requisite when the left or right limb, as the case may be, is to be amputated.

Fig. 121.

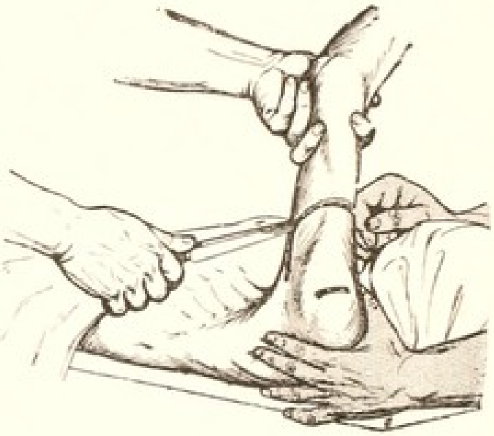


Fig. 122.

Suppose, for instance, the operator is about to cut an *external flap from the left arm or leg.* He grasps in his left hand the extremity of the limb, and it is evident that nothing will prevent his following from end to end the contour of the U ; the flap lies to his right, and he can cut round it in a single stroke. Commencing in front, he cuts

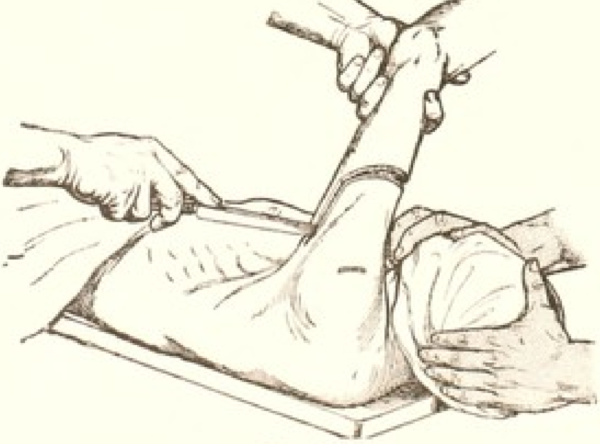


Fig. 123.

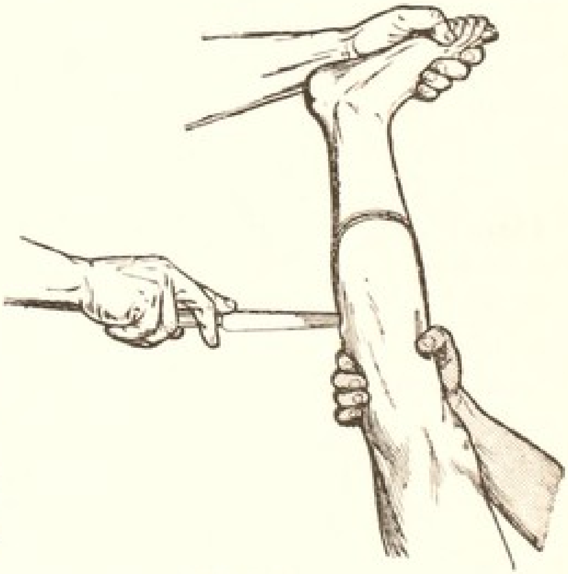


Fig. 124.

all the while from left to right, and by manipulating the limb in a direction opposite to the incision, exposes successively the surfaces which are to be divided. The principle is always the same—twist the limb to the right in order to see to the left, raise it to see its posterior surface, both hands working together.

After piercing the skin, the operator draws the knife straight towards him along the anterior branch of the U; then rotating the limb inwards and raising it gradually at the same time, he crosses the outer surface; lastly, after turning on the point, he finishes by reversing along the posterior branch, cutting with the point of the knife in little sawing movements (*Figs.* 121–4).

Fig. 125.

It has not been thought necessary to introduce further figures showing how to cut an external flap from the left leg; it is sufficient to show the finish at the end of the posterior incision (*Fig.* 124), and to state that the positions are the same as in the case of the arm, and that the finish should be made similarly, with the limb raised in order to expose the posterior surface.

Fig. 126.

In the case of the *right arm or leg*, on the other hand, if the attempt is made to operate by grasping the limb with the left hand and proceeding as on the left side, the operator will find himself obliged to move round to the right, towards the internal aspect of the limb and away from the flap, in order to continue the incision. To avoid this the limb is seized as before, but the operator raises his left elbow, with the wrist well flexed and pronated, and passes his right hand, holding the knife, under the bridge so formed, just as in cutting a posterior flap. He can now proceed without interruption, and cut the flap in a single stroke, performing with the right hand the manipulations described above, and rotating the limb with the left in a corresponding manner (*Figs.* 125, 126, 127). In the more bulky portion of a limb, such as the thigh, the work is facilitated if an assistant supports the part. The operator must himself turn round the flap, so to speak, as he cuts it, finishing with his face towards

Fig. 127.

the dorsum of the foot, as shown in *Fig.* 127. Afterwards he will face the side of the limb, the umbilicus to his left, the only convenient position for completing this amputation. The operator finds himself

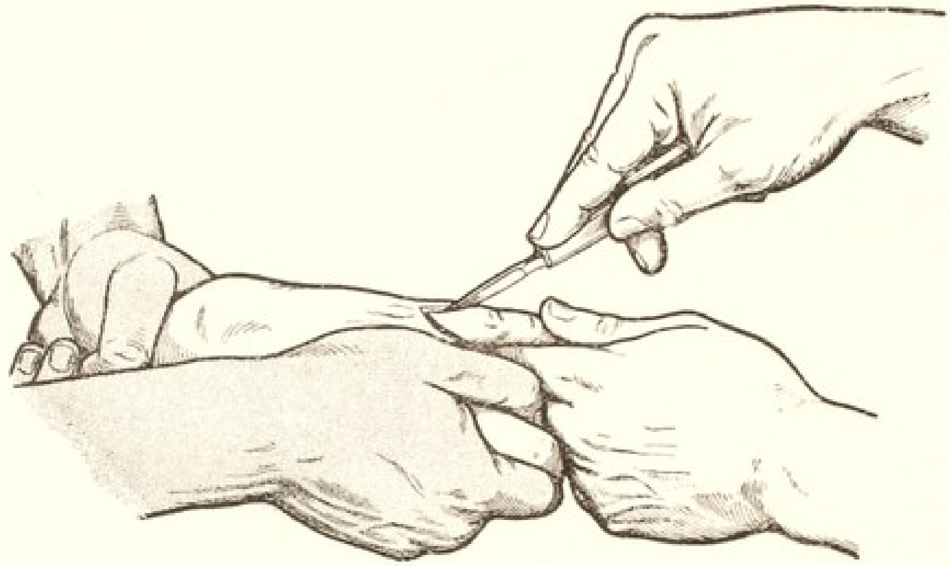


Fig. 128.

in a similar position, without crossing the hands, at the finish of the incision for cutting an external flap from the left leg (*Fig.* 124).

The flaps for amputation of the little and index fingers are cut symmetrically to the axis of the hand, presented in pronation, as shown on the left hand in *Figs.* 128 and 129. Both flaps are external and palmar, but one lies to the right (the little finger), and the other to the left (index finger); the surgeon therefore cuts straightforwardly for the first, and with one hand passed under the other for the second—using in fact the same method just described in the case of the leg.

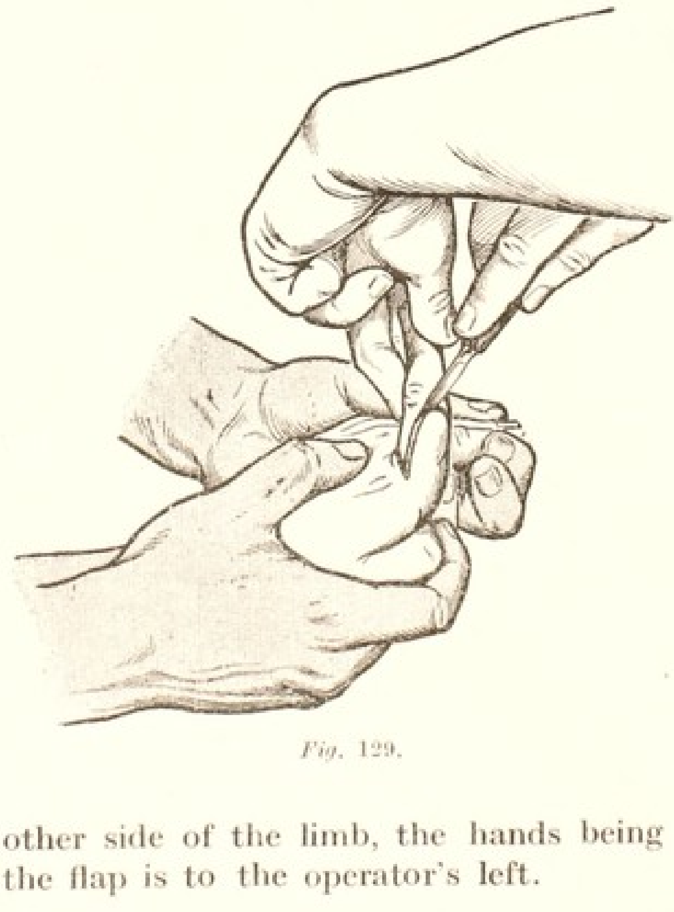


Fig. 129.

If *Figs.* 104–129 are compared, it will be understood that similar movements are required for cutting flaps from the other side of the limb, the hands being crossed at the start when the flap is to the operator's left.

4. **The Racket Incision.**—The simplest racket incision is made when a longitudinal slit is drawn to meet a circular incision. It is frequently used: to disarticulate a finger, for instance (*Fig.* 130), or in disarticulation at the hip-joint (*Fig.* 506).

But the line of incision is more graceful—and the movements also—if, after a rectilinear course of varying length the incision is made to divide into two branches which pass round the limb

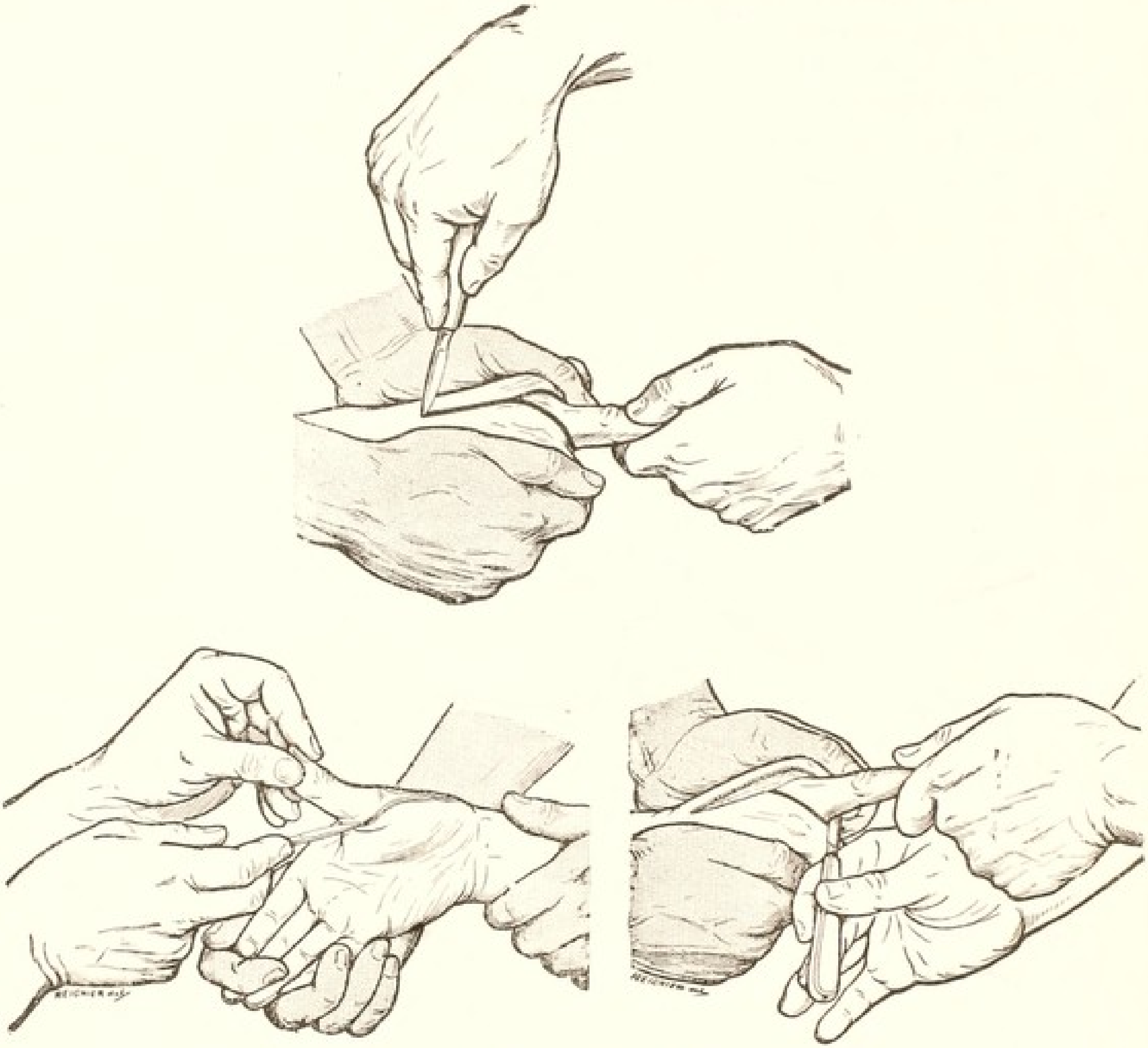
Fig. 130.—Circular incision with slit.

obliquely, like the shoulders of a racket (*see Figs.* 131, 363). In this manner two rounded flaps are made, with the convexities towards one another.

The incision is made in two steps:—

a. With the left hand grasp the limb beyond the joint subjacent to the racket; pierce the skin at the extremity of the handle of the racket and draw the knife along the straight portion; then, with the handle raised and cutting with sawing movements of the point of the knife, turn along the right shoulder of the racket. After turning, lower the handle of the knife, and at the same time rotate and bend the limb to the left, so stretching the skin and exposing the lowest part of the circle; continue with the whole blade from heel to point, the knife held like a violin bow, cutting transversely from right to left as far to the left as possible, either exposing the palmar surface by rotation when feasible (*see Fig.* 132), or dropping the back of the blade towards the commissure of your right thumb (*see Figs.* 133, 370).

b. The racket is completed by reversing to form a left shoulder. For this, rotate and bend the limb to the right with the left hand, so stretching the skin and exposing the end of the first incision. Now pass the right hand over the limb, apply the heel of the knife in the angle exposed, and finish (in the violin-bow position) by rejoining the handle of the racket with the point of the knife.



Figs. 131, 132, and 133.—The racket incision; first step.

Fig. 134.—The racket incision: second step

4. FREEING THE SKIN.

Whatever may be the later steps of an amputation, *the skin must always be freed most carefully*, and the muscle flap to be cut, or the line of the joint to be disarticulated, must be completely cleared ;

Fig. 135.—The surgeon holds between thumb and index finger the lip of the incision under which the skin is to be freed. The work is done with the point, the blade parallel to the skin and bone.

Fig. 136.—The procedure is the same in freeing a small rectangular flap.

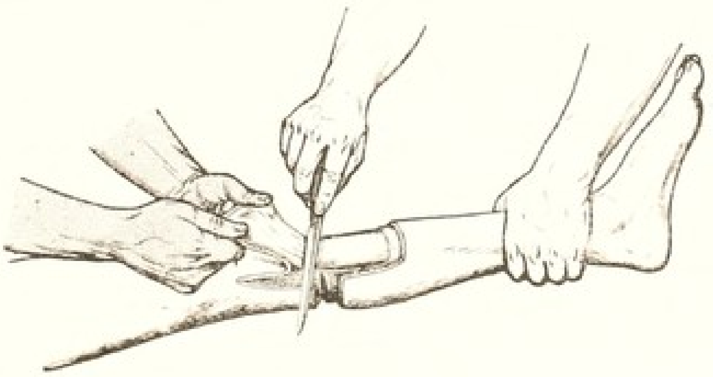


Fig. 137.—If the skin is to be liberated for a considerable distance, an assistant stretches the flap at each corner, and exposes the connective-tissue strands by traction ; the surgeon divides them as they appear.

Fig. 138.—In turning back a cuff, the action is the same, but the blade is directed circularly.

otherwise the flap may be buttonholed, or its edges injured, as the operation proceeds.

The skin is nearly always freed by dividing with the cutting part of the point of the knife, from end to end of the incision, the connective-tissue strands running from the deep fascia to the subcutaneous fat, while the assistant retracts the skin. It is well to direct the blade somewhat obliquely, so that the point is engaged beneath the skin to be freed.

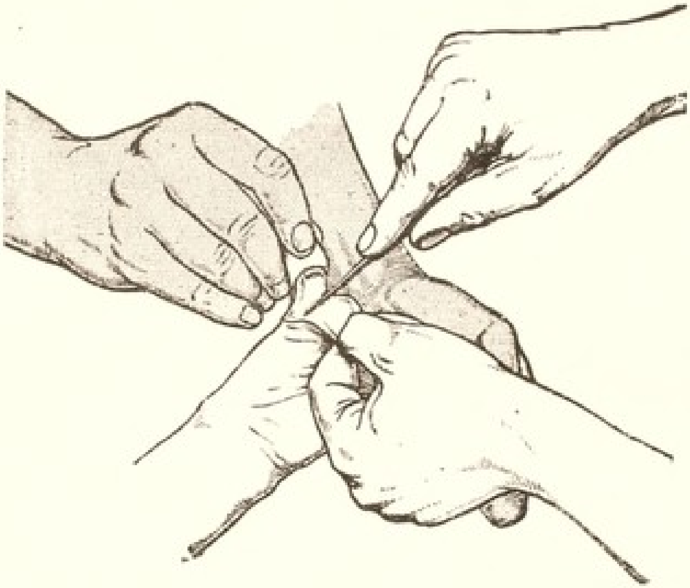


Fig. 139.—Freeing a skin flap from the palmar surface of a finger.

Fig. 140.—Method of freeing a palmar flap in disarticulation at a metacarpo-phalangeal joint. The blade is held parallel to the bone, and moved in a semicircular direction.

To *turn back a cuff*, pass the knife in a circular direction from left to right round the corresponding half circumference of the limb, insinuating half an inch of the point on the flat between skin and muscle, the knife held parallel to the long axis of the limb.

The same movement is used to liberate the skin of the palm in disarticulating a finger.

It is nearly always best in liberating the skin to begin by holding the edge oneself (*Figs.* 135, 136), and then have it retracted by an assistant if it is necessary to proceed further (*Figs.* 137, 138)

CHAPTER VII.

ON THE DIVISION OF THE MUSCLES AND THE PREPARATION OF THE STUMP.

THE muscles should be divided obliquely, so that they are shorter than the skin. The chief procedures used are :—

1. **Circular Division.** —The muscles are always arranged round a limb in two concentric layers. The long muscles are the more superficial, and run longitudinally; the short muscles lie round the bone like a muff. The first of these layers should be left longer than the second, in order that the divided bone may lie at the apex of a hollow muscular cone; but as the long muscles retract more than the others, it is necessary to *divide the second layer twice*.

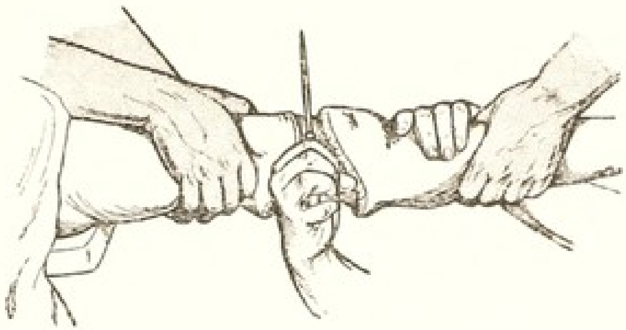


Fig. 141.—Circular division of muscles ; first stage.

Suppose a circular division of skin has been made, and that the skin has been properly freed and retracted to leave a space of about an inch between the lips of the incision. Now, at the level of the retracted skin divide the muscles in a direction perpendicular to the bone, and down to the bone, cutting with the whole blade from heel to point, and going through the same movements as when dividing the skin—in one step or two, as already described (*Fig.* 141). This will give a stump it would be impossible to suture, and which would certainly become conical later on if suture were feasible.

Figs. 142 and 143.—Circular division of muscles ; second stage.

Tell the assistant, therefore, to grasp the whole circumference of the limb and retract the soft parts towards its base. This exposes the bone, over which muscles and skin form a projecting cone. At the base of this cone, close to the skin, divide the tissues circularly again, even slanting the blade a little towards the root of the limb (*Fig.* 142). This division may be carried out in one step (which is difficult), or in two. An adherent collar of muscle will now be left round the bone below the point of section; after using the saw the muscles will fall back into place and form a hollow cone below this point.

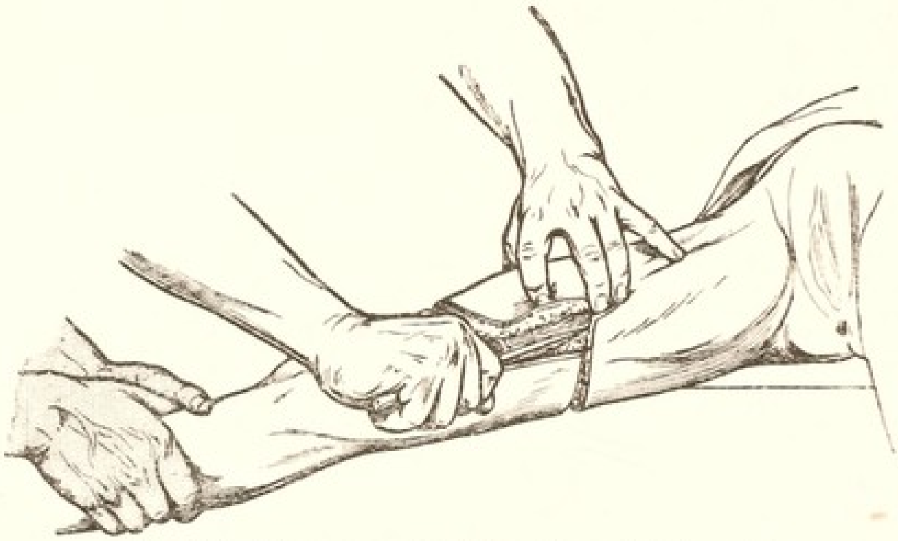


Fig. 144.—Commencement of dissection, with the point.

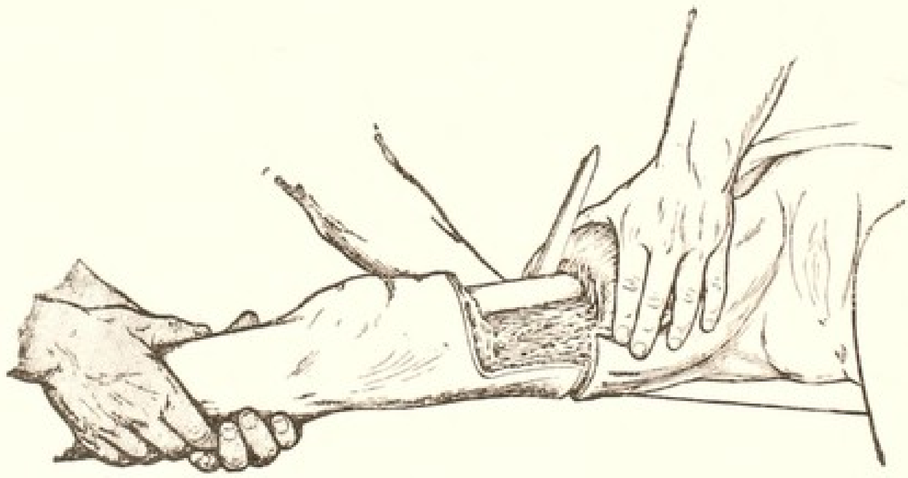


Fig. 145.—Finish of dissection, with the heel.

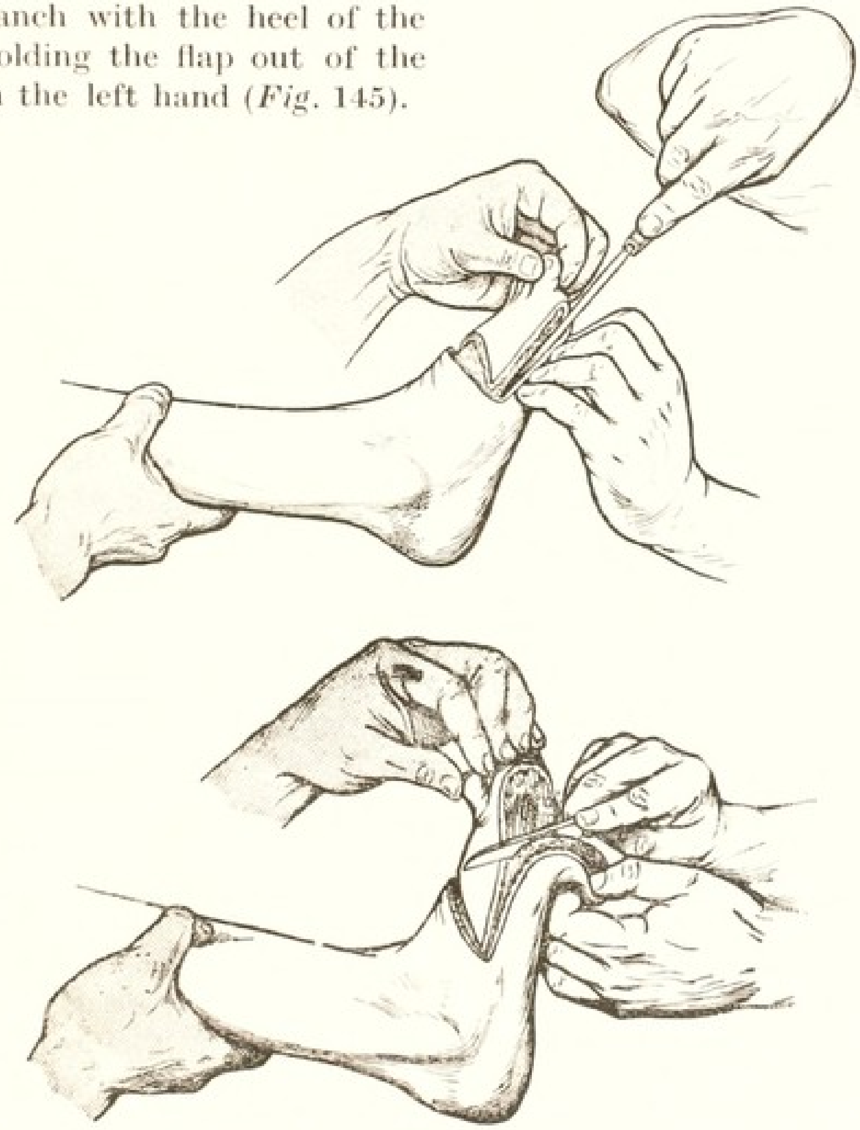
2. **Muscle Flaps.**—A muscle flap may be cut by (*a*) *Dissection;* (*b*) *Transfixion;* (*c*) *Dissection to begin with, finishing with transfixion.*

a. The main actions in dissecting a flap consist in gripping the free extremity, and applying the blade transversely and obliquely so as to cut away from you, using the full blade with a transverse sawing movement.

The manœuvre is more rapid and more graceful if *the dissection is made by turning round the flap.* That is to say, first draw an incision along one branch of the U, the point reaching to the bone, which must be felt and followed; then cut transversely with the whole blade under the free end of the flap, and finish by reversing up the other branch of the U, after turning on the heel of the blade, keeping the heel and adjoining part of the edge in contact with the bone.

The type of this method of dissection is best shown in amputation of the right thigh by an anterior flap, which may be studied in *Figs.* 144 and 145.

Standing on the outer side of the limb, the operator pierces the tissues to the bone at the upper end of the inner branch of the U, with the knife held horizontally, while he retracts the skin with his fingers (*Fig.* 144). Then, after drawing the point along the bone, and crossing the front of the limb so as to cut the muscles obliquely, he approaches the upper end of the outer branch with the heel of the blade, holding the flap out of the way with the left hand (*Fig.* 145).



Figs. 146 and 147.—Dissecting a plantar flap.

If the flap is to be a posterior one, or on the surface distal to the surgeon as the limb is presented, the same method is used, but with the hands crossed, right under left. It is in this way, for instance, that the muscles are cut in disarticulation of the first metacarpal bone: the muscles are on the palmar surface, it is true, but the hand is presented in pronation, the dorsum towards the surgeon.

If a flap is to be cut from part of a limb which faces the operator directly, as in the case of Chopart's and Lisfranc's disarticulations, he entrusts the end of the foot to his assistant, and picking up the edge of the flap, he dissects transversely, turning from left to right, the blade parallel to the skin (*Figs.* 146, 147). And always, when starting from the left end of the incision, twist and incline the limb to the right, put it straight when crossing it, and twist it to the left when finishing on the right side. Just as in dividing the skin, the left hand should move in the opposite direction to the right.

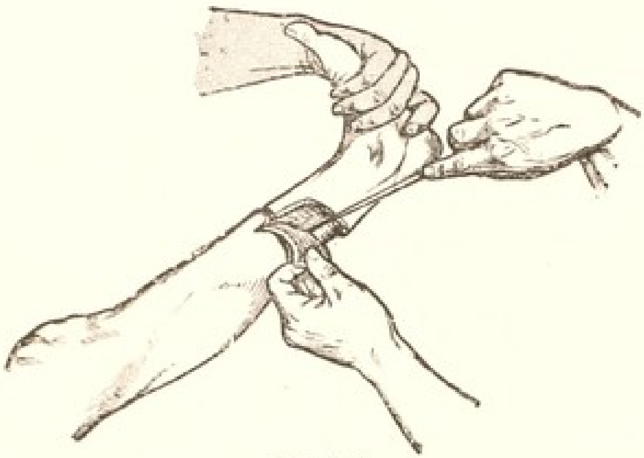


Fig. 148.

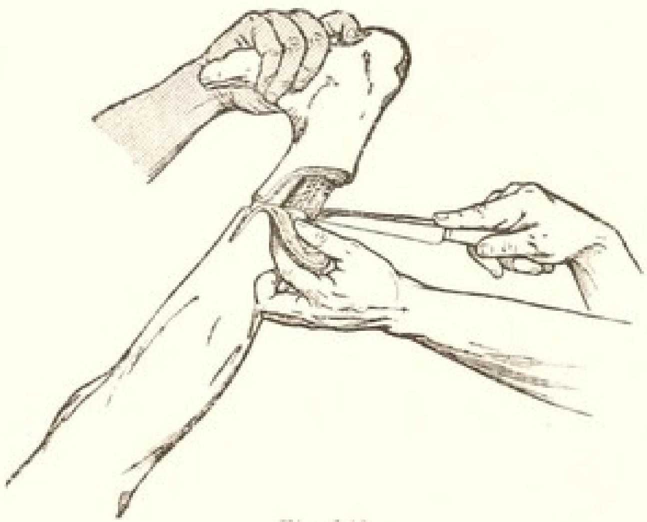


Fig. 149.

Fig. 150.

In certain cases it is necessary *to dissect up the flap, muscle by muscle*, in successive steps—in the leg, for instance, where the deep muscles are hidden at the bottom of the interosseous space. It is necessary therefore: (1) To divide longitudinally, on either side, the muscle sheath; (2) To pinch up the muscle transversely between the left thumb and index finger, and cut it obliquely close to the fingers (*Figs.* 148–150).

This method must also be adopted in disarticulation at the hip-joint by a racket incision, in order to ensure hæmostasis; and it is best to use it in disarticulation at the shoulder-joint, unless sure of the assistant.

The metacarpal and metatarsal bones may truly be said to be *enucleated*, so closely must the bone be shaved.

b. In *transfixion*, the base of the flap is pierced transversely with the knife, the edge towards the operator; then, by means of sawing movements, it is brought out again at the level of the retracted skin. The blade must be long enough to allow both ends to remain outside the skin continuously while these movements are being made.

The point should enter the branch of the U to the operator's right as high as possible, and emerge equally high on the branch to his left.

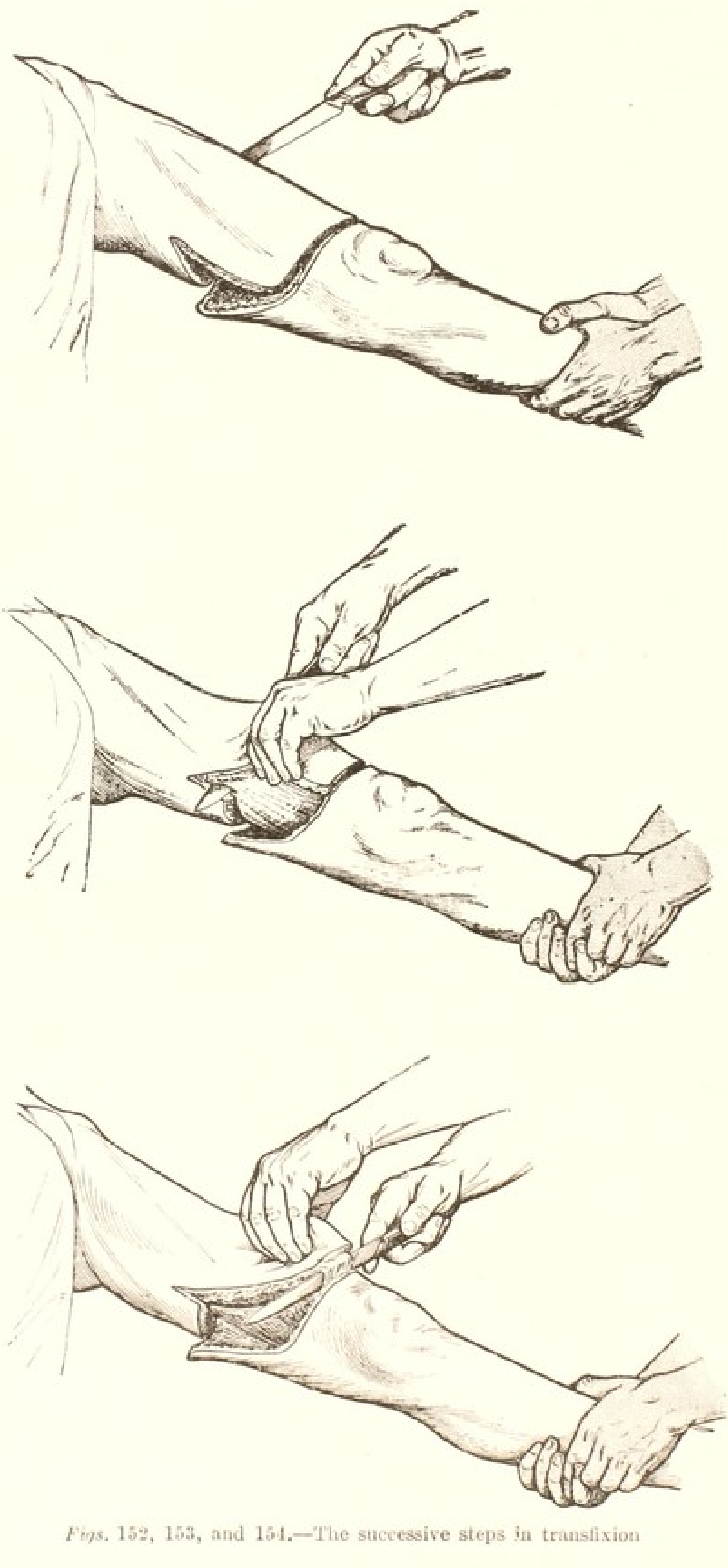
If there are two bones at the point of amputation, as in the forearm, the limb should be placed quite flat in supination, and the blade flat against the borders of the bones; otherwise there is a risk of perforating the interosseous space and passing behind the bone which lies to the operator's left.

Fig. 151.—Transfixion. The muscles are kept tense by extension of the wrist.

If there is one bone only, the knife must be so passed that the point is arrested by the lateral surface of the bone; drop the handle to bring the point on to the anterior surface, then raise it again to pass round this and on to the opposite lateral surface. These movements are reversed if, as may exceptionally happen, a posterior flap is to be transfixed.

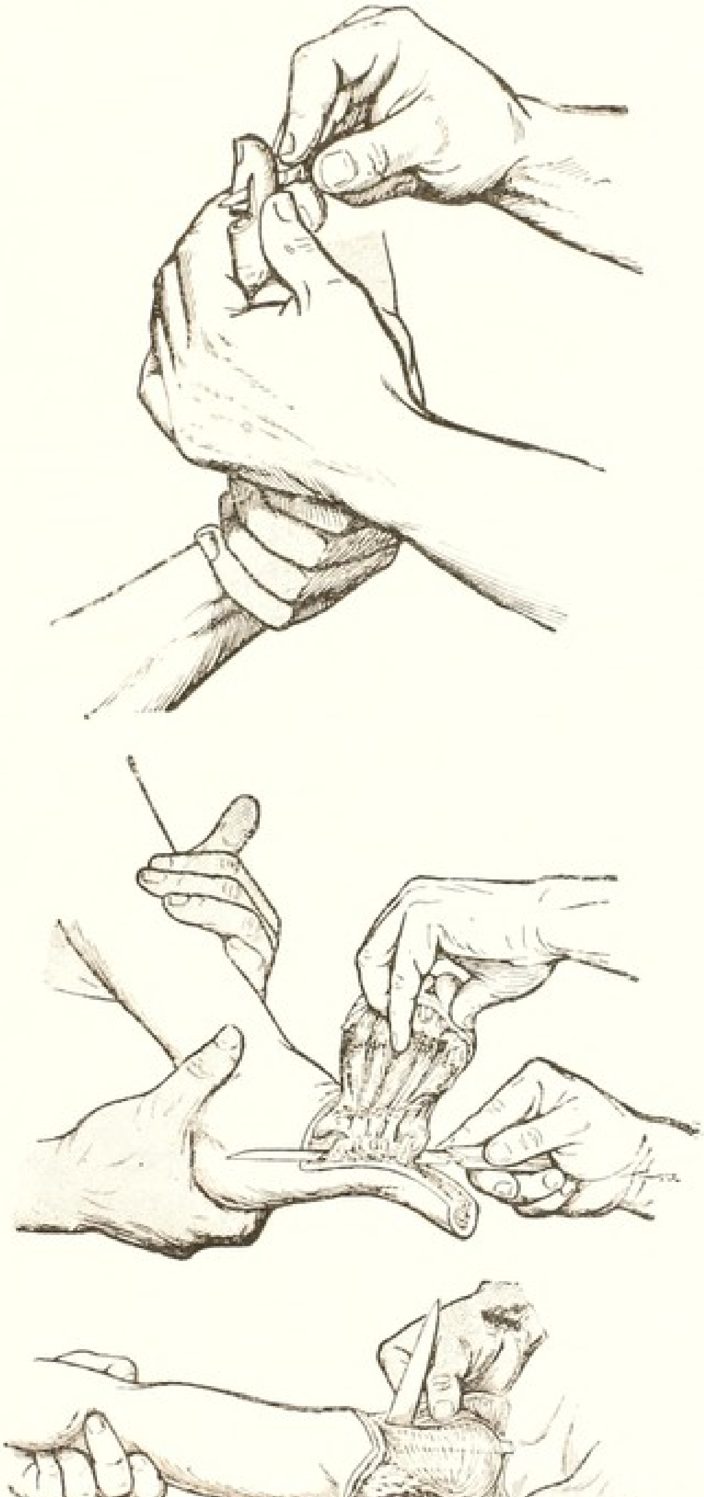
The muscles to be divided must be kept tense—in the forearm by extension of the wrist (*Fig.* 151); cut with little sawing movements, the blade quite flat, without allowing the point to re-enter the tissues until the free end of the flap is reached (*Figs.* 152, 153). To finish the movement, turn the blade perpendicular to the muscles, edge upwards, and come out level with the skin (*Fig.* 154).

c. Sometimes after *partially dissecting the flap it is finished by transfixion.* This method is merely mentioned here; the details may be studied in the disarticulation of the third metacarpal bone (*see* p. 173), and in amputation of the leg by an external flap (*see* p. 121). In tarso-metatarsal and scapulo-humeral disarticulations (*Figs.* 155–157), the surgeon *transfixes after disarticulation*; after a preliminary dissection of the flap, he opens the joint and passes the knife transversely under it, then replaces the joint in position (re-articulation), and brings the knife out close to the bone (*Fig.* 155).



Figs. 152, 153, and 154.—The successive steps in transfixion

In this manœuvre it is necessary, before replacing the joint over the blade, to make sure the angles of the wound have been carefully freed, so that the whole breadth of the blade may be used on the flat without injury to the base of the flap.



Figs. 155, 156, and 157.—Re-articulation and transfixion.

THE PREPARATION OF THE STUMP.

In the living, after disarticulation or division of a bone, the operation is completed by a series of steps which unfortunately are not as a rule carried out on the cadaver.

The first care will be to *secure, then to ligature, the arteries*, which must be done quickly to avoid loss of blood ; the student must learn, therefore, to seize the principal arteries without hesitation. There will be no difficulty in this, if he is thoroughly familiar with the anatomy shown in the sections in *Figs.* 14–18 ; 32, 33 ; and 38–40, and can therefore make straight for the place where the vessel is to be found. This can be practised in the dissecting room. A jet of blood forms a guide to the smaller vessels in the living.

Fig. 158.—Resecting the nerve.

Next it will be necessary to *resect the large nerves*, which may form painful neuromata if they end on the surface of the stump. This step is absolutely essential if the nerve lies in a flap on which pressure will be borne—the posterior tibial nerve, for instance, in a subastragaloid amputation (*Fig.* 158). It is almost essential when a large nerve appears on the divided surface of any stump : take the end in a pair of forceps, pull it down, and resect about an inch ; the nerve is then drawn upwards and hidden in the tissues.

If, finally, the student practises *suturing*, his day's work will not have been wasted.

Chapter VIII.

THE CHOICE OF OPERATION, AND OF THE ARTIFICIAL LIMB.

A patient with an artificial limb should be able :—

1. To utilize the movement of the last joint preserved.
2. To take pressure on the stump below this joint.

The apparatus consists, generally speaking, of two parts :—

1. A part to maintain it in position, fixed above the last joint preserved.
2. A part, more or less complex in shape and in its articulations, into which the stump is passed, taking support from it and communicating movements to it.

In an amputation of the leg or forearm, for instance, the apparatus is fixed to the thigh or arm, articulated at the knee or elbow, and moved by the stump of the leg or forearm. In the same way, after amputation of the thigh or arm, the apparatus is fixed to the trunk above the hip or shoulder. It is necessary it should be thus fixed and suspended, otherwise it would fall off owing to its weight.

Let us suppose the fixation has succeeded (its exact arrangement does not interest us here) ; we must next consider the mechanical conditions bearing on the transmission of weight and movements from the stump to the functioning part of the apparatus. From these considerations we are able to determine the best form of procedure for each amputation.

In a general way it may be stated that, whatever the terminal arrangements or mechanism of the apparatus may be, its base consists of a cone, into which the stump is passed. This cone must fit the stump exactly, for it transmits thereto pressure of two kinds : (1) Vertical pressure ; (2) Lateral pressure, corresponding to the movements of the articulation above.

1. *Vertical pressure* is taken at two points : (*a*) The apex of the cone presses on the extremity of the stump ; (*b*) The base of the cone presses on the bony prominences below the last joint. The fit is never close enough to allow much vertical pressure to be taken by the sides of the cone.

2. *Lateral pressure* is transmitted by the whole of one surface of the stump to the corresponding surface of the cone : by the anterior and posterior surfaces only in hinge-joints such as the knee and elbow, but by any part of the surface in joints like the hip and shoulder, where circumduction is possible.

Having stated the general principles which should guide us, we have now to consider their application in detail, to the upper limb in amputations above or below the elbow, and to the lower limb in amputations above or below the knee.

1. THE UPPER LIMB.

After disarticulation of the shoulder or *amputation through the arm*, the cone of adaptation (fixed to the trunk by a shoulder-strap) encloses also the anterior thoracic wall and the scapular region. It is evident, therefore, that to make the transmission of movements possible—forwards, backwards, or outwards (it is never very good),—a fairly long humeral stump is necessary; the power of the lever is not of much value, indeed, unless the amputation is below the middle of the arm. The apparatus keeps its place much better, and its suspension from the shoulder-piece is much more secure if the stump is filled out by the head of the humerus and the anatomical neck; hence the superiority of an intradeltoid amputation over a disarticulation; this is almost the only advantage, however, for the transmission of movement by the fragment of bone preserved is practically nil.

When the stump of the humerus is long enough to be used, the pressures sustained by it in the transmission of movements to the apparatus are taken by the anterior, posterior, and outer surfaces. There is no pressure in a longitudinal direction. A terminal cicatrix, therefore, is no inconvenience, if it is not adherent to the bone, and a circular amputation, or one by equal lateral flaps, may be employed according to taste.

The same applies to *amputation of the forearm*, where the stump executes hinge movements in the sagittal plane, and there is no terminal pressure. In this case it is of considerable importance to keep the lever as long as possible, both to give the stump more mechanical advantage and to enable it to be better enclosed.

Amputation at the wrist allows, in certain special actions, a direct use of the stump without apparatus—in pushing something, for instance, or in maintaining an object in position by pressure. The ends of the bones must therefore be well padded by palmar skin, and the cicatrix definitely dorsal; an anterior flap, or one of its modifications, is for this reason to be preferred. But Ducroquet has drawn attention to the fact that the projection of the styloid processes and articular heads of the bones is undesirable, and that it is perhaps better to remove them—that is to say, to make a very low amputation of the forearm, comparable to Syme's amputation at the ankle.

After amputation of the arm, neuromata of the median and ulnar nerves occur frequently, and are very troublesome; these nerves must therefore be resected as high as possible. In my experience, this difficulty is much less common in amputations through the forearm.

2. THE LOWER LIMB.

In contrast to those of the upper extremity, the principal function of stumps of the lower extremity is to sustain vertical pressure while transmitting the weight of the body to the ground in standing or walking; and we have more especially to consider whether pressure should be taken from the end of the stump, from the bony projections below the lowest joint, or from both of these combined.

Two essential conditions must be fulfilled if direct terminal pressure is to be possible—the cicatrix must not be terminal, and the ends of the bone must be well padded by a thick and non-adherent flap. When a stump is used in walking, we have not only to deal with direct pressure, but also with the friction caused by a necessary to-and-fro movement of greater or less extent. Perfect conditions for this friction are only realized if the skin of the flap is structurally adapted for this purpose, as is the case on the sole of the foot ; where dermis and epidermis are thick, the subcutaneous fibrous network is continuous with the deep fascia, and encloses numerous little spaces filled with fat, forming a cushion of little liquid balls which glide over one another when pressure and friction are sustained. The skin over the apex and the posterior aspect of the heel is less adapted for this purpose than the sole ; it is good and serviceable none the less, and a patient is able to walk on the stump after a Syme's amputation without having part of the pressure supported by the tibial tuberosities.

Fortunately, skin which is not normally suited by its structure for this purpose can adapt itself to pressure and friction if only it is amply padded with a double layer of muscle, and, wherever possible, with fibrous tissue as well. Skin not so padded, especially in fair, stout patients, with thin and tender skins, is easily ulcerated by friction, or even by pressure alone ; corns and blisters may also appear. Consider, for instance, the condition of the skin over the dorsum and external surface of the foot in a bad case of equinovarus.

The muscles of the flap under the bone do not remain as muscular tissue, but become fibrous. They are useful nevertheless, because :—

1. They interpose a fibrous sheet of greater or less thickness between bone and skin, so that the skin continues to be movable over the bone and is not directly compressed.

2. They adhere to the bony surface, forming a tendinous attachment thereto, which increases their action on the piece of bone preserved.

A flap supports pressure badly when the muscles have retracted to the level of the bone, leaving it covered with skin only ; *the soft tissues after an amputation should remain soft and lax.*

There is no doubt the length of bone that can be saved is often a consideration of great importance, and in crushes followed by suppuration the surgeon is frequently placed in a dilemma, his decision resting between a stump with short soft parts, cicatricial and adherent in places, and a bone well covered with movable tissues, and with a good scar, but so short that it is difficult to adapt an artificial limb. This is a question which calls for careful judgement, and it is necessary sometimes to sacrifice without hesitation an inch or two of bone. For instance, a good subastragaloid amputation is better, far better, than a Chopart with short flaps.

We will now proceed to the consideration of special cases.

Amputations of the Foot.—The general rule is to preserve the plantar skin for the patient to walk on, arranging the scar entirely on the dorsal surface, so that the anterior extremity of the bones is covered by a flap as thick as possible, and there is no pressure on the scar. Pressure is exerted principally on the sole, but also on the end of the foot.

After amputation of all five toes at once, the artificial apparatus consists simply of a boot with the toe artificially filled. This operation, which is frequently necessary for frost-bite, is only successful if all the plantar skin can be saved, the line of incision passing through the digito-plantar fold, and preserving at least half the skin over the proximal phalanx of the great toe. Even then the flap will not reach above the heads of the metatarsal bones, but the tension on the scar is not excessive. If this amount of skin cannot be saved, it is better to sacrifice without hesitation the heads of the metatarsals, rather than to be hypnotized, so to speak, by thinking of the support provided, by the head of the first metatarsal especially, in walking and standing. Our experience is that the functional disadvantages of complete or partial amputation of the first metatarsal bone have been much exaggerated ; it is far better to sacrifice the head of this bone than to leave it, a constant source of pain, pressing continuously on thin, tense, and cicatricial skin.

In amputations through the tarsus and metatarsus, we should aim at preserving as long a foot as possible : an intrametatarsal operation would therefore be preferred to a Lisfranc, and Lisfranc's amputation to that of Chopart. In proportion as the length of the lever in front of the tibiotarsal joint is diminished, the predominance of the extensor muscles over the dorsiflexors is increased ; especially is this true of the tendo Achillis, for the length of the posterior calcaneal lever is in no way shortened.

It must always be remembered, however, in applying this rule, that the soft tissues of the sole must be long enough to be sutured without tension on the dorsum of the foot.

In Lisfranc's amputation, for instance, the chief difficulty lies in the considerable projection on the inner side made by the internal cuneiform bone ; if this prominence cannot be padded by bringing the plantar flap in front of and above it, it is better to remove the bone, shaving it as closely as possible in order to preserve the fibrous expansion of the tibialis anticus, which is inserted into the internal cuneiform and the base of the first metatarsal bone. This fibrous shell is continuous below with the plantar ligaments, which must also be preserved, by shaving the plantar surface of the disarticulated metatarsal bones ; in this manner retraction of tibialis anticus is prevented, and it develops secondary attachments to the scaphoid bone.

Whatever amputation is practised, it is most important to preserve the fibrous bands on the sole (running from tarsus to metatarsus and constituting the articular ligaments), the tendon sheaths, and the origin of the short muscles of the foot. These serve to build up a well-padded flap which supports pressure much better than muscle tissue alone. It is for this reason that in Lisfranc's and Chopart's amputations the old method by simple transfixion must be abandoned : and the procedure by dissection up to the line of the joints seems to us equally undesirable. When the plantar flap is cut by transfixion commencing with disarticulation, and without preliminary dissection, there is a risk first of all that sufficient skin will not be preserved on the dorsum of the foot ; secondly, that in passing the blade on the flat under the metatarsal arch, concave downwards, the cut will pass through the plantar muscles and not deep to them. On the other hand, if dissection is fully carried out from before backwards (some surgeons even advise approaching Lisfranc's ligament from below, because it is easier), it is not possible to get near enough to the bone to preserve the fibrous shell. This is only achieved by working, with the blade vertical, from left to right and from end to end of the wound in the front part of the foot, this being depressed vertically after section of the dorsal ligaments.

Dissecting-room theory this was often called in times of peace, when a set amputation, as practised on the cadaver, was exceptional ; but we have since seen numbers of amputations for injury, with results good, bad, and indifferent ; the bad and indifferent are in the majority. Doubtless this is generally due to the conditions imposed on the surgeon by suppuration ; but it is due in a great measure also to an ignorance of those principles on which Farabeuf was wont to insist.

What we have just said is perhaps not of such great importance in Lisfranc's amputation, but it is essential in that of Chopart. In this the dorsal tendons are left without an attachment, and retract if they are not reinserted into the fibrous tissue of the sole, so that the heel becomes raised and the front of the os calcis presses insupportably on the anterior part of the flap. If, however, the plantar fibrous tissue has been preserved, the dorsal tendons—the extensors and tibialis anticus—may be fixed to it by a few sutures ; they then lift the anterior extremity of the os calcis from below, and counterbalance the tendo Achillis.

It is better, though not essential, to resect the nerves in the flap. They are small, and, if the os calcis does not become tilted, they are not pressed upon when the patient stands or walks.

After Chopart's and Lisfranc's amputations, the patient walks on the os calcis, covered with its normal plantar skin. In subastragaloid, tibiotarsal, and supramalleolar amputations, the posterior part of the bony skeleton of the foot is partially or wholly removed, and the plantar skin must be freed by enucleation of the os calcis, and brought under the remaining bone (astragalus or lower extremities of the leg bones).

The plantar or internal flap of a tibio-tarsal or subastragaloid amputation gives a perfect direct support if two conditions have been observed :—

1. The soft parts must be shaved off quite close to the bone, leaving fibrous tissue in the flap.

2. The posterior tibial nerve must be resected. Otherwise a neuroma will form and walking will be impossible.

The flap for a Syme's amputation is perfect if the tendo Achillis has been divided quite close to its insertion and remains adherent to the skin of the heel. There is no need to fear a neuroma in this amputation.

Guyon's supramalleolar amputation permits an apparatus which presses directly on the end of the stump; the body weight presses on the posterior skin of the heel, reinforced by the tendo Achillis, and brought down under the divided bones. Pressure will not cause atrophy of this skin if it is padded by the tendo Achillis; and the tendon will not retract if divided quite close to the bone. The tendon may also, with advantage, be cut obliquely at the level of the upper border of the os calcis; and the fibrous sheet which unites it to the skin may be held in position by suturing its lower border to the tendons in front.

I have considered the supramalleolar operation with amputations of the foot, because the prosthetic principles involved in each are similar. As already pointed out, the surgeon must remember the following principle whenever compelled to sacrifice the foot. The length of the segment preserved is important without doubt, but only on condition that the soft parts are long enough to be united without tension; a good subastragaloid amputation is far better than a Lisfranc (and still more, than a Chopart) with a shortage of skin, a Syme is better than a subastragaloid under like conditions, and a Guyon than a Syme.

Amputations of the Leg.—It was long believed that in any amputation higher than the supramalleolar, the support should come from the upper part of the tibia, and that direct support from the end of the stump should not be used, or only to a minor extent; after amputations at the so-called 'site of election,' pressure was borne on the tubercle of the tibia, the patient walking with his knee flexed at a right angle.

It is now recognized that the artificial limb is more serviceable in proportion as a greater direct pressure is taken on the end of the stump,* and that this pressure can be supported—with great advantage, moreover—in high amputations such as those at the site of election. Now this is incompatible with a terminal cicatrix, as left after a circular amputation; it necessitates a padded flap. Below the middle of the leg a posterior flap is the best, above this level an external one. These are padded with a thick layer of muscle, and cover the projecting tibia very well.

* The same statement will be found in the last edition of Farabeuf's *Manual*. The question was treated in a different way in the first edition, and the difference in principles as stated in 1872 and 1909 may be observed. But it must be recognized that in practice direct support on the end of the stump was, even at the later time, still imperfect, and merely accessory. To-day this is really the chief point of support, thanks especially, we believe, to Ducroquet.

With regard to the bones, there are two indispensable conditions if support is to be taken from the extremity of the stump: (1) The tibial crest must be divided obliquely; (2) The fibula must be divided above the tibia, which alone must press on the apparatus. In high amputations, about three inches below the knee-joint, it is best to remove the small end of the fibula remaining, for it tends to become displaced outwards if left, and to project under the skin.

Until the last few years, the only practical apparatus after an amputation at the site of election was the peg and bucket, the patient walking on the knee flexed at a right-angle; pressure was quite well supported by the skin in front of the tubercle of the tibia. Present-day apparatus, taking pressure both from the end of the stump and the tibial tuberosities, allows active flexion of the knee to be preserved when the stump is three inches long or more. Moreover, the apparatus now made is much stronger than it used to be.

We no longer insist on the principles in vogue but a short time since—namely, low amputation, with the use of the leg and knee in walking, when an expensive artificial limb is possible; amputation at the site of election in the case of a labourer, who will then have to walk on the flexed knee. The form of apparatus used in the latter case is, however, the only one possible when the knee is flexed and stiff, incapable of active extension.

Although an apparatus with free movement at the knee has become available for all classes (though it will still be necessary to note, in a few years' time, the results attained in those who follow manual occupations), it does not now follow that it is always necessary to amputate in the lower part of the leg for this to be applied; the high position is no longer the 'site of election,' and that is all. Two other points must also be mentioned: (1) If half the leg is saved, there is not much difference in the value of different stumps as regards the adaptation of the cone to them and the power of movement; (2) If a good solid apparatus is to be fitted, direct pressure on the end of the stump is essential, and therefore a long flap must be made, which is not stretched over the bone. A circular amputation through the lower part of the leg, in particular, nearly always gives an unpadded deplorable stump.

Amputations of the Thigh.—Disarticulation of the knee is mechanically the same as a true amputation; the lowest functioning joint is the hip, and the only difference between this and the higher amputations is in the length of the lever preserved.

The indirect support, beneath the lowest active joint, is taken from the ischium, and it is very advantageous to relieve it, frequently even to replace it, by support taken directly from the end of the stump. Now Ducroquet has taught us (what, we believe, he himself has learnt since he has been studying our wounded soldiers) that in amputations through the middle of the thigh, or even above this level, excellent limbs may be made which take direct pressure from the end of the stump: so that indirect support is only necessary at all in amputations in the upper third, and even then should be relieved by direct support.

But this arrangement is impossible with a terminal cicatrix ; it necessitates a flap, preferably an anterior flap. This fact must be kept in mind, and the surgeon must not allow himself to be influenced exclusively by the question of the length of bone to be preserved. The length is of greater importance when the bone is sawn above the middle of the thigh ; for in this case a stump which is too short does not remain firmly in the cone of the apparatus ; moreover, as terminal pressure will be absent, or at most accessory to indirect pressure, the position of the cicatrix is less important.

Below the middle of the thigh, a little length must always be sacrificed for the sake of an efficient pad.

For instance, we believe that disarticulation at the knee-joint is often disappointing because the projecting femoral condyles must press on thin skin not reinforced by muscle. It is preferable in this region, if it is desired to take direct pressure on the end of the stump, to amputate through the condyles and remove the patella ; a surface of skin accustomed to friction, and reinforced by the quadriceps tendon, is thus brought over the broad flat surface of the divided bone. Care must be taken to divide the patellar tendon as low as possible, so that it will be long enough to suture to the soft tissues posteriorly. The bony extremity is very well covered in this way, and we are not convinced that there is any advantage in fixing to it the freshened posterior surface of the patella.

Neuromata of the sciatic nerve seem to be less frequent and much less troublesome than those which occur after division of the nerves of the arm.

PART 2.—AMPUTATIONS IN CONTINUITY.

CHAPTER IX.

GENERAL OBSERVATIONS.

IN the preceding pages the general rules have been given for planning and cutting flaps, which are the same both for amputations and disarticulations. There only remains to explain the rules for sawing in amputations in continuity.

This may be considered in two stages: (1) Exposure of the bone at the point of section; (2) Sawing.

1. **To Expose the Bone**—it is necessary to push back the soft parts still further, because the muscles and skin of the completed flaps reach to a lower level than the point where the bone should be divided. Divide the periosteum therefore, all round the bone, with a periosteal elevator; or, more simply, scrape the whole circumference of the bone from below upwards with the heel of the knife.

Then pull back the flaps, protect them under a linen retractor (with two ends if there is one bone, but three ends if one of them has to be passed between two bones), and use the saw.

The retractor with two ends consists of a square of linen split to the centre from the middle of one of its sides. The bone is placed in the fork from below upwards, the two ends are placed one in front of the other, and by pulling on them and on the body of the retractor the soft parts are drawn upwards out of the way.

The retractor with three ends is similar, but has two slits, leaving between them a tongue about two and a half inches wide. Both bones are placed in the fork as before, and the ends brought one in front of the other, then the median strip is passed through a hole in the interosseous membrane and held in front of the other ends.

2. **Manipulation of the Saw.**—To use an ordinary amputation saw, keep the hand uppermost and pull and push alternately. It is usually *during the pulling movement that the saw bites*, and it is in this movement therefore that a little pressure may be applied, but always very little. To saw quickly, the whole length of the saw is passed to and fro without haste, and with hardly more pressure than the weight of the instrument. Whether the portion of the limb to be sacrificed is held by the surgeon himself, or by an assistant, it should be allowed to drop slightly, so as to make the opening gape a little in front; not too much, or the bone may break when only a thin layer remains. Beginners are apt to raise the limb so that the blade becomes gripped between the two surfaces and cannot be moved.

The first step in sawing is *to make a track for the saw.* To do this, apply the nail of the left thumb perpendicularly to the bone, the distal phalanx flexed ; then apply the heel of the saw to the bone, against the thumb nail, and by *drawing it towards him* the operator makes a shallow furrow. For this step the blade must be held perpendicular to the bone, even though it is to be used obliquely afterwards. After a few very slow to-and-fro movements, the groove is deep enough to proceed in the usual way.

A *frame-saw* also may be used ; this is an instrument consisting of an open framework with a narrow blade which can be adjusted by screws at either end, and the blade, being narrow, can turn in any direction in its passage between the bony surfaces, so allowing a curvilinear section to be cut and projections to be rounded off (*see Figs.* 184 and 185).

Chapter X.

AMPUTATIONS OF THE THIGH.

1. CIRCULAR AMPUTATION—Lower Portion of the Thigh.

A circular amputation may be performed at any level; but the lower part of the thigh is usually chosen to practise this operation in the dissecting-room. In the living it is probably better to make flaps, because, as already explained, modern artificial limbs allow the pressure of the body weight, or part of it, to be taken from the end of the stump if the cicatrix is not terminal.

General Plan.—The principle is the same for all circular amputations: the skin must be divided at a distance below the point of section of the bone equal to a quarter of the circumference of the limb (easily measured with a piece of string folded in four). After retraction the skin will then project beyond the bone for a distance of half a diameter all round the limb.

Line of Incision.—It must be remembered that in the thigh, especially in the lower part of it, the skin retracts more on the inner side and behind than on the outer side and in front. In order therefore to make an incision which will ultimately be circular, it is necessary to cut an ellipse, running obliquely downwards and inwards.

Fig. 159.

If the femur is to be sawn about four inches above the joint, the incision should begin in front above the base of the patella; it then descends on the inner side over the internal condyle, nearly to the line of the joint, crosses the limb posteriorly at the same level, and ascends again on the outer side to its starting point (*Fig.* 159).

The patient is placed flat on his back, the gluteal fold at the edge of the table, the sound limb drawn out of the way; the limb to be removed now reaches beyond the edge of the table for its whole length, and is held in the horizontal position by an assistant. A second assistant, standing on the outer side at the level of the hip, stretches the skin by grasping the circumference of the limb in his two hands.

The surgeon, using a knife with a blade about eight inches long, also stands outside the limb, but at the level of the knee.

Division of the Skin.—This is done by the novice *in two steps*: (*a*) Resting the left hand on the limb, he passes the right, which grasps the knife fully, under the posterior surface, and, with the point upwards, applies the heel of the blade to the internal surface. Now he draws the knife towards him round the thigh, and ends with the point on the outer surface, handle uppermost, having rotated it in his fingers while making the incision. (*b*) Then, passing the knife in front of the thigh, and drawing it towards him from heel to point again, he joins the two ends of the first incision (*see Figs.* 95 and 96).

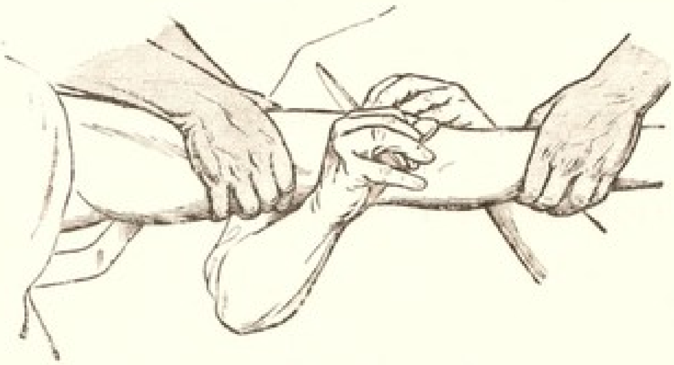


Fig. 160.

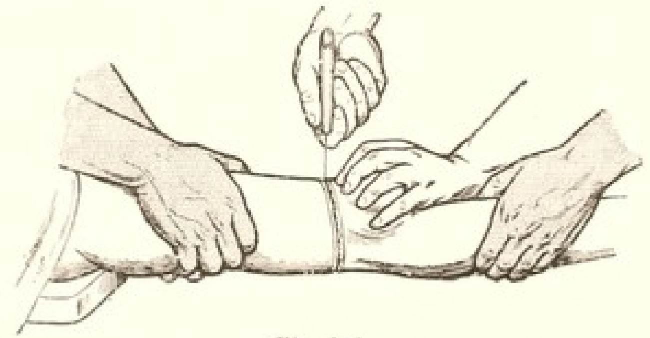


Fig. 161.

Fig. 162.

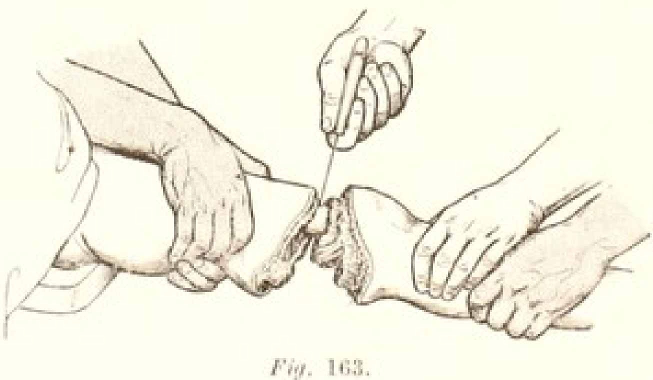


Fig. 163.

A practised operator divides the skin *in one step*. Kneeling on one knee, he passes the right hand, strongly pronated and extended, round the limb from below, and applies the heel of the blade to the external aspect of the limb, handle uppermost; he then draws the knife over the skin, sawing gently, and rises little by little from the time the knife reaches the posterior surface until he finishes erect, the knife handle again uppermost, retracing with the point the commencement of his incision (*Figs.* 160, 161).

The skin *must be completely freed* until the assistant is able to retract it and leave an interval of rather more than an inch between the lips of the wound, the deep fascia at the level of the internal and external intermuscular septa being divided with a stroke of the point.

Division of the Muscles.—(*a*). *The first division.* The assistant who is retracting the tissues grips firmly the circumference of the limb near the edge of the divided skin, and the surgeon divides the muscles to the bone close to the skin.

This division is made exactly as in the case of the skin, in two steps (first from below, then from above), or in one step, according to the skill of the operator (*Figs.* 162, 163).

(*b*). *The second division.* The assistant, grasping the limb as before, drags his hands towards him ; the skin gapes, and discloses a muscular cone reaching from its base at the skin edge to its apex at the bone where the first incision has been made. The base of the cone must now be divided at the level of the skin, exactly as before, in two steps or in one (*Figs.* 164, 165).

Fig. 164.

Fig. 165.

Below the point of the second section a collar of muscle is seen to be left round the femur (*Fig.* 166). The muscles have now been divided circularly and also obliquely, and after division of the bone its upper end will be at the bottom of a muscular funnel.

Fig. 166.

Raising the Periosteum.—Before using a saw, the periosteum must be raised, which is done by scraping the bone with the heel of the knife. At the linea aspera, it will be remembered, the tendinous attachments are firm, and a vigorous stroke of the heel of the knife will be required.

Sawing the Bone.—The bone is sawn with the handle of the saw raised, finishing on the external surface. If the frame-saw is employed, it is held horizontally instead of obliquely, and the prominent angle of the linea aspera can be rounded off. This procedure, which is the same whatever the operation, is represented in *Figs.* 176, 177, and *Figs.* 184, 185.

2. FLAP AMPUTATION OF THE THIGH—Middle Third.

This is the method to select in amputation through the middle of the thigh. The scar must be on the posterior surface, so an *anterior* flap must be cut, *not a single flap, but a predominant one.*

Line of Incision.—The anterior flap should be in length from a diameter to a diameter and a half of the limb at the point of section of the bone, measured anteroposteriorly. It is U-shaped, as broad below as above, and descending a little further on the inner side than the outer, because the skin on the inner side retracts more. The branches of the U should descend vertically, about a finger-breadth behind the mid-point of the limb, and should commence one finger-breadth below the point where the bone is to be divided.

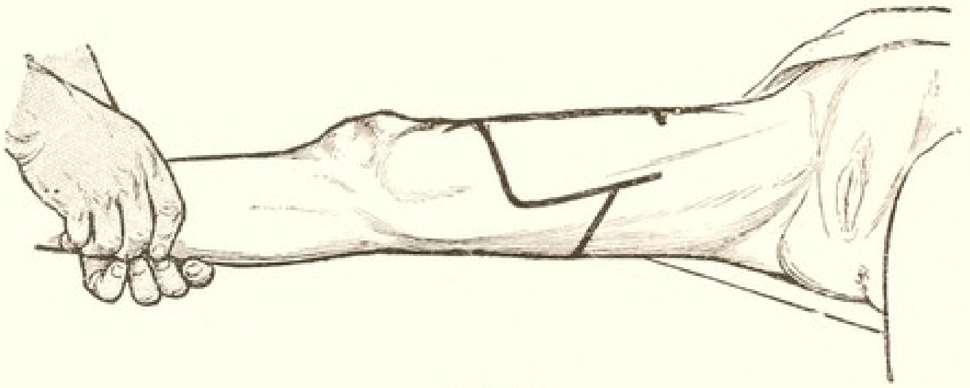


Fig. 167.

The *posterior flap*, equal to half an anteroposterior diameter if the anterior flap is of one diameter length, is straight, or convex downwards; it unites the two branches of the U about three finger-breadths below their commencement.

The positions of the surgeon, of his assistants, and of the patient are the same as for the circular amputation.

The procedures on the right side and on the left are different, and must be described separately.

A. The Right Side.

Division of the Skin Anteriorly.—Facing the limb, which is held horizontally before you, grasp the anterior surface of the flap that is to be made, thus stretching the skin. By a movement of outward rotation the assistant presents the inner surface of the thigh; now lean a little forwards, and pierce the skin with the point of the knife; then draw the blade downwards (*Fig.* 168), turn on the point, making a rounded right angle, and cross the anterior surface with the limb in the normal position (*Fig.* 169). Turning again at the outer angle of the flap, begin to rotate on the left foot until you face the dorsum of the patient's foot, and can draw the knife along the outer branch of the U while the assistant rotates the limb inwards (*Fig.* 170). The skin must then be thoroughly freed.

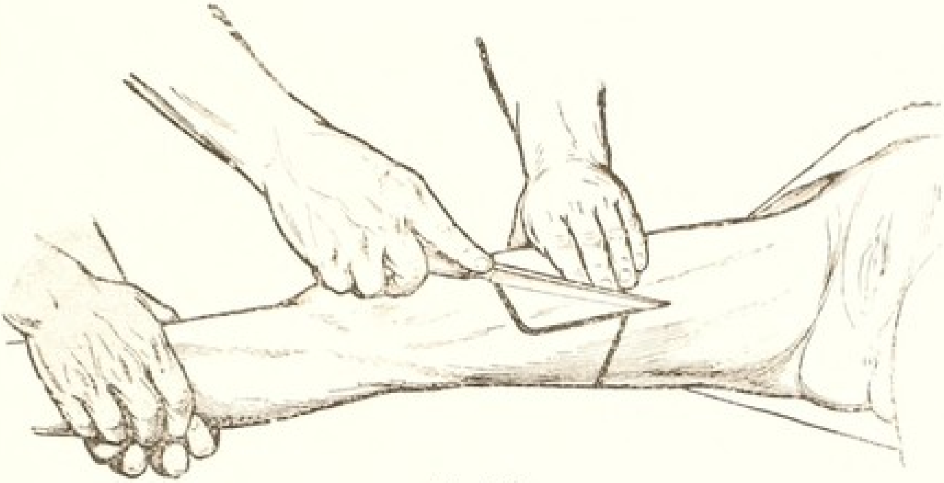


Fig. 168.

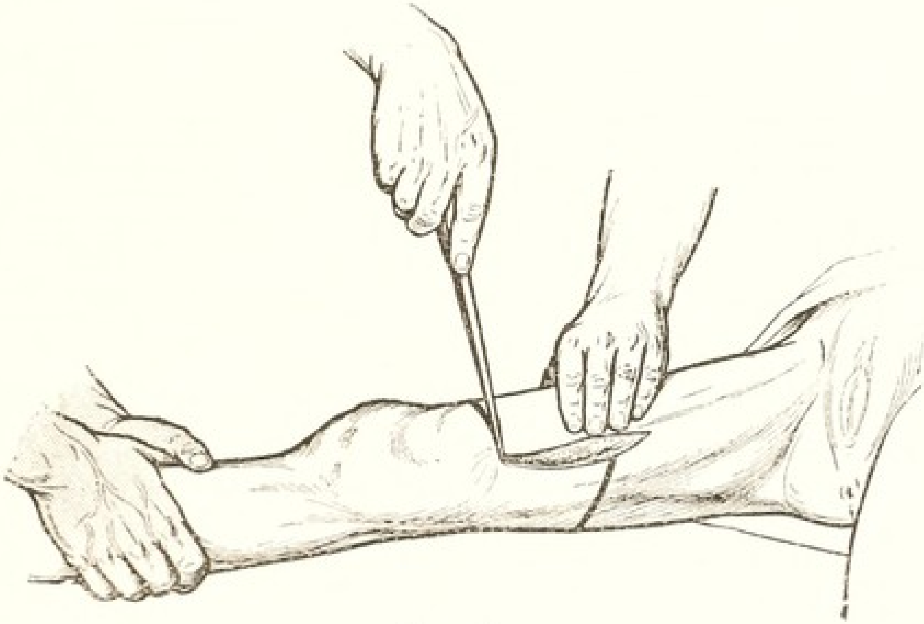


Fig. 169.

Fig. 170.

Division of the Skin Posteriorly.—Facing the limb again, pass the knife under the posterior surface and cut with the same movement as in a circular amputation, using the whole length of the blade: start with the heel, point upwards, blade vertical (Fig. 171); cross with

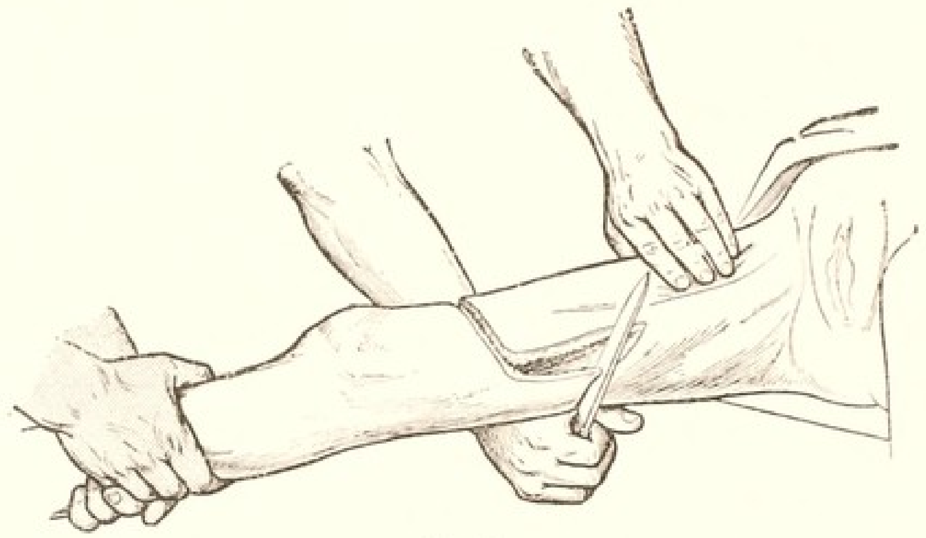


Fig. 171.

the blade horizontal, making a slight convexity downwards; and end with the point, handle uppermost, blade again vertical. Repeat this manœuvre to free the skin, paying special attention to the angles where the flaps join, and the sites of the lateral intermuscular septa.

Dissection of the Anterior Flap.—Grasp the flap with the pronated left hand, thumb close to the outer lip, fingers close to the inner. Now raise the flap by dragging it outwards, and cut the muscles longitudinally, with the point of the knife in contact with the bone;

Fig. 172

pass behind the artery if amputating above the middle of the thigh; but in front of it if below this level (*Fig.* 172). Turn at the level of the inner angle of the flap, and follow the convexity of the femur from below upwards, shaving the bone with the middle and heel of the blade (*Fig.* 173), and raising the tissues with the left hand, at first straight upwards, and finally upwards and inwards. The dissection is made in one stroke or two, according to the experience of the operator.

The assistant standing at the root of the limb now seizes the flap and raises it.

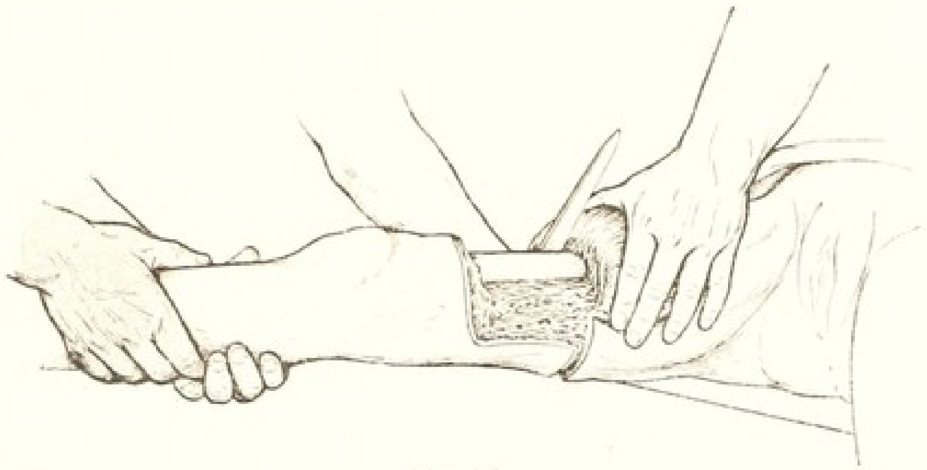


Fig. 173.

Fig 174

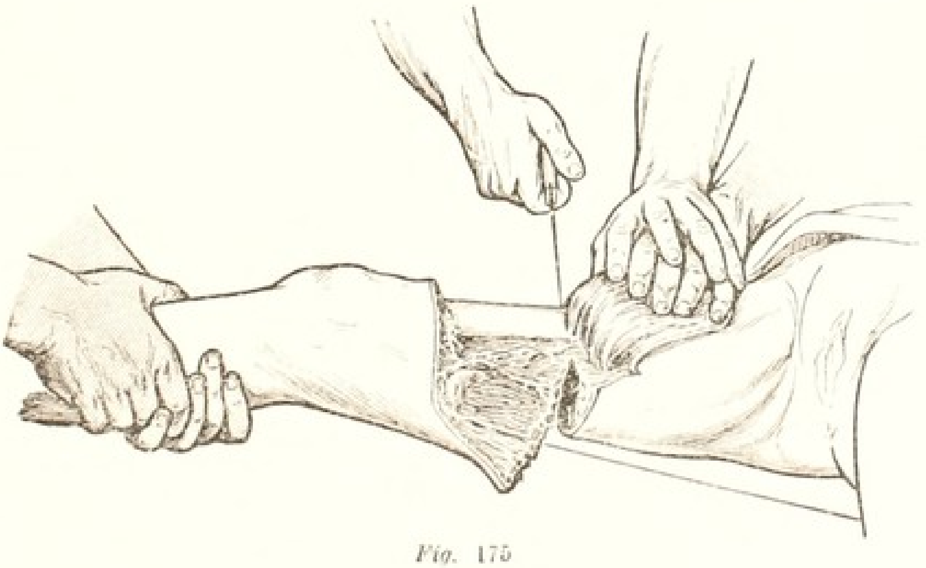


Fig. 175

Division of the Muscles Posteriorly.—This is accomplished with the knife passed under the limb by the same movement as in dividing the skin; one semicircular stroke is made right to the bone from heel to point of the blade (*Figs.* 174, 175). The edge should be applied at the level of the retracted skin, and directed slightly towards the base of the limb so as to cut the muscles somewhat obliquely.

Section of the Bone.—This includes pushing back the musculo-periosteal cuff for about an inch, scraping the linea aspera, and sawing the bone, and is always done in the same way, whatever method

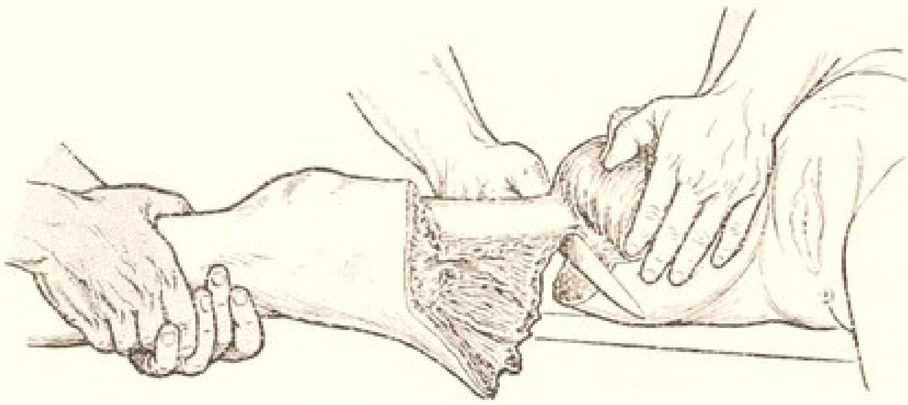


Fig. 176.

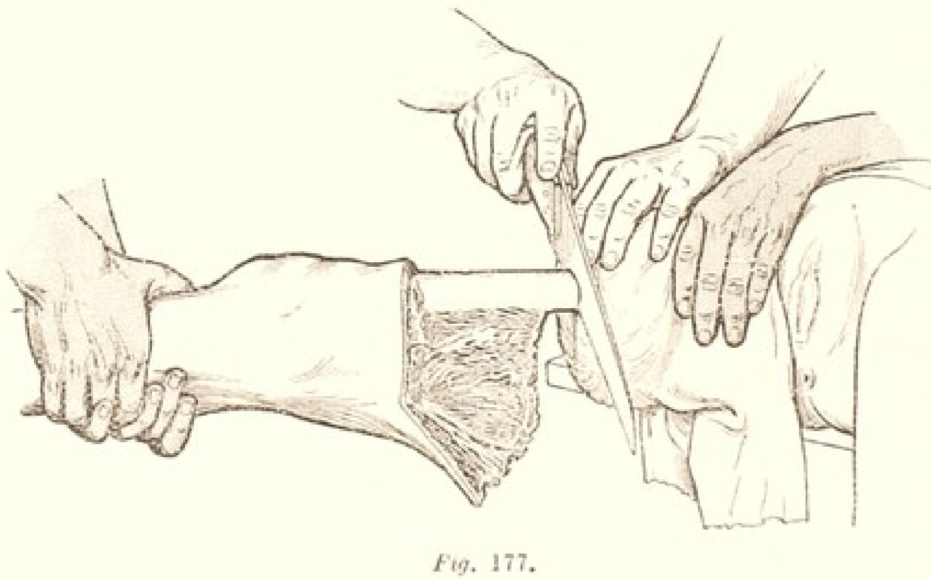


Fig. 177.

for division of the soft parts may have been employed. Begin by dividing the periosteum circularly at the base of the muscle mass, then with the elevator, or the heel of the knife, raise the periosteum, with the muscles inserted therein until, two finger-breadths higher, the point is reached where the bone is to be sawn. In *Fig.* 176 is shown the method of clearing the tendons from the linea aspera; the blade is held horizontally, with its edge slightly turned towards the root of the limb.

The soft tissues are next drawn upwards by a linen retractor with two ends, as described on p. 107. The saw, which should be broad and with a detachable back, is held at an angle of about 45° (*Fig.* 177); the external surface should be the last to be divided, and not the linea aspera, which easily breaks. While the operator is sawing, the assistant should pull on the leg and carry it a little downwards, to make the saw-track gape.

B. The Left Side.

Division of the Skin Anteriorly.—Seize the leg just below the calf with the semipronated left hand, the knee and hip slightly flexed, and bring the limb into a position of abduction and external rotation

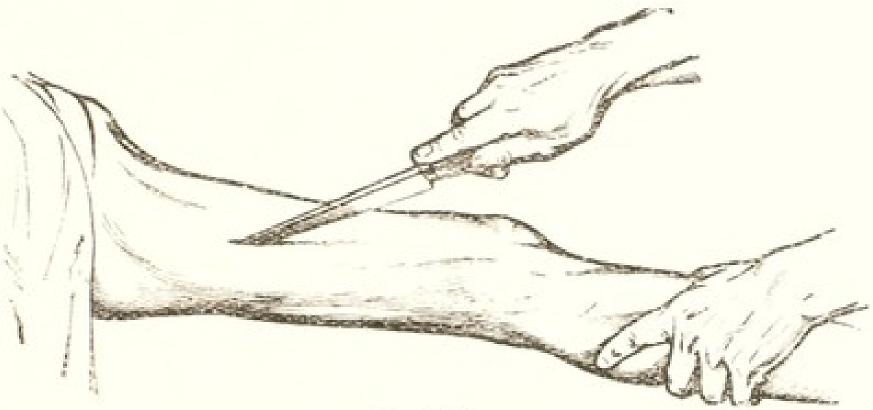


Fig. 178.

(*Fig.* 178). An assistant standing at the root of the limb stretches the skin; a second may support the foot and relieve the operator's left hand of some of the weight. This position enables the operator to draw the knife along the inner branch of the incision, turn, cross

Fig. 179.

with the limb in the normal position, and then, rotating little by little on his right leg until facing the patient's foot, draw the outer branch of the incision upwards as the limb is gradually rotated inwards, adducted, and slightly flexed again.

The manipulation of the limb may be entrusted to an assistant, the operator then pressing with his left hand just above the knee to keep the skin tense (*Figs.* **179, 180**), and cutting very much as described for the right thigh.

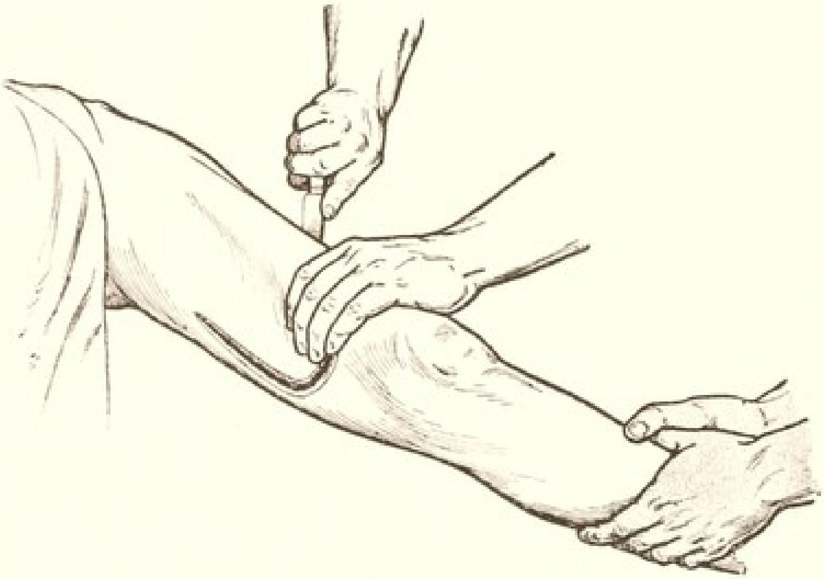


Fig. 180.

The skin is divided posteriorly, and freed, exactly as on the right side.

Transfixion of the Anterior Flap. (On this side the surgeon is not in a convenient position to dissect a flap).—Grasping the flap from below upwards with the pronated left hand, the outer lip is drawn inwards by a movement of the thumb, and the blade of the knife is passed horizontally inwards, quite at the base of the U, the edge to the left, until the point touches the bone. Now drop the handle and then raise it, so that the point, rising and descending in the opposite direction, follows the curve of the bone from without inwards, to emerge finally at the inner branch of the incision—which is drawn open by the fingers—again quite at the base of the U. According to the level of the amputation, the knife will come out in front of or behind the femoral artery as already described.

In *Fig.* 181 the left hand, which is drawing the outer lip of the incision towards the axis of the limb, is removed in order better to show how the knife is directed horizontally, and held like a trocar, the end of the handle resting against the palm of the operator between the thenar and hypothenar eminences. But the action of the thumb on the outer lip, and the fingers on the inner lip, of the wound is readily understood by reference to *Fig.* 182.

Once the knife is in position, raise the flap upwards, pinching it broadly from side to side, and cut the muscles with sawing movements of the horizontal blade as it rests in contact with the femur (*Fig.* 182), until the end of the flap is reached, when it emerges at the level of the divided skin, with the edge upwards (*Fig.* 183).

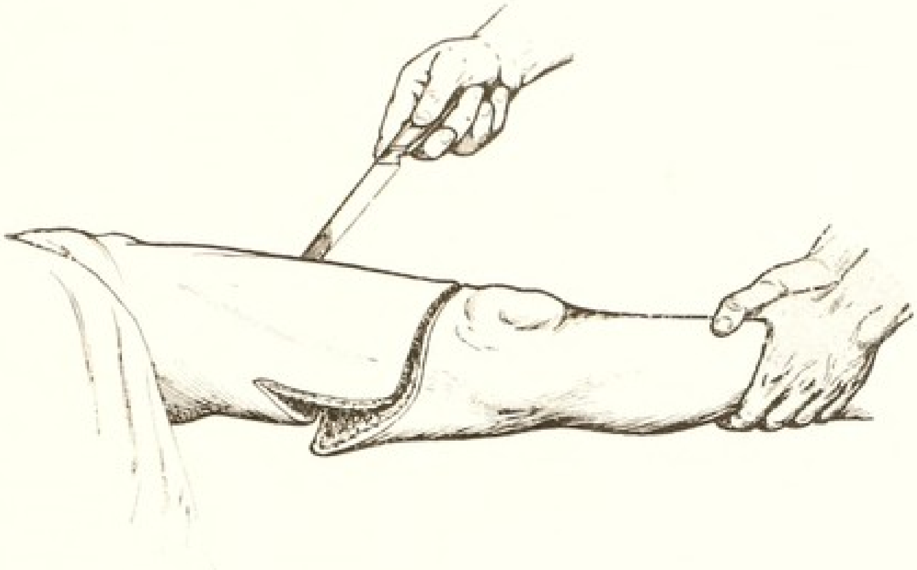


Fig. 181.

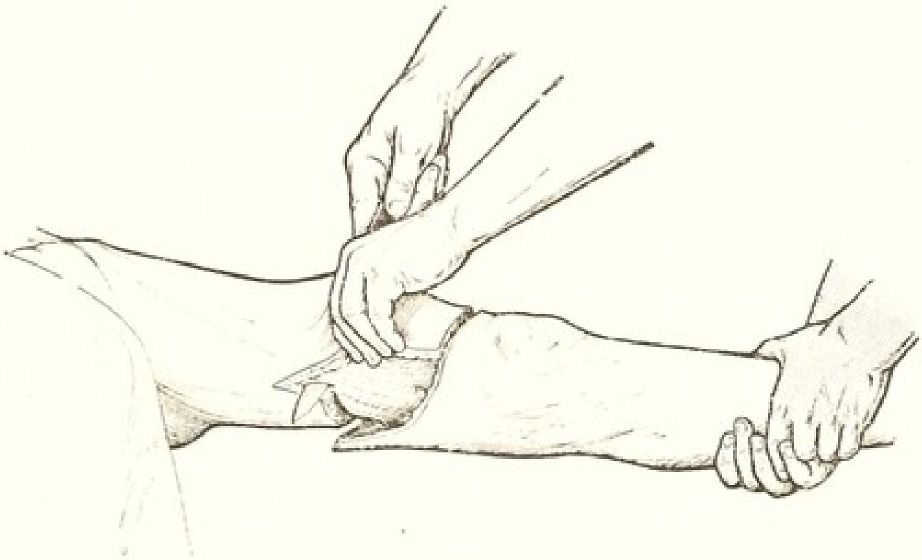


Fig. 182.

Fig. 183.

While making the sawing movements described, both the heel to the outer side and the point of the knife to the inner side should remain outside the mass of muscle which is being divided. To increase the tension of the muscles—they can be divided more neatly if they are tense—ask the assistant to flex the knee a little.

The Division of the Muscles Posteriorly, and the Raising of the Periosteum, take place as on the right side.

Sawing the Bone.—The manner of using the ordinary amputation saw is described on p. 116.

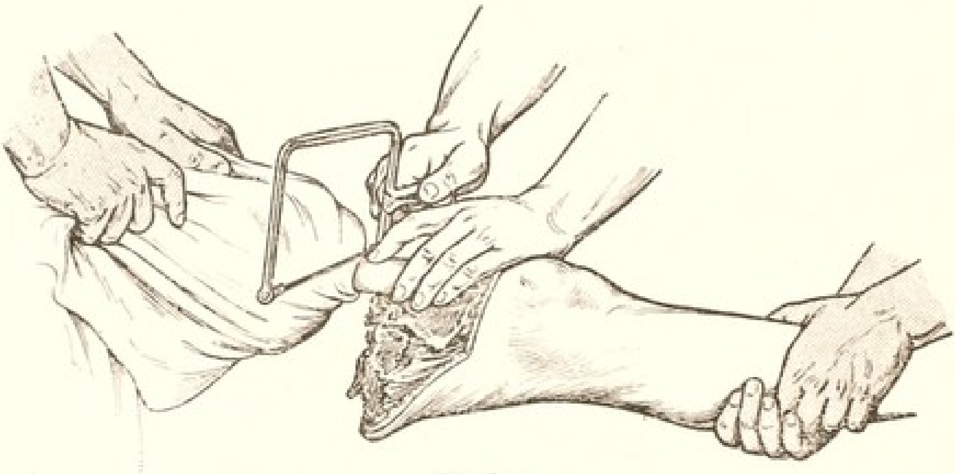


Fig. 184.

Fig. 185.

On the right side an assistant to retract the soft parts of the stump may be dispensed with, but on the left side, as shown above, the root of the limb lies to the surgeon's right, and retraction by an assistant is essential. *Fig.* 184 shows the first step, in which the operator is making a path for the saw by drawing the blade towards him for one or two strokes, guiding it to the proper position by the nail of the index finger.

In *Figs.* 184 and 185 is shown the use of the fret-saw, the narrow blade of which enables it to cut a curved section. It is used horizontally, not at an angle of 45° like the ordinary amputation saw, and it is brought out through the linea aspera, smoothing the projecting angle as it does so; the back of the framework is inclined towards the knee, and the teeth therefore turn in the opposite direction, towards the stump.

Chapter XI.

AMPUTATIONS OF THE LEG AND FOOT.

I propose now to describe in order :—

1. *The high amputation with external flap.* In this the two sides must be considered separately. The surgeon stands with the umbilicus to his left.

2. *Amputation below the middle of the leg, with a posterior flap.* An elliptical amputation may also be performed at this level, much in the same way.

3. *Guyon's elliptical supramalleolar amputation.*

1. AMPUTATION OF THE LEG WITH EXTERNAL FLAP—The so-called 'Site of Election' Amputation.

Amputation of the leg at the site of election, allowing the patient to walk on the bent knee, is performed at a hand-breadth below the line of the knee-joint, four finger-breadths below the tuberosities of the tibia.

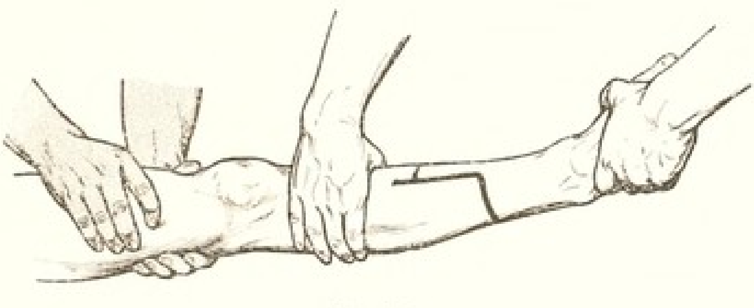


Fig. 186.

Line of Incision.—The *flap*, which should be one and a hal times the anteroposterior diameter of the limb at the point of section of the bone, is U-shaped, and is as broad below as above ; the *anterior branch* runs downwards from one finger-breadth below the point of section of the bone, along the internal surface of the tibia, half an inch inside the tibial crest ; the *posterior branch* runs upwards in the mid-line of the calf, but stops two finger-breadths below the highest point of the anterior branch.

The highest point of the posterior branch is united to the anterior by a transverse *postero-internal* incision, which therefore reaches the anterior branch two finger-breadths below its upper limit.

It is best to have *two assistants*, one facing the operator, the other at the patient's foot. A knife with a blade six inches long should be used.

Division of the Skin.—The level of the incision, which must not reach as high behind as in front, may be easily marked as follows. An assistant standing to the outer side of the left limb, or to the inner side of the right, grasps the limb in his hand, thumb above, index finger over the calf, both exactly perpendicular to the axis of the limb; the thumb marks the point of departure of the incision anteriorly, and the index finger marks this level posteriorly (*Fig.* 188 et seq.). The leg is presented in extension and nearly horizontal.

Fig. 187.

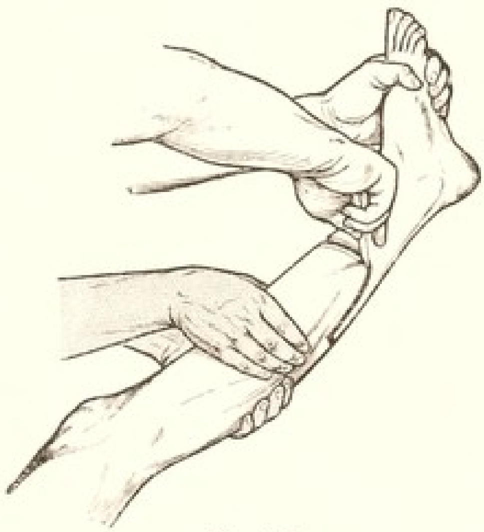


Fig. 188.

Fig. 189.

A. Right Side.

Standing at the extremity of the limb, a little to the outer side, seize the front part of the foot with the left hand, and passing the right hand under the left, make the anterior incision by drawing the point of the knife, in contact with the bone, along the limb as it is held horizontally (*Fig.* 187); then turn on the point, cross, turn again (*Fig.* 188), and ascend the posterior branch with little sawing movements of the point (*Fig.* 189). Whilst performing these movements with the right hand: (1) Raise the leg in the left hand, so that it is nearly vertical at the end of the incision, and twist it to the left to expose the posterior surface; (2) Gradually rotate to the right, pivoting on the left leg, so finally facing the patient's foot.

An assistant, placed at the level of the thigh, has seized in his left hand the postero-external aspect of the limb between his thumb and index finger, the thumb marking the upper limit of the anterior branch of the U, and the index finger therefore the same level posteriorly, two finger-breadths below which the incision must end.

The operator thus finishes the incision standing on the outer side of the limb, the patient's umbilicus to his left, and continues in this position during the remainder of the operation.

Division of the Internal Skin.—This is done transversely, with the full edge of the knife from heel to point, cutting between the head of the posterior branch of the U and the anterior branch, which is reached therefore two finger-breadths below its commencement.

Fig. 190.

Free the skin carefully, especially at the postero-internal angle, which must be quite free. The small internal cutaneous flap over the inner surface of the tibia, is held between the left thumb and index finger, and freed from below upwards with the blade on the flat (*Fig.* 192 ; photograph taken from the inner side).

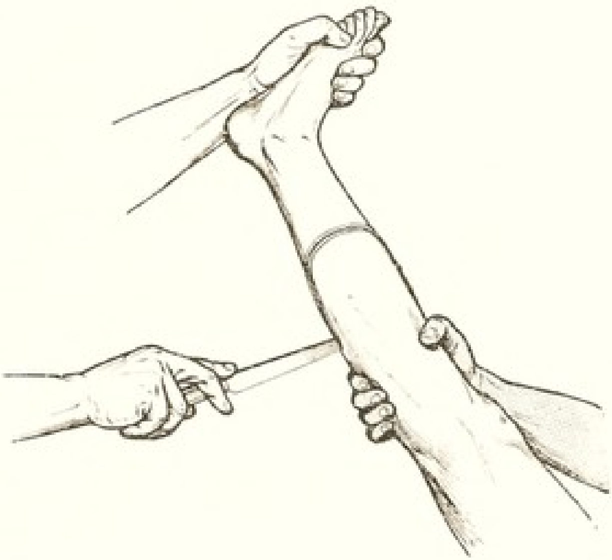


Fig. 191.

B. Left Side.

The surgeon grasps the inner border of the foot in his left hand, pierces the skin at the head of the U with the point of his knife (*Fig.* 190), and draws it along the internal surface of the tibia ; he turns at the angles of the U as they are reached,

Fig. 192.

exposing the surfaces by rotation of the limb with his left hand ; and finally he reverses, sawing with the point, along the middle line of the calf, which lies directly opposite to him as he raises the limb to an angle of 45°. The incision is terminated two finger-breadths below the assistant's index finger, which marks the point of departure as already described (*Fig.* 191).

The skin on the postero-internal aspect can now, without change of position, easily be divided transversely, exposing it by rotating the limb to the right.

This completed, the surgeon takes his stand to the inner side of the limb, which is supported in a horizontal position by one assistant who holds the calf and another who holds the foot. The small internal flap is freed from the tibia, as shown in *Fig.* 192 for the right side, and the surgeon then proceeds to *complete the external flap*.

Fig. 193.

Division of the Muscles. — On whichever side the surgeon is operating, he is now placed so that the *patient's umbilicus is on his left*, and he must first of all dissect up the external flap, then the muscles on the posterior aspect of the limb.

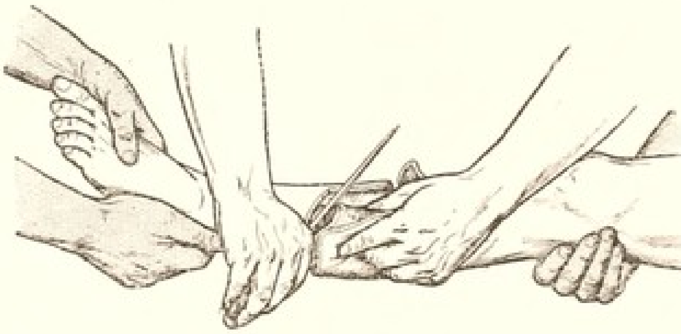


Fig. 194.

A. Left Side.
(Viewed from without).

Pulling aside the skin, held between the left thumb and index finger, the operator exposes the deep fascia, and pricks it with the point of his knife as high as possible and close to the crest of the tibia, along which it is then divided from end to end of the wound (*Fig.* 193).

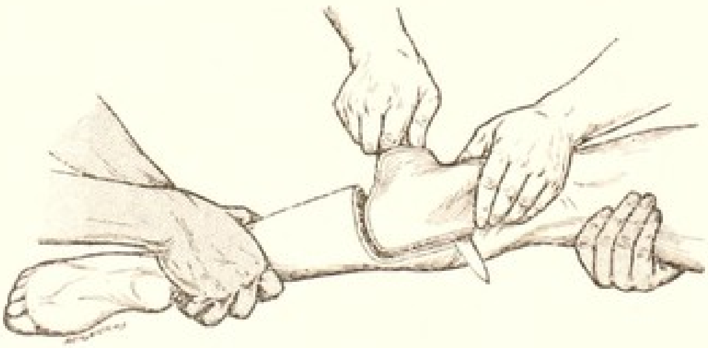


Fig. 195.

Then seizing with his left hand the skin and muscles of the flap, he passes the right hand over the limb, and cutting with the whole edge, and away from him, divides the fascia and muscles flush with the skin until arrested by contact with the fibula (*Fig.* 194).

The raising of the flap (which cannot be seen from this side, but can be seen on the right side in *Fig.* 196) is commenced by insinuating the left thumb between the tibia and tibialis anticus, and passing the knife along the path thus opened. A series of strokes with the point are now made from left to right, and from end to end of this portion of the wound; first the external surface of the tibia is lightly cleared, then the interosseous ligament, and then the internal surface of the fibula, the muscles being detached from their origins and pressed outwards, together with the artery, by the flat of the blade. This process is continued until the anterior border of the fibula has been cleared for the whole length of the flap, and the septum between the extensors and peronei has been opened.

The postero-external muscles of the flap are divided by transfixion (*Fig.* 195). The base of the flap is taken between the thumb and index finger of the left hand, the fingers dragging as much of the calf as possible forwards and outwards, the muscles are relaxed by flexion of the knee, which is turned inwards as far as possible, and the knife is passed through the flap, from before backwards, at the level of the posterior head of the U, where the point is brought out. The blade is inclined a little, so that its edge turns towards the fibula and its back towards the posterior tibial vessels, which are also protected above and drawn out of the way by the pulp of the left thumb. Starting in this position, the knife is made to cut from left to right along the fibula, and on reaching the free end of the flap the blade is turned through a right-angle and brought out, dividing the muscles transversely on the way.

The remaining muscles on the posterior aspect of the leg are divided transversely at the level of the skin, the knife being passed under the limb.

B. Right Side.

After piercing the deep fascia alongside the crest of the tibia as high as possible, and dividing it for the length of the wound, turn, dropping the handle at the same time, and divide the muscles transversely at the skin level as far as the fibula. The anterior tibial artery is cut therefore at this level, and should not be divided again.

The muscles being thus mobilized below, raise them with the left hand at the base of the flap to prepare a path for the knife, which is used nearly longitudinally; and with several strokes of the point from end to end of the wound, tibia, interosseous membrane and fibula are cleared (*Fig.* 197).

The postero-external muscle mass is divided by transfixion, just as described on the preceding page. In *Fig.* 198, which depicts this step, notice: (1) The position of the limb and of the left hand, which is dragging the calf outwards; (2) The slight inclination of the edge of the blade towards the bone; (3) The back of the blade directed towards the vessels.

It is unnecessary to describe the *transverse division of the posterior muscles*. When it is completed, the bones are cleared with the heel of the knife up to the point where they are to be divided.

Fig. 196.

Fig. 197.

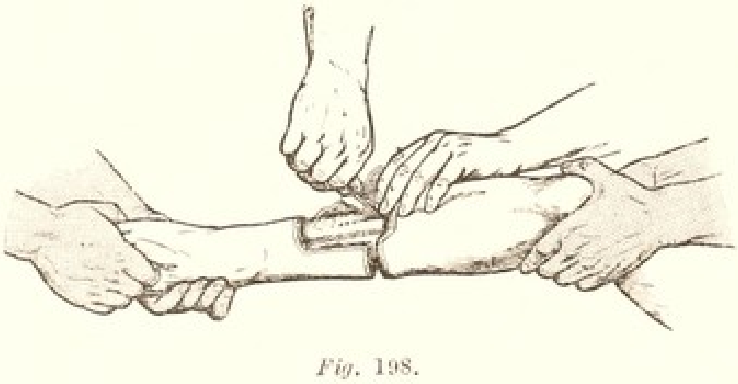


Fig. 198.

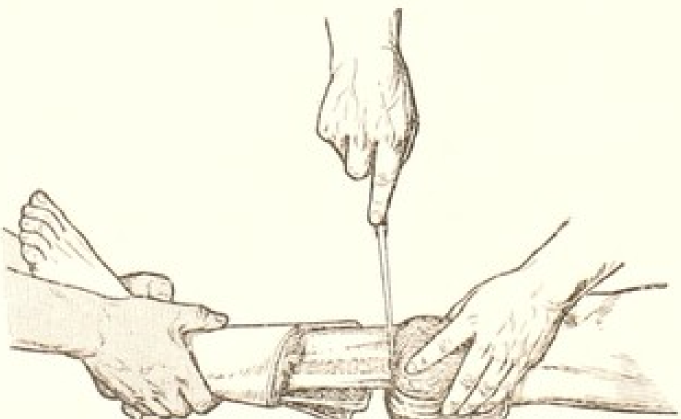


Fig. 199

The final preparation before division of the bones is the *figure-of*-8.

The Figure-of-8.—This movement is explained in the following figures (left leg, amputation at site of election, external flap).

1. The blade is drawn towards the operator with the edge resting horizontally on the anterior borders of the two bones, so dividing the periosteum over these borders.

2. Raising the handle, force the point over the internal surface of the fibula, then through the interosseous membrane, then over the external surface of the tibia (*Fig.* 199).

3. Lowering the handle, divide the periosteum over the inner surface of the tibia (*Fig.* 200).

4. Now, passing the knife under the limb, the point upwards, attack with the heel the external surface of the fibula (*Fig.* 201).

5. After drawing the blade horizontally over the posterior borders of the bones and following by a slight depression of the handle the internal surface of the fibula, perforate the interosseous liga-

ment vertically, taking great care not to injure the artery at the base of the flap (*Fig.* 202).

6. Coming in contact with the tibia again, emerge against its internal surface, the handle of the knife above (*Fig.* 203).

Sawing the Bones.—Apply the nail of the left index finger to the crest of the tibia, and make the saw bite transversely, perpendicular to the bone, at this level. As soon as it is engaged, direct the saw obliquely to your right, handle above, so as to *saw the tibia obliquely* half way through its thickness (*Fig.* 204). Now leave this saw track, and, noting its lower limit, apply the saw, again transversely and horizontally, one finger-breadth below the commencement of the first cut (*Fig.* 205). When half way through the bone, raise the handle of the saw and *divide the fibula half an inch higher up*. Then resume and complete the division of the tibia in a horizontal direction. In this manner the projecting crest of the tibia has been rounded off.

A stump in which the bones have not been sawn thus — the tibia obliquely and the fibula higher than the tibia—is generally a painful one.

The steps of this part of the operation can be followed in *Figs.* 204–207.

Fig. 200.

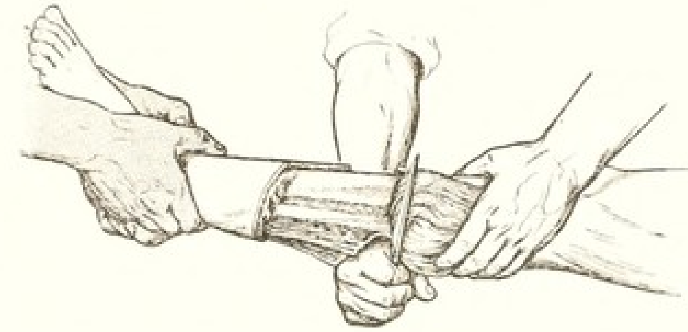


Fig. 201.

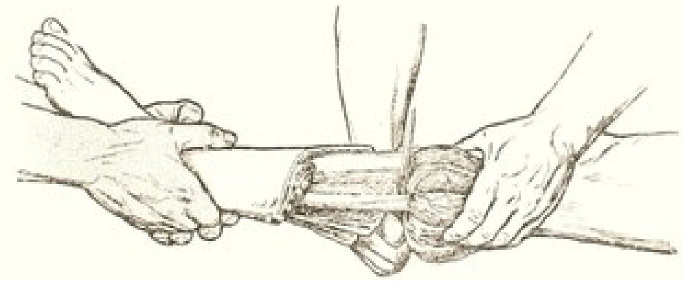


Fig. 202.

Fig. 203.

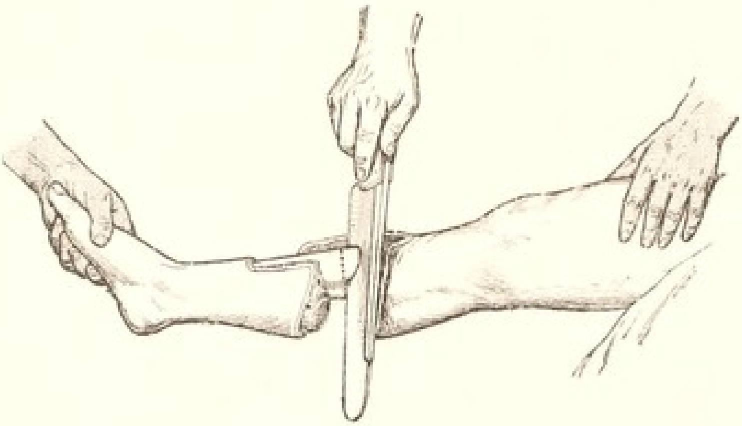


Fig. 204.

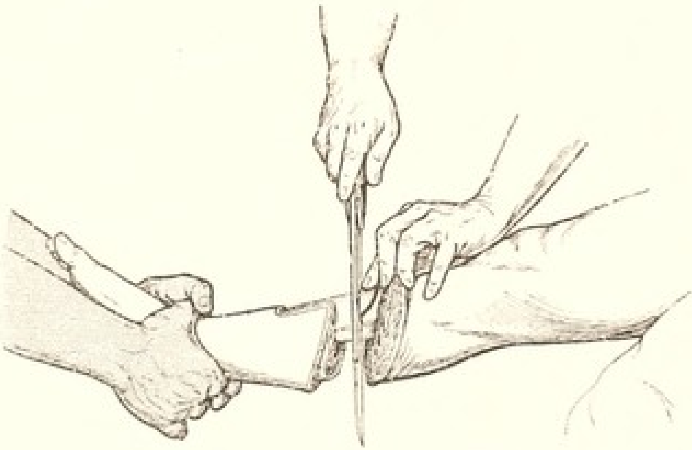


Fig. 205.

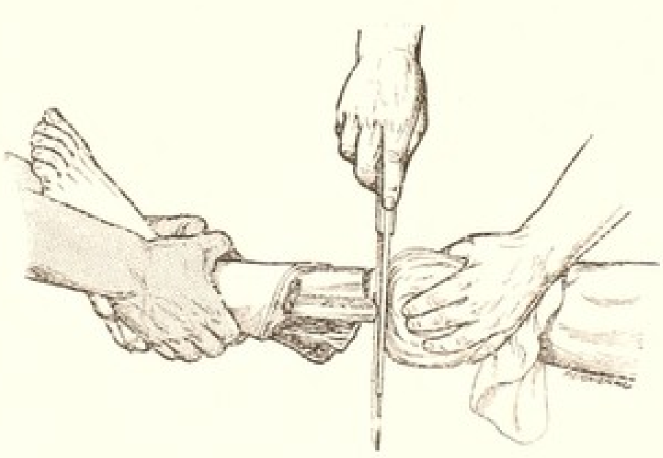


Fig. 206.

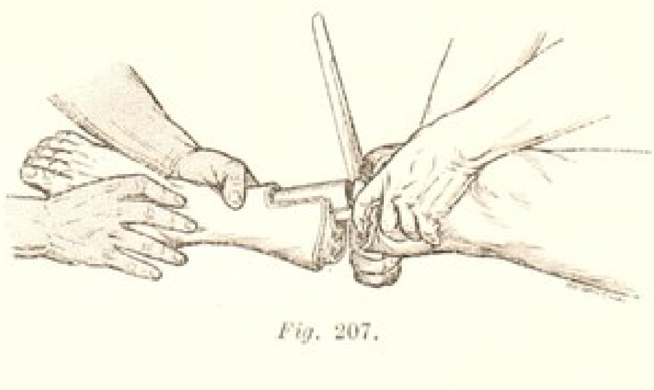


Fig. 207.

Fig. 204 illustrates the first stage in sawing the tibia. The saw is directed obliquely through the internal surface and anterior border up to half way through the bone.

In *Fig.* 205 the second stage is shown. The saw is directed transversely, and so cuts off the corner.

To saw the fibula on the *left side*, you have only to leave the tibial saw track when half way through that bone, raise the handle, and saw with the hand well raised (*Fig.* 206). Continue sawing the tibia after the fibula is divided.

To saw the fibula on the *right side*, begin by sawing half way through the tibia, then leave the tibial track ; instruct the assistant to flex the limb and rotate it inwards, so bringing forwards the fibula, which is situated considerably behind the tibia ; then depress the handle of the instrument, and saw from below upwards (*Fig.* 207), returning to your tibial track when the fibula has been divided half an inch higher up.

2. AMPUTATION OF THE LEG WITH POSTERIOR FLAP

(Middle of the Leg or below).

Line of Incision.—Begin by estimating, as described on p. 76, the anteroposterior diameter of the limb which has to be covered; then cut a *posterior* flap.

This flap is U-shaped, as broad below as above, and the arms of the U should reach one finger-breadth below the point of section of the bone. The two branches pass downwards, one a little in front of the inner border of the tibia (over the superficial internal surface therefore), the other behind the fibula. The flap thus made is placed a little to the inner side of the leg, and is broader than the transverse diameter of the limb. Its length should be one and a third diameters, allowing the third of a diameter for retraction.

A transverse incision should join the two branches of the U *in front* at about an inch below their upper extremities. If the skin on the posterior aspect is insufficient, the length of the anterior flap must be correspondingly increased.

Division of the Skin Posteriorly.—The surgeon's movements must be so arranged that he is standing at the side of the limb when the anterior muscles have to be divided and the saw to be used. The rule is, as in the preceding operation, to operate with the root of the limb to the left; but it is also possible to saw holding in the left hand the part to be removed.

If the foot is taken in the left hand, the thumb under the sole, and the right hand is passed under the left, the incision will be from left to right, and will finish to the inner side of the right limb, to the outer side of the left limb; the foot to the left in each case.

To end with the umbilicus to the left, the incision must be made in the opposite direction; from within outwards on the right side, from without inwards *on the left*, as shown in *Figs.* 208 to 211.

The sole is then grasped with the operator's left hand under the heads of the metatarsal bones, thumb inside, wrist extended, hand in extreme pronation; and the elbow is then raised to the level of the shoulder, bringing the limb, which is kept extended at the knee, nearly to a vertical position. The tibiotarsal joint is maintained in dorsiflexion, so keeping tense the posterior skin and the tendo Achillis, and the limb is carried inwards and twisted at the same time to expose the external surface. The operator, standing at the end of the limb, rather to the inner side, and facing the sole of the foot, applies the point of his knife at the head of the outer branch of the U, and draws it longitudinally towards the sole (*Fig.* 208).

After turning on the point with slight jerking movements, he diminishes the torsion of the limb to the left, bends his elbow a little, still keeping it horizontal, and rotating at the same time on the left leg, he begins to face the internal surface of the limb (*Fig.* 209).

After crossing the posterior surface, cutting with the full edge of the knife, the limb still raised, the inner angle of the **U** is turned with the point of the knife, and the limb is then carried and rotated to the left, and dropped to an angle of 45° with the horizontal. The operator is now standing on the inner side, facing the patient's foot, and can draw the knife towards him, cutting with the point along the inner branch of the **U** (*Fig.* 210).

Division of the Skin Anteriorly.—Facing thus the inner side of the limb, and cutting with the full edge, the surgeon next divides

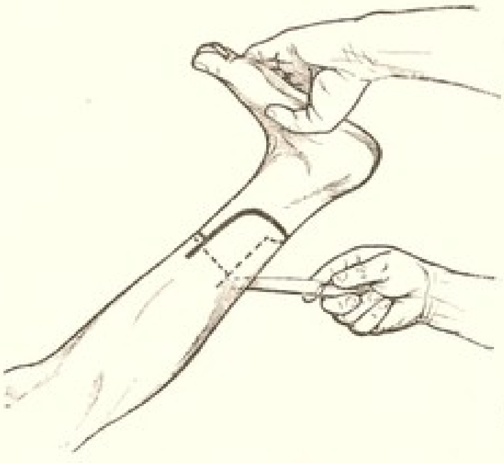


Fig. 208.

Fig. 209.

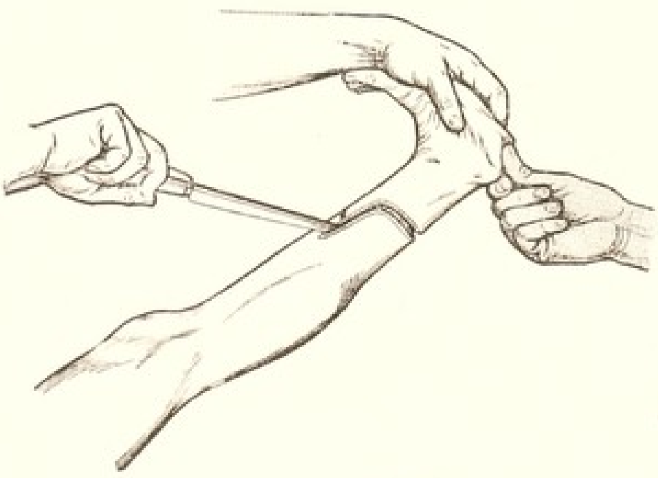


Fig. 210.

Fig. 211.

the skin *on the anterior surface* from without inwards, and then frees it carefully, while an assistant holds the foot and maintains the leg in a horizontal position.

Dissection of the Posterior Muscles.—The leg is given to an assistant, placed opposite to the operator, who raises it almost vertically, the ankle-joint dorsiflexed to stretch the tendo Achillis. Turning on his left foot, the operator resumes his position at the end of the limb, facing the heel, the leg rotated and carried to his right (*Fig.* 211).

The skin is now freed, and the deep fascia is then incised longitudinally over the inner border of the tendo Achillis—to the operator's left, that is—by drawing the point of the knife from below upwards, the handle raised (*Fig.* 211).

Still keeping the limb raised, it is next carried and rotated to the left and the deep fascia divided, this time from above downwards, along the outer border of the tendo Achillis exposed by the manipulations (*Fig.* 212).

Fig. 212.

Fig. 213

Fig. 214.

Fig. 215.

The limb is next brought back to the sagittal plane, without any rotation, and, level with the skin, the operator divides transversely the tendo Achillis, which faces him directly. The division should be made obliquely, at the expense of the anterior surface, and as soon as it is completed, hyperflexion of the foot becomes possible (*Fig.* 213).

The limb being again inclined and rotated to the right, the intermuscular aponeurosis is divided from below upwards along the posterior border of the bone to the left of the operator (*Fig.* 214).

The limb is next rotated and inclined to the left once more, so that the aponeurosis to the right of the operator may be divided from above downwards close to the bone (*Fig.* 215).

The left thumb and index finger are now inserted through the openings which have been made in the aponeurosis, and the tibialis posticus and flexor muscles are picked up and divided obliquely at the expense of the anterior surface; care being taken, after the blade comes in transverse contact with the bones, to raise the handle of the knife and carry it a little to the left to make sure the point reaches as far as the interosseous membrane at the bottom of the interosseous space (*Fig.* 216).

Fig. 216.

Division of the Anterior Muscles.—When the posterior flap has been completed and turned back, the foot must be grasped just above the heel in the supinated left hand, and the operator, turning slightly to the right, divides the deep fascia longitudinally on the anterior aspect of the limb, first along the border of the tibia (*Fig.* 217), then alongside the fibula.

Fig. 217.

The anterior muscles are then divided transversely, the operator standing still more to the right of the limb (in the illustration the surgeon is shown at the extremity of the limb, in order to give a better view of the field of operation), and taking care to raise the handle of the knife again so as to reach the interosseous membrane with the point (*Fig.* 218).

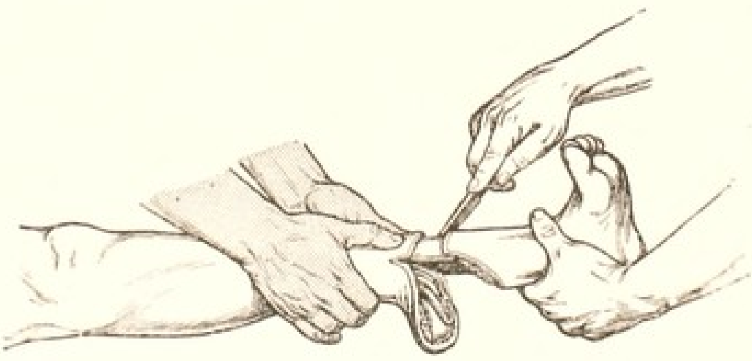


Fig. 218.

Sawing the Bones.—The rules for this step are the same as for amputation at the site of election.

1. Carry the detachment of the muscles a finger-breadth higher up.

2. Divide the periosteum in a figure-of-8.

3. Round off the crest of the tibia, and divide the fibula half an inch higher. The tibia should always be partly sawn first, then the fibula completely, lastly the tibia again.

In sawing according to these rules, when the foot lies to the left, the fibula is attacked *on the right side* with the handle raised and the limb extended ; *on the left side* the fibula may be sawn by dropping the handle of the saw or bringing forwards the bone by flexion of the knee and rotation of the thigh inwards.

3. SUPRAMALLEOLAR AMPUTATION (Guyon's Elliptical Incision).

This is an excellent operation, which allows the patient to walk on the end of the stump, and can still be performed when the skin is destroyed or injured to the point of the heel.

Landmarks.— It is sufficient to mark the position of the malleoli.

The Line of Incision is an ellipse, the lowest point of which reaches the apex of the heel behind, and the highest point the level of the joint in front. The ellipse is not regular, but has a bend opposite the malleoli.

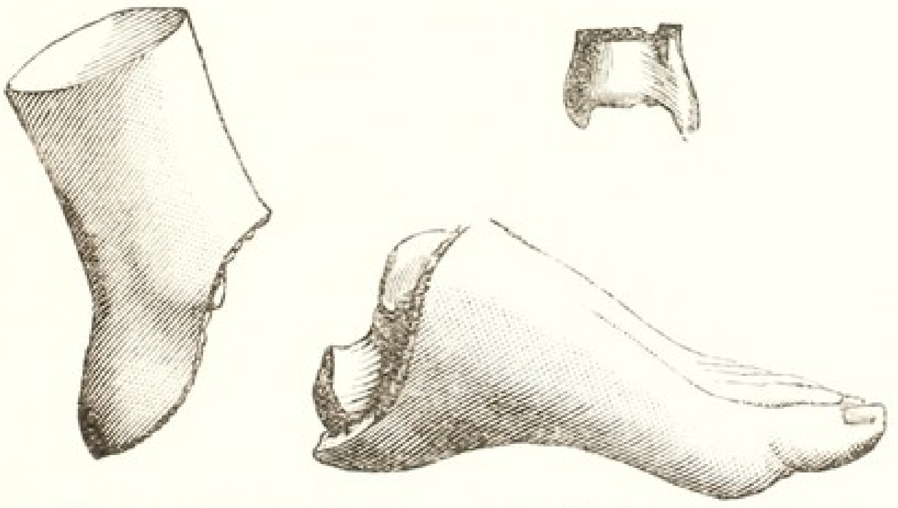


Fig. 219.—Guyon's supramalleolar amputation.—To impress it on the memory the curved shape of the flap has been preserved. In reality this does not occur ; the flap retracts and bares the malleoli as soon as the incision is completed. Above the foot is shown the length of bone to be removed (Farabeuf).

The line begins on the outer side at the apex of the heel, or a little in front of this if the condition of the skin allows, and slopes slightly upwards to a point half an inch below the tip of the external malleolus, more to the front of the process than behind. Here the line bends to form a curve with the convexity forwards, and then passes, like the lower edge of a gaiter, on to the dorsum of the foot just at the level of the line of the joint ; it then descends symmetrically to a point about one inch below the tip of the internal malleolus, whence it passes somewhat obliquely to the starting point (*Figs.* 219 and 220).

Principal Steps of the Operation.—

1. Division of the skin.
2. Detachment and division of the tendons behind the external malleolus.
3. Section of the tendo Achillis.
4. Section of the tendons behind the internal malleolus.
5. Sawing.

A knife with a blade about $2\frac{1}{2}$ inches long (Syme's knife) is to be preferred.

Fig. 220.

Fig. 221.

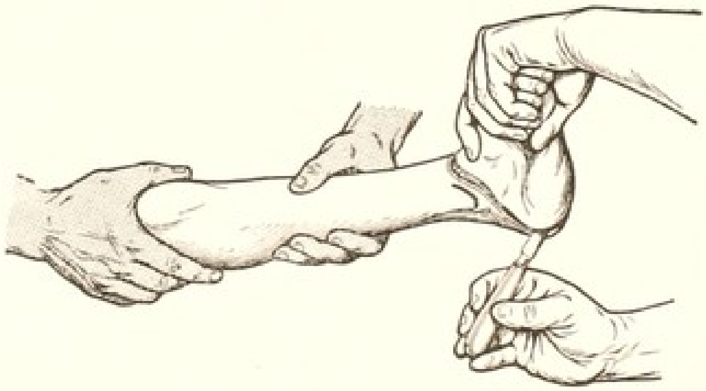


Fig. 222.

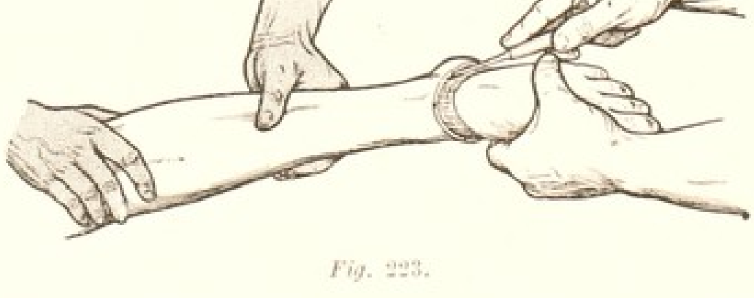


Fig. 223.

Division of the Skin.—The thigh of the patient is placed against the trunk, and an assistant, standing to the outer side, takes the knee under his arm, as shown in *Fig.* 394, and presents the leg hanging, with the calf supported. The surgeon now takes his stand at the extremity of the limb, seizes the forepart of the foot with his left hand, and twisting it to the right in order to see to the left, commences with the heel of the blade at the lowest point of the ellipse (*Fig.* 221, A), a little beyond the middle line; cutting with the whole edge, he follows the line described from left to right (*Fig.* 221, B), ending the incision on the right side with the point, handle to the left and held like a violin bow, having completed the ellipse in a single stroke (*Fig.* 222). While the right hand is executing the movements described, the left hand twists the foot so as to present in succession the surfaces which are to be divided.

The skin alone is to be divided, and then freed with great care all round.

Dissection of the Flap.—When the skin incision has been made, the *easiest procedure* is to disarticulate at the ankle and enucleate the os calcis as in a Syme's amputation (q.v.), but with less trouble.

A *neater procedure* is to clear the bones at the point of section in three stages without disarticulating.

1. Divide the tendons behind the external malleolus.
2. Divide the tendo Achillis.
3. Divide the tendons and vessels behind the internal malleolus.

It is best to get into the way of ending on the inner side, because it is in this position that the posterior tibial artery is cut across, and a copious flow of blood results.

The operation figured is that practised on the left foot, in the following order, commencing to the right :—

1. Leg horizontal, the external malleolus is freed.
2. Leg raised to assist in dividing the tendo Achillis, foot held by an assistant.
3. Leg horizontal again, the internal malleolus is freed, the assistant still holding the forepart of the foot.

The order is the same when operating on the right side, but in this case beginning to the left.

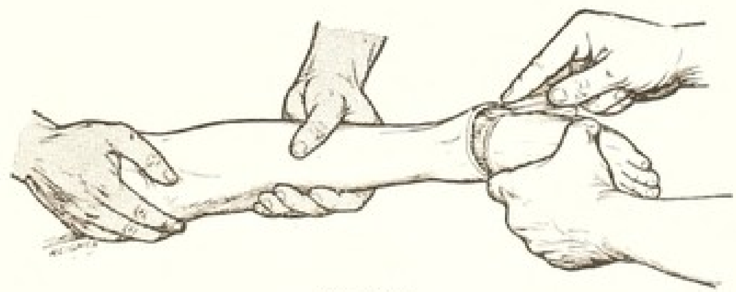


Fig. 224.

Such being the order of the manipulations (which are excellent for training the hands), they will now be described in detail.

1. *External Malleolus (to the operator's right).*—Incline the foot to the left with the left hand, and insinuate the blade of the knife, horizontally and on the flat, along the anterior border of the malleolus, between the skin and bone, the edge to the right. Now with small sawing movements pass from left to right, rounding the slight convexity of the bone, until its posterior border is reached (*Fig.* 224). At this point the edge of the knife is felt to lose the support of the bone. Turning the blade through a right angle, cut on to the bone, close to and just behind its border, and divide the tendon sheaths

perpendicular to the bone by drawing the knife longitudinally downwards as far as the wound extends. The blade is thus placed longitudinally between the bone and the anterior surface of the tendons. If now your flexed and pronated wrist is moved away from you

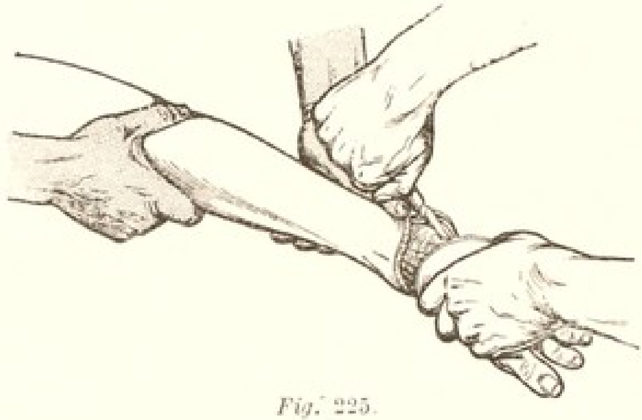


Fig. 225.

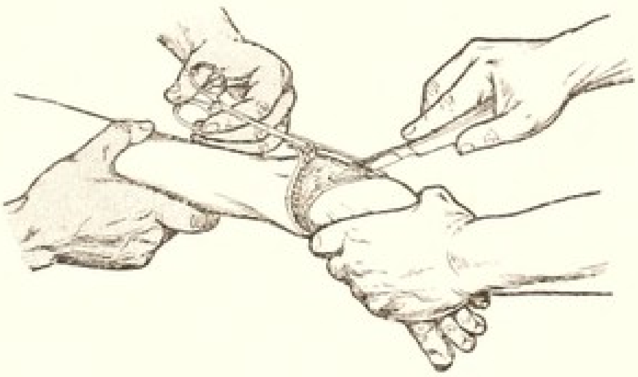


Fig. 226.

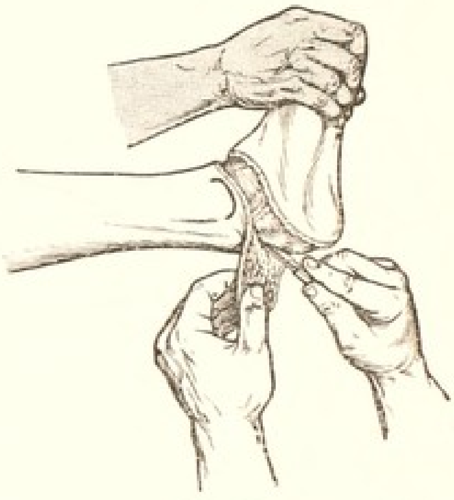


Fig. 227.

Fig. 228.

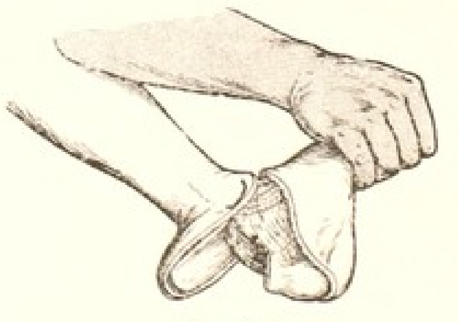


Fig. 229.

(*Fig.* 225), and the handle dropped towards the leg and a little to the left, pushing gently at the same time, the point of the knife will pass under the tendons obliquely and come out again to the right, the back of the blade resting against the lateral surface of the os calcis.

Next press on the point, and at the same time make a fanshaped movement of the hand, bringing the handle forwards, and with the left hand twist the foot firmly to the left. In this way the tendons are divided under which the knife was passed, the os calcis being used as a leverage point. (*Fig.* 226 shows the tendons held in a pair of artery forceps after division).

2. *Section of the Tendo Achillis.* — An assistant, seizing the front part of the foot, raises it, with the sole vertical, until it reaches the level of the operator's chin. Taking now the heel flap between the index finger and thumb of his left hand, the surgeon liberates the skin over the back of the heel by cutting away from him with the blade horizontal until he feels the knife pass beyond the bone (*Fig.* 227). The insertion of the tendo Achillis has now been reached; it is divided close to the bone, turning the blade upwards through an angle of 90° (*Fig.* 228). The flap now lies before the surgeon, and he continues to liberate it as far as the malleoli (*Fig.* 229).

Fig. 230

Fig. 231.

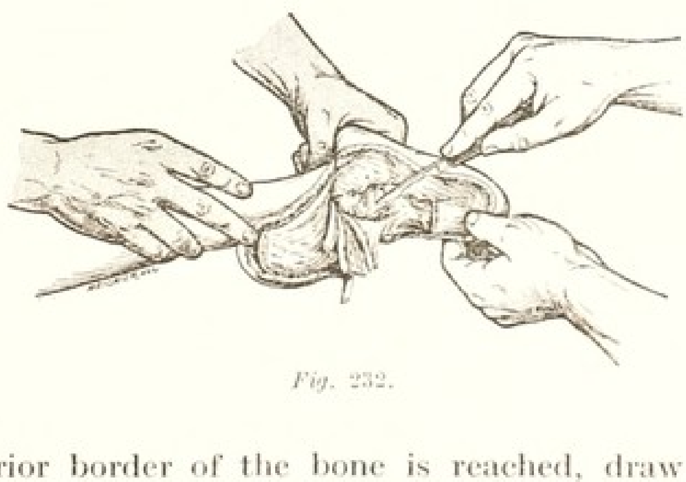


Fig. 232.

3. *Internal Malleolus (to the left).*—Twisting the foot to the right, pass round the superficial surface of the internal malleolus with the flat of the knife from right to left; as soon as the posterior border of the bone is reached, draw the knife downwards (*Fig.* 230) against this border to divide the tendon sheaths, and then slip the point between bone and tendons as before. Now turn the wrist and handle towards the left, in a manner similar to that shown in *Fig.* 225. *Fig.* 231 shows how the tendons are next divided by bringing the wrist and handle towards

you while the point is held fixed against the bone on which they are divided ; at the same time the tendons are stretched by dorsiflexion of the foot (*Fig.* 232).

When the malleoli are cleared and the posterior flap is liberated as far as the point of section of the bone, take up a position to one side of the limb, still holding the foot in the left hand, and divide the antero-external muscles transversely at the level of the retracted skin. Next divide the periosteum circularly (there is no interosseous space at this level).

Sawing the Bones.—Saw the bones with the hand well raised, commencing and ending with the tibia.

The crest of the tibia must be rounded off, as described on p. 127, and care must be taken to resect the posterior tibial nerve, which will otherwise be pressed against the divided bones.

The operation gives excellent results, and terminal pressure is well supported if the skin is reinforced by the tendo Achillis. P. Duval and Farabeuf even advise taking off the surface of the os calcis with a saw where the tendon is inserted.

Chapter XII.

AMPUTATIONS OF THE ARM AND FOREARM.

AMPUTATIONS OF THE ARM.

Below the deltoid insertion *a circular amputation* is the best to choose ; or two equal flaps may be cut, anterior and posterior. A terminal cicatrix does not matter here, because in using an artificial limb the patient does not press on the end of the stump, but makes lever movements only, in different directions, without thrusting.

Above the deltoid insertion *an external flap* must be cut. This is not because the scar must be arranged on the inner side, for even lever movements are almost completely absent with so short a stump, but because of the way in which the deltoid is inserted, covering closely the upper third of the humerus at least.

No description is needed of the amputations at lower levels, which are carried out just as in the case of the thigh. It is only necessary to mention that the skin on the inner side of the limb should be divided lightly, because the vessels are very superficial.

The line of the circular incision may be perpendicular to the axis of the limb, as the skin retracts very nearly to the same extent all the way round. Nevertheless, there is a little more retraction in front and to the inner side, and the appearance of the stump will be better, therefore, if the incision is inclined in this direction.

The *chief steps* of the operation are the same as in a circular amputation of the thigh.

The blade of the knife should be 6 inches long, and the surgeon should stand so that the hand of the patient is to his left ; the arm is abducted to a right angle. If an assistant is not available at the root of the limb to compress the artery and retract the tissues, the surgeon may stand the other way round and grasp the circumference of the limb with the left hand.

After amputations of the arm, the great nerve trunks, especially the median and ulnar nerves, are likely to give rise to painful neuromata unless they are carefully resected for about an inch of their length after division of the muscles.

INTRADELTOID AMPUTATION (with External Flap).

Line of Incision.—The transverse diameter of the limb having been estimated, as described on p. 76, a **U**-shaped flap is marked out, at least a diameter in length (the skin on the internal surface can be used on occasion to supply the extra third made necessary by retraction). The flap should be as wide below as above ; the extremities of the U should be placed at each end of the anteroposterior diameter of the shoulder, or a little to the inner side of these points, and should begin a finger-breadth below the point of section of the bone.

A small internal flap is marked out by uniting the two branches of the U across the axillary surface of the arm.

Division of the Skin.—The operator must first make sure that the position of his hands allows him to cut the whole flap without interruption. This position should be as indicated on p. 85; *on the left side* he attacks the flap directly, his hands alongside one another and the flap to his right; *on the right side*, however, he starts the incision with the right hand passed under the strongly flexed and pronated left forearm and wrist.

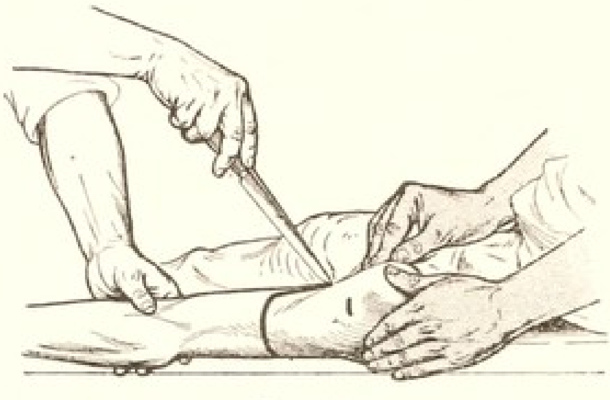


Fig. 233.

Fig. 234.

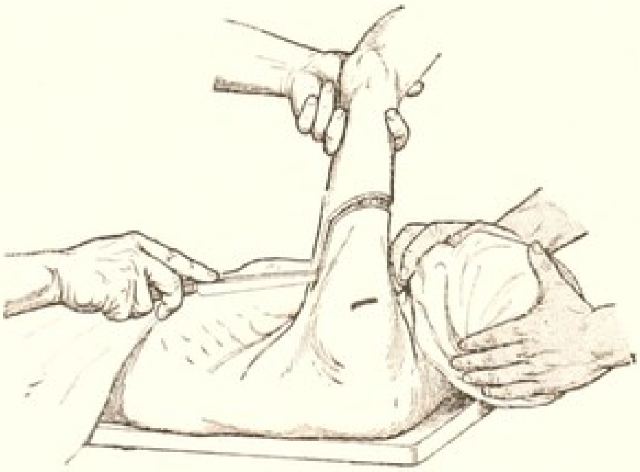


Fig. 235.

The assistant, standing behind the shoulder, stretches the skin with one hand on each side of the stump. The surgeon, grasping the internal surface of the limb with his left hand, holds it in a horizontal position, slightly abducted and rotated outwards, while with the blade held nearly vertical he pierces the skin at the head of the anterior branch of the U. He draws the knife along the anterior angle and crosses the limb transversely while he rotates it progressively inwards. After turning again posteriorly, he raises the limb until vertical, abducting it and rotating it still further inwards, while he reverses from above downwards along the posterior branch of the U (*Figs.* 233-235).

After freeing the skin, without being afraid of injury to the deep fascia, the surgeon stands outside the limb, which is now held horizontally and abducted by an assistant and, passing his right hand under the limb, the point upwards, he unites the two branches of the U by a cut somewhat convex downwards, giving an internal flap equal to about half a diameter.

Division of the Muscles.—One of two procedures may be used :—

1. *Transfixion.*—Hold the flap, raise it, and transfix it, as described for the thigh on p. 118 ; but pierce the limb vertically and not horizontally, from above downwards on the right side, from below upwards on the left side.

2. *Dissection.*—Grasping the flap in the left hand, pass the knife longitudinally under the anterior lip, which is raised by the thumb (*Fig.* 236), and draw it towards you, the point in contact with the bone. Turn with the blade held obliquely and reverse up the posterior branch of the U, raising the flap with the left hand as you proceed (*Fig.* 237).

Fig. 236.

Fig. 237.

Division of the Tissues and Vessels internally.—This is done transversely, cutting with the whole blade. The coracobrachialis is held with the left hand to make it tense, and divided by the surgeon drawing the knife towards him. An assistant, standing at the root of the limb, then grips the vessels while the operator divides them transversely.

Sawing the Bone.—This is done with the hand above. The surgeon stands outside the limb if two assistants are available ; if there is only one assistant, he stands in such a position that the patient's hand lies to his left.

AMPUTATIONS OF THE FOREARM.

In the upper part of the forearm, where there are thick masses of muscle, a flap amputation is performed, the best method being with equal anterior and posterior flaps ; one or other of these may be made to predominate, according to the needs of the case.

The flaps are planned with the forearm in supination ; the external branch is arranged along the palpable outer border of the radius, a little behind the transverse axis of the limb therefore, and the internal branch a little in front of the anterior border of the ulna, that is, a little in front of the transverse axis.

The blade of the knife should be 5 or 6 inches long.

The positions necessary to divide and to liberate the skin are the same as in disarticulation of the elbow with an anterior flap.

The muscles are divided, with the forearm supinated, either by transfixion or dissection ; first in front and then behind.

The steps used in dividing the periosteum in a figure-of-8, and sawing, are the same as for an amputation lower down.

CIRCULAR AMPUTATION WITH CUFF.

In the lower part of the forearm there are no muscle masses, and there is little more than skin available to pad the stump ; *a circular amputation with a cuff of skin* is therefore used.

It is more convenient to have two assistants for this operation, one holding the hand and standing at the extremity of the limb, the other placed on the inner side at the level of the arm. A single assistant, standing opposite the surgeon, and holding the wrist with one hand and the arm with the other, will, however, suffice if necessary.

Principal Steps of the Operation.—

1. Circular division of the skin.
2. The turning back of a cuff.
3. Division of the muscular flaps.
4. Division of the periosteum and interosseous membrane in a figure-of-8.
5. Sawing.

A wrist knife is used for this operation.

The limb is presented horizontally and in supination. The surgeon stands so that the patient's hand is to his left.

After determining where the bone is to be sawn, measure the anteroposterior diameter of the limb at this point, and, using the right index finger as a marker, apply the knife to the anterior surface of the limb, and note the level at which the skin must be divided circularly, and perpendicularly to the axis of the limb.

Division of the Skin.—An inexperienced operator does this *in two steps*, first cutting the posterior skin by drawing the knife across the under surface. Starting with the heel of the knife, blade vertical, point uppermost, on the border away from him, he crosses the limb posteriorly, and finishes with the point, handle above, on the border near to him ; he then divides the anterior skin by drawing the knife across the arm between the two ends of the first incision.

It is easy to practise in this case the *circular division of skin in a single step*. To do this, the right hand in extreme pronation is passed under and over the limb, and the heel of the blade applied, point downwards, to the surface nearest the operator, the handle being held fully in the hand. The blade is then passed circularly round the limb till the point is brought out at the starting-place, handle above ; in this movement the handle rotates in the palm, and at the end is only held between thumb and index finger.

Turning back the Cuff.—The assistant drags the divided skin towards the stump, and as he does this, the surgeon frees it by dividing, with the knife used on the flat, the connective-tissue strands which unite skin and deep fascia. Begin this process on the anterior

Fig. 238.—Freeing the cuff.

surface with the forearm supinated, and continue on the posterior surface in pronation; repeat this many times, turning and re-turning the limb, while the assistant turns back the cuff of skin, until the level is reached where the bone is to be divided.

Division of the Muscles.—This is done by transfixion.

With the knife held on the flat, pierce the tissues just in front of the bone, the edge towards the wrist, the back to the cuff, and emerge, with the knife still on the flat, in front of the more distant bone. The passage of the knife is facilitated if the muscles are relaxed by slight flexion of the wrist.

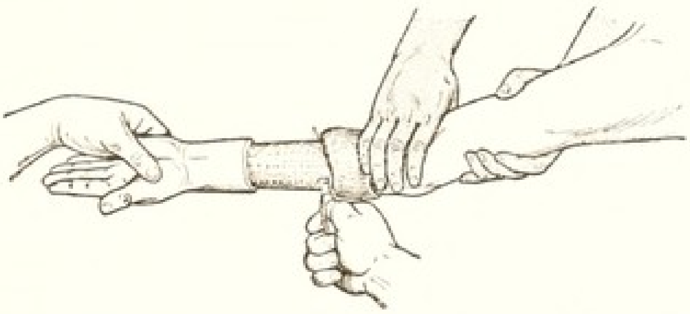


Fig. 239.—Transfixion of the anterior muscles.

Then extend the wrist to stretch the muscles, and turning the knife through a right-angle, edge upwards, divide the muscles so as to form a little flap hardly broader than the blade of the knife.

Now execute a similar manœuvre posteriorly, reversing the movements of the patient's wrist; extending it therefore to relax the muscles, and flexing it to stretch them.

Divisions of the Periosteum and Interosseous Membrane.—

1. *In Front.*—Passing the knife over the limb and holding it fully in the hand, apply the heel of the blade over the inner surface of the ulna, the point reaching vertically downwards. Now, drawing the knife from below upwards, until the anterior surface is reached,

divide the periosteum transversely over both bones at the same time. When the point reaches the anterior border of the ulna, raise the handle slightly, and so pass the point of the knife over the outer surface of the ulna, the interosseous membrane, and the inner surface of the radius ; now lower the wrist, and pass the blade from heel to point over the outer surface of the radius, ending with the point vertically upwards, the handle having rotated in the palm until it is held like a violin bow between the thumb, index, and middle fingers.

2. *Behind.*—Pass the knife under the limb as for the circular division of the skin, the blade vertical, the point uppermost, and applying the heel to the inner surface of the ulna, draw the knife from above downwards. Continue to draw the knife transversely with the edge against both bones, and follow the contour of the bones as you reach them with the point of the blade by lowering the handle as described above. When passing over the interosseous membrane, lower the handle until the blade is vertical, and then pierce the membrane from below upwards. End with the point on the outer surface of the radius, the blade vertical, handle above (*Figs.* 199-203).

This description is for the left side, the surgeon standing on the outer side of the limb ; on the right side, the surgeon standing to the inner side of the limb, the radius is the more distant bone.

Sawing the Bones.—With the limb in supination, begin obliquely, with the hand at first above, by making a track on the ulna, the bone which is more solidly attached to the humerus ; now, with the saw horizontal, and then slightly ascending, commence and complete the division of the radius ; after this, raising the hand again, end with the ulna.

Part 3.—DISARTICULATIONS.

Chapter XIII.

GENERAL OBSERVATIONS.

It is essential to have a very exact knowledge of the surgical anatomy of any articulation before entering it with the knife, so that it may be possible by examination of the bony landmarks to determine the line of the joint. The ligaments must also be specially considered in their relation to the surface from which the joint is to be opened.

Every articulation has what may be termed its surgical side, through which it is best opened ; and it will readily be understood that while an error of half an inch in sawing a bone is of no consequence, it is necessary to be exact to a millimetre when a joint has to be opened. If the skin is divided too high, the bony end projects ; if too low, the knife scratches vainly against the lower bone.

In the following pages an anatomical *résumé* precedes each description of an operation, because great accuracy is necessary in making the flaps, and in entering the joint when its position has been determined. A joint should be opened from left to right, with the point, body, or heel of the knife, as the case may be, after once more noting the landmarks ; and care must be taken to make *the line of the joint gape* at the point where it is to be entered, either by traction, torsion, bending the limb, or, sometimes, by holding it in a definite position, such as the equinovarus position in mid-tarsal and sub-astragaloid amputations.

A joint must be entered without force, the knife following lightly its direction, and even the sinuosities of its outline, which should always be kept in mind. The ligaments (and tendons also sometimes) may be considered the keys of the joint ; a knowledge of their direction, and how to make them tense, enables the operator so to touch their left border (that is, the border to his left) with the point of his knife that they almost divide themselves. To do this successfully two conditions must be fulfilled : the knife must be applied exactly at the right spot, and force must be used with the left hand only, while the right depends entirely on skill and precision. It is for this reason that disarticulations provide such a valuable education in manual dexterity.

Chapter XIV.

DISARTICULATIONS OF THE HAND AND WRIST.

DISARTICULATION OF A PHALANX.

Anatomy.—The interphalangeal joints are ginglymus joints ; the upper articular surface shows two small condyles like those of the femur, the lower surface two little depressions, almost flat, and separated by a blunt crest which is prolonged posteriorly into a little projecting beak, so that the *dorsal surface of the interline is shaped like a circumflex accent much flattened.* The palmar border of the upper surface of each phalanx is lengthened by a *glenoid pad,* to which is attached the sheath of the flexor tendon. The bones are held in position by two *lateral ligaments,* running somewhat obliquely downwards and backwards, and joining on the dorsal surface the fibrous plane of the *extensor tendons.*

Examination.—If with the hand in pronation the sides of the extended finger are nipped from below upwards between the nails of the thumb and index finger, the articular enlargement is felt to be formed on each side by two little superimposed tubercles between which the nail slips into a groove.

If the joint is flexed, the lower phalanx becomes displaced towards the palm, and it is the trochlear surface of the upper phalanx which projects under the skin ; if a line tangential to the dorsal surface is prolonged beyond the head of the bone, the line of the joint will be found 3 to 4 millimetres below it, in the direction of the palm, running horizontally.

Line of Incision.—The cicatrix must be dorsal, so a *palmar flap* must be cut, limited laterally by two lines following the junction between the dorsal and lateral surfaces, and extending downwards, with rounded angles, so as to include the whole palmar surface of the phalanx which is to be removed.

Across the *dorsal surface* an incision is made, which should not extend on to the lateral surfaces, and which lies slightly below the line of the joint, so that after retraction the head of the phalanx will still be well covered.

Principal Steps of the Operation.—1. Transverse division of the skin and extensor tendon on the dorsal surface, with the joint flexed so that it can be entered directly.

2. Successive division of each lateral ligament.

3. To shave closely the palmar surface of the removed phalanx with the point of the knife, in order to leave in the flap the detached glenoid cartilage.

4. Completion of the palmar flap by transfixion.

Division of the Skin.—To divide the skin on the dorsal surface, the assistant, placed to the outer side, presents the hand to the operator in a nearly vertical position, the wrist pronated and extended.

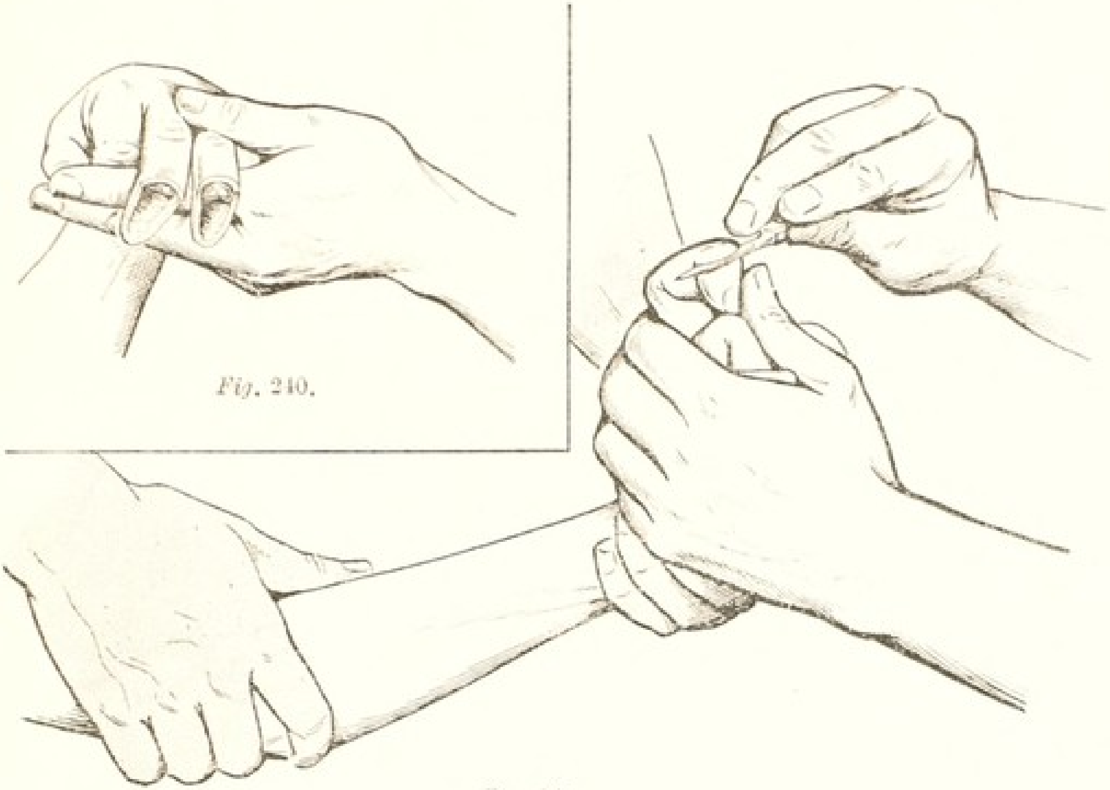


Fig. 240.

Fig. 241

Pressing the nail of the distal phalanx with the left thumb, and with his index finger over the dorsum of the proximal phalanx, the operator flexes both interphalangeal joints to a right angle, and applies the middle of the blade of the scalpel about 5 millimetres below a line tangential to the dorsal surface of the middle phalanx (*Fig.* 241). Drawing the knife from left to right, pushing slightly at the same time, the joint is entered, as announced by a little dry cracking sound and a slight increase in flexion of the distal phalanx under pressure of the operator's thumb. The fault usually made is to incise the dorsal skin over the head of the middle phalanx with the blade more or less vertical instead of horizontal (*Fig.* 242).

Fig. 242

In such a case the knife reaches the neck of the middle phalanx, disarticulation becomes difficult, and the bony end remains exposed instead of being hidden under a little hood (compare the two results in *Fig.* 240).

Fig. 243.

Fig. 244.

Fig. 245.

When the joint has been entered, the projection on the posterior surface of the distal phalanx is freed with a short stroke of the knife made like a circumflex accent, and the bones are seen to gape (*Fig.* 243).

Division of the Lateral Ligaments.—To divide the lateral ligament on his left, the operator presses the hand to his right, makes an incision about 5 millimetres long from below upwards at the level of the lateral border of the bone, and divides the ligament, stretched by hyperflexion, with 1 or 2 millimetres of the point of the scalpel, held vertically and near the point like a pen, the little finger being used as a support (*Fig.* 244).

The ligament to the right of the operator is similarly divided after pressing the hand to the left and drawing a short preliminary incision with the point of the scalpel.

The finger is then replaced in the former position, still hyper-flexed, and from left to right the palmar surface of the phalanx is shaved with the point of the knife so as to make a path, close to the bone, between the lateral incisions, as long as the blade is broad.

The bones are now re-articulated behind the blade engaged on the flat, the distal phalanx is pinched between the operator's thumb (below) and index finger, and with little transverse sawing movements the knife is brought out at the end of the pulp in contact with the nail (*Fig.* 245).

METACARPO-PHALANGEAL DISARTICULATIONS (Excepting the Thumb).

Anatomy.—The metacarpo-phalangeal articulations of the fingers are condylarthroses running transversely between: (1) *The head of the metacarpal bone*, a segment of a sphere with flattened sides; and (2) *The upper extremity of the phalanx*, shaped like a glenoid cavity with the long axis placed transversely, slightly hollowed, and extended at its palmar border by a *glenoid cartilage*, which blends with the flexor tendon sheath and often contains sesamoid bones (especially in the case of the index and little fingers).

The bones are held together by :—

1. *Two lateral ligaments* running somewhat obliquely downwards and forwards.

2. *The extensor tendon* on the dorsal surface, which adheres to the capsule, and is united on either side by a tendinous expansion to the lateral ligaments as well as to the tendons of the interosseous muscles and lumbricales.

Examination.—The lines of the joints are very nearly in the same transverse line, but those of the index and little fingers are somewhat above those of the two middle fingers. The joints are not situated at the level of the interdigital commissures or the digito-palmar folds, but lie in the palm nearly a finger-breadth above.

On the dorsal surface, *in extension*, the longitudinal prominence in the middle line of each digit made by the extensor tendon is seen, with a small flattened area on each side of it at the level of the joint. This flattened area becomes hollowed transversely by the sinking in of the skin when the joint surfaces are separated by traction on the finger (as children do when they try to crack their fingers), and the line of the joint can then easily be localized between the nails of thumb and index finger applied from below upwards to the lateral surfaces of the phalanx.

Without traction the sides of the joint may similarly be made to gape by *slight flexion* of the finger combined with little lateral movements. As flexion increases, the phalanx slides towards the palm, the head of the metacarpal bone becomes disengaged, and finally, *in complete flexion*, is the only bone to project, the phalanx lying at right angles to the metacarpal. It is with the heads of the metacarpal bones that a blow with the clenched fist is struck. In complete flexion the metacarpal bone projects for about half an inch behind the line of the joint ; and below it the extensor tendon can be seen, with a flattened area on either side. The line of the joint, still transverse, is now parallel to the plane of the palm.

Line of Incision.—It is the palm of the hand and the borders of the palm which have to withstand blows and pressure, so the scar must be placed dorsally and towards the axis of the hand.

In disarticulation of *the middle fingers* (middle and ring) the scar will be protected by the adjoining fingers, and a symmetrical racket may therefore be made.

The easiest method is to *make a circular transverse incision at the level of the digitopalmar fold, and a median dorsal slit, which reaches from a quarter of an inch above the line of the joint to where it joins the first incision* (*Fig.* 246). A little palmar pocket is thus formed, about three-quarters of an inch below the head of the bone, and two little rectangular lateral flaps (the corners of which are easily rounded by an expert operator).

Fig. 246.

In disarticulating an end finger (index or little finger), *a flap must be cut which is external to the axis of the hand* (or excentric, if the word is preferred), in order that the scar may be placed on the dorsum of the hand, near the adjacent sound finger which will form henceforth the border of the hand.

The incision commences therefore at the excentric border of the extensor tendon, on a level with the line of the joint, and follows this tendon longitudinally half-way down the proximal phalanx, or even a little farther, where a rounded corner is cut. It then crosses the lateral surface of the phalanx and passes obliquely over the palmar surface as far as the commissure, where it ends, still remaining on the finger that is to be removed. The palmar part of the incision, therefore, is a rectilinear one, passing obliquely upwards and inwards (in relation to the axis of the hand), a direction inverse to that of the digito-palmar fold, which it joins obliquely at the level of the commissure.

The dorsal and palmar ends of the flap are united by a *straight incision passing from the level of the commissure upwards* (an experienced operator makes it slightly convex inwards).

The above description applies equally to *disarticulation of the toes* ; disarticulation of the great toe will however be described separately.

The general rules for planning the flaps in disarticulation of end fingers and end toes are the same.

Principal Steps of the Operation: (1) Division of the skin; (2) Dissection of the flap or flaps; (3) Section of the flexor tendon about half-way down the phalanx; (4) Disarticulation, leaving the glenoid cartilage in the flap.

An ordinary scalpel is used.

DIVISION OF THE SKIN FOR A MIDDLE FINGER.

The assistant, placed on the outer side, grasps the two borders of the hand, thumb above, fingers below, in order to flex and separate the patient's ring and index fingers, while with the thumbs he stretches the dorsal skin. At the same time he raises the hand to a convenient level for the operator, and presents it vertically and pronated, the palmar surface forwards.

Fig. 247.

Division of the palmar skin and the flexor tendon.—The surgeon, taking in his left hand the end of the finger, holds it in the air, rather like a pen-filler, in order to expose clearly the digito-palmar fold. The assistant keeps the adjoining fingers out of the way by flexing them at a right angle to the metacarpus. In this position the centre of the blade of the scalpel, held flat to the dorsum of index and ring fingers, is applied to the digitopalmar fold (*Fig.* 247), and is made to cut deeply by drawing it from left to right, the movement ceasing only when a sudden hyperextension of the finger shows that the flexor tendon is completely divided (*Fig.* 248). If the lips of the bony groove in which the tendon lies project, the deeper fibres will probably have escaped division, and this must be completed by raising the handle of the knife so that the point reaches the remaining strands of the tendon at the bottom of the groove (*Fig.* 249).

Fig. 248.

The finger is next brought back from hyperextension to the vertical position, and *the skin is freed in front of the articulation* by passing about an inch of the blade on the flat against the bone, handle above, and cutting from the left to the right side of the finger in a semicircle (*Fig.* 298).

Hand and finger are then lowered until horizontal, *and the dorsal half of the circle* is made by cutting transversely from left to right across the dorsum of the finger, from one commissure to the other (*Fig.* 250). Then, with the finger flexed to stretch the skin, the median dorsal slit is drawn (*Fig.* 251), and the little angular flap thus made on either side is taken between index finger and thumb and carefully freed. The joint is now accessibie from every side, and can easily be disarticulated. The manipulations requisite for this are the same for any finger, and will be found on page 157.

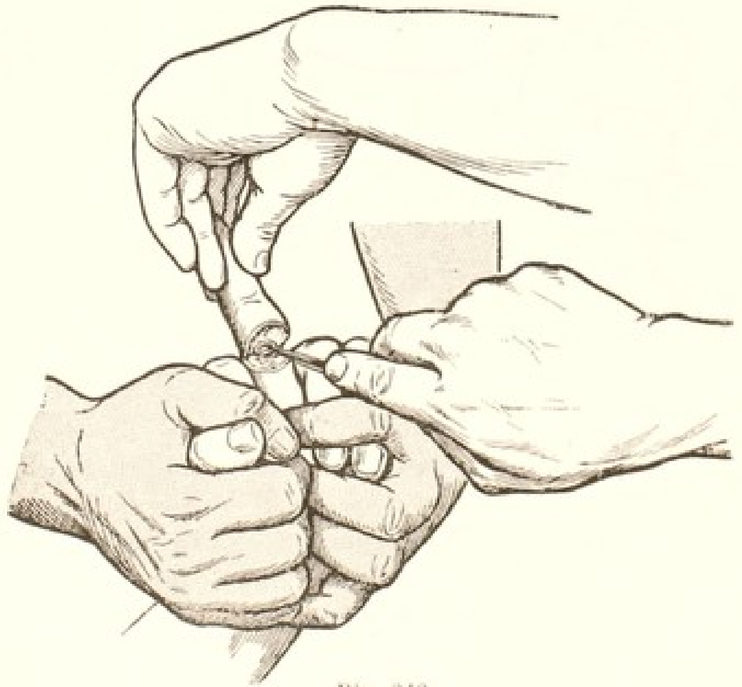


Fig. 249.

CUTTING A FLAP FOR AN END FINGER.

Figs. 246–251 show the circular method with a dorsal slit. In making *a symmetrical racket*, it will readily be understood that the line of incision is the same, but with rounded angles. The division of the skin in this case is commenced on the dorsal surface, turning thence to the right over that commissure and along the digitopalmar

Fig. 250.

fold. A *second stroke*, made by reversing, divides the left commissure. I have thought it unnecessary to show this incision (which is similar to that for the third metacarpal bone shown in *Figs.* 295 and 296), because the different steps can be understood by reference to the figures for the same operation on an *end finger*, when an *asymmetrical*

Fig. 251.

racket incision is made with an eccentric palmar flap. The general rules for this procedure must now be described; they are the same for both metacarpal and metatarsal disarticulations.

The chief rule is so to arrange the movements that *the flap can be cut without interruption by drawing the knife from left to right.*

When the hand is presented in pronation, the *right index finger* or the *left little finger* will be to the operator's right. If he takes one of these fingers horizontally in his left hand, he can draw the knife towards him along the back of the phalanx, turn, without interruption, towards the side which lies to his right, and then cross the palm obliquely to join the outer digital commissure while he raises the finger before him.

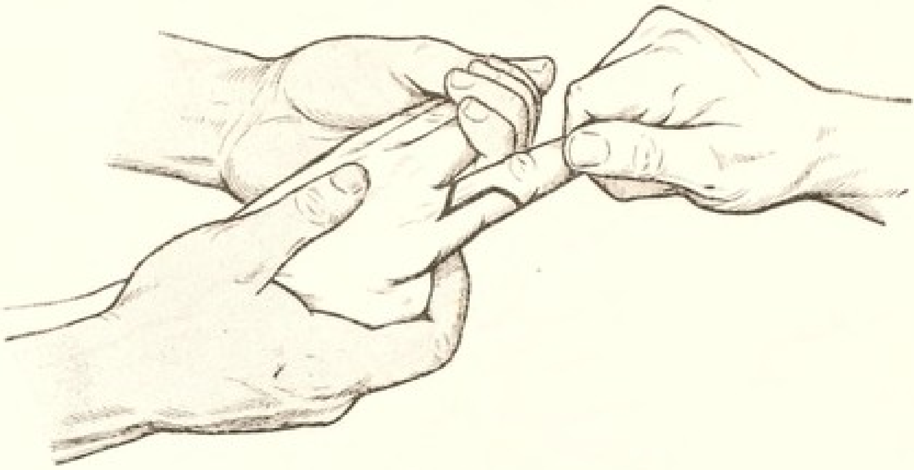


Fig. 252.

Returning to the back of the hand, the incision is completed by a second stroke made by reversing from the palm towards the dorsum.

But in the case of the *left index finger* or the *right little finger* the incision must be commenced *with the hands crossed.* Seizing the end of the finger in his flexed and pronated left hand, the surgeon passes

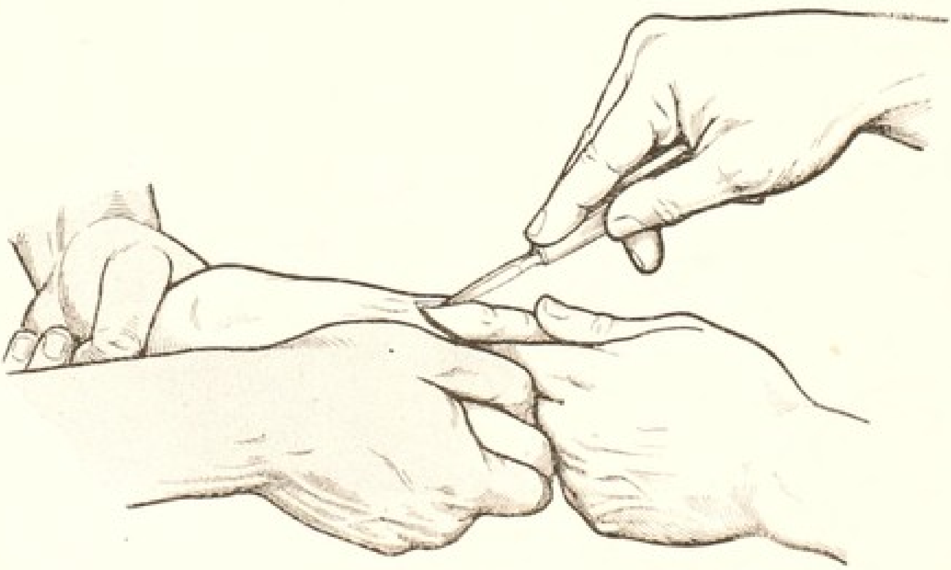


Fig. 253.

the scalpel under this hand, and is thus enabled, without interruption, to draw an incision along the dorsum, turn, then, raising the finger, to cross the palmar surface obliquely. The commissure is next divided by drawing a second incision from the dorsum to the palm.

Left Little Finger.—The finger being held extended at the level of the distal phalanx between the operator's index and thumb, the assistant separates the other fingers downwards and holds the ulnar surface of the hand above, while the operator pierces the skin at the level of the joint over the extensor tendon, and *draws* his knife along the tendon to a point half-way down the proximal phalanx (*Fig.* 253). At this point the corner is turned, and the palm is then crossed, as will be described for the left index finger (*Figs.* 255 and 256).

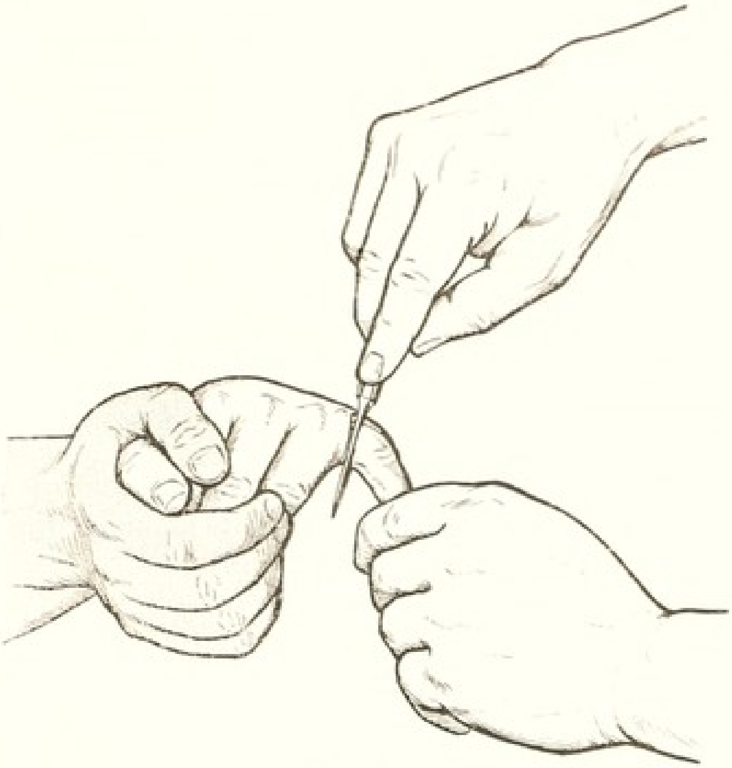


Fig. 254.

Fig. 254 shows how the commissure is divided by a *second incision* made in the reverse direction with the full blade from the palmar to the dorsal surface, the operator stretching the skin by bending the flexed finger towards his right and twisting it slightly to the left.

Left Index Finger.—In order *properly to cut the flap, the hands must be crossed* at the commencement of the operation, the right under the fully flexed and pronated left hand, which grasps the distal phalanx. The finger being raised to the erect position, the first incision is drawn along the extensor tendon, as just described. From *Figs.* 255 and 256 it will be seen how, after reaching half-way down the proximal phalanx, the finger is raised little by little, while the knife turns the outer corner and passes to the palm exposed by the manipulations.

Fig. 255.

The finger is now replaced in a horizontal position, and the *second incision* is made by drawing the knife from the dorsal to the palmar surface (*Fig.* 257).

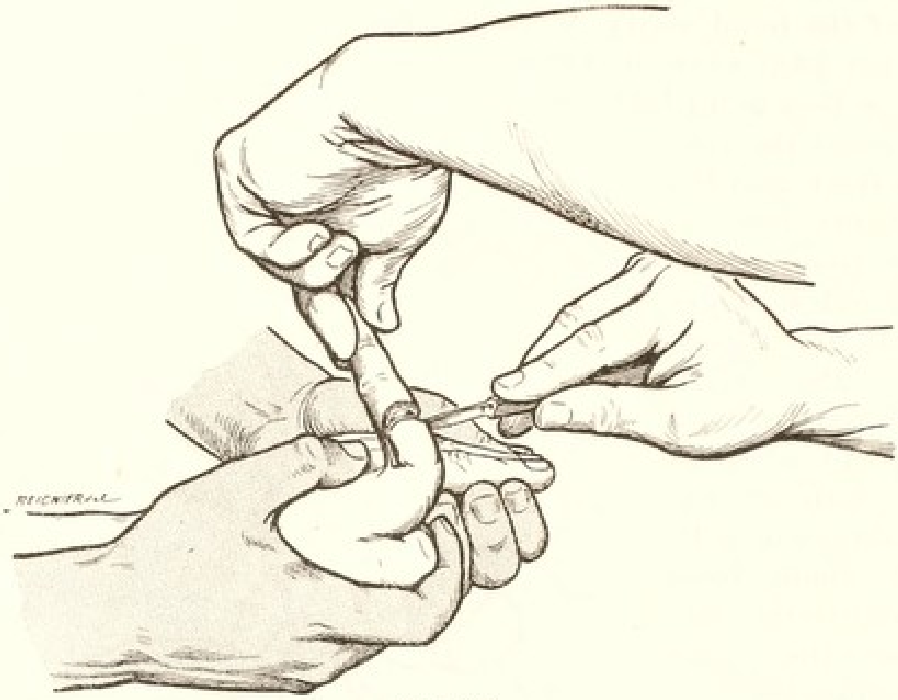


Fig. 256.

Fig. 257.

Fig. 258.

The next step is to liberate on all sides the lips of the skin incision, then *to dissect the flap* as far as the palmar surface of the articulation ; this is done by entrusting the finger to an assistant, who *holds it in the normal position* (extension makes the head of the bone project towards the palm) ; the operator then grasps the edge of the flap between thumb and index finger, and shaves the bone with the flat of his scapel, held like a pen (*Fig.* 258).

DISARTICULATION OF A FINGER.

After the skin has been divided and freed, and section of the flexor tendon has been completed, the method of disarticulation is always

Fig. 259.

Fig. 260.

the same. The hand is presented pronated and in a horizontal position to the surgeon, who takes the finger in his left hand at the level of the first interphalangeal joint and pulls on it, so separating the articular surfaces. He then inserts half an inch of the point (not more, or it may perforate the palm) on the flat against the left side of the phalanx, the blade vertical, edge towards the wrist (*Fig.* 259), and reverses until the tubercle at the base of the phalanx is reached. Round this the knife is passed, and a line of non-resistance can then be felt. The blade is now turned through a right-angle, and cuts with little sawing movements towards the right. In this manner the left lateral ligament is divided, and in a single stroke, with the blade still vertical, the line of the joint is traversed from left to right, dividing at the same time the fibrous sheet formed by the dorsal ligament and extensor tendons (*Fig.* 260). It is necessary to fix the tendon by pressing with the left thumb against its right border, otherwise it may escape before the knife. When the right lateral ligament has been divided, the little vertical and transverse sawing movements are stopped, and without removing the scalpel from the wound, the finger is twisted with the left hand from

Fig. 261.

right to left (*Fig.* 261); the only ligaments which still hold are those on the palmar surface (glenoid ligament and sheath of the flexor tendons), and these are brought upwards by gradually increasing torsion until the palmar surface becomes uppermost and they can be divided, close to the palmar surface of the phalanx, with little strokes of the point of the knife drawn from left to right.

This method of twisting the finger in one direction while the knife cuts in the other should be carried out most carefully, as it is very important for the teaching of general surgical technique.

DISARTICULATION OF THE THUMB.

Anatomy.—The metacarpo-phalangeal joint of the thumb follows the type of interphalangeal articulations, and the trochlear surface in which the first metacarpal ends (the general shape of which bone is that of a phalanx) takes very clearly the bicondylar form, with marked projections towards the palmar surface. The glenoid cartilage attached to the palmar border of the upper surface of the phalanx is very well developed, and always contains two sesamoid bones, internal and external, into which the muscles of the thenar eminence are inserted. The lateral ligaments are also attached to the sesamoid bones, as they pass over them, by a deep fasciculus, the metacarpo-sesamoid ligament; the internal ligament is the stronger, and the internal sesamoid bone the larger.

Examination.—*The transverse line of the joint* is not hidden in the palm as in the case of the other fingers, but corresponds to the root of the thumb at the level of the metacarpo-phalangeal fold.

To feel the line of the joint, the articular swelling must be pinched from above downwards between the thumb and index finger of one hand, while the other hand holds the distal phalanx in extension and

Fig. 262.

imparts little movements to the thumb. The nails then slip into the grooves of the joint at the sides of the thumb (*Fig.* 262).

Line of Incision.—A *palmar flap* must be made, so that the cicatrix will be on the dorsal surface. The line of incision is an ellipse (or perhaps more like a pessary with U-shaped ends) of which the uppermost point is on the dorsum of the thumb, 2 or 3 millimetres below the line of the joint (which can be marked with the operator's thumb-nail), and the lowest point is on the palmar surface, 2 or 3 millimetres below the interphalangeal fold. The edges of the line run along the middle (or rather nearer the dorsum) of the corresponding lateral surfaces of the phalanx. A little hood is thus formed which covers the lower extremity and lateral projections of the head of the metacarpal bone (*Fig.* 263).

The *assistant* holds the forearm with one hand in semipronation, and with the other holds the four fingers, which are flexed and pressed downwards away from the thumb.

Division of the Skin.—The operator seizes the distal phalanx with his pronated left hand, and twists it rightwards in order to see to the

Fig. 263.

Fig. 264.

left. Commencing as far to the left as possible (*Fig.* 264), he incises the skin on the palmar surface transversely, turns on the point of his knife at the left lower angle of the flap, and reverses along the lateral surface as far as the left upper angle, all the time moving his left hand correspondingly, untwisting from right to left, so that the

Fig. 265.

thumb is in the normal position and the hand in semipronation when the dorsal surface is reached. He crosses this transversely (*Fig.* 265); then holding the thumb to the left, and twisting leftwards in order

Fig. 266.

to see to the right, he turns, and draws a longitudinal incision along this lateral surface. Finally he turns again, to the right of the interphalangeal fold, and rejoins the palmar incision (*Fig.* 266).

Dissection of the Flap (*Fig.* 267).—The thumb should be entrusted to an assistant, who, taking it between his own thumb (above) and index finger, holds it vertical and slightly extended. The surgeon now takes the palmar flap between thumb and index finger, and dissects it upwards to the level of the joint, working from left to right and from above downwards, as the thumb is placed.

Fig. 267.

The flexor tendon must be divided (*Fig.* 268) about the middle of the phalanx, the blade perpendicular to the bone, while pressure from the assistant's finger keeps the joint extended and the tendon stretched.

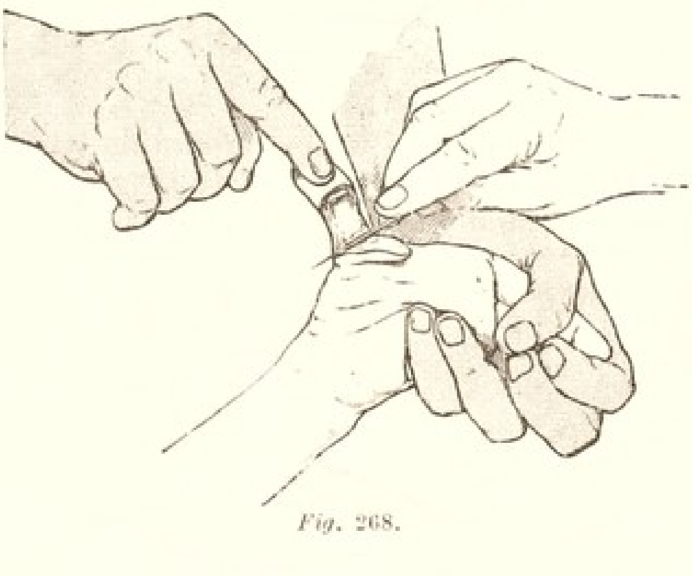


Fig. 268.

Disarticulation.—This is carried out as with the middle finger (p. 157); the assistant retracts the skin while the surgeon crosses the joint transversely from left to right, the bony surfaces being held apart by traction on the finger. Finally, in order to leave in the flap the glenoid cartilage and sesamoid bones, the knife is brought out after shaving with short strokes of the point the palmar border of the upper surface of the phalanx, which is strongly twisted to the left.

DISARTICULATION OF A FINGER WITH ITS METACARPAL.

There are a few *general rules* for this operation, and the same apply, for the most part, to operations on the metatarsals as well.

The *type of incision* is the *racket*, the ring of which surrounds the root of the finger to be removed at the level of the interdigital commissure, while the handle stretches over the back of the metacarpal bone. The handle may end in a straight line, or may curve backwards over the border of the hand or foot (5th metacarpal, 1st metatarsal). For a middle finger the racket is symmetrical; for an end finger it is arranged to give a palmar, excentric flap, for the same reasons as those given on page 153.

Principal Steps.—After division of the skin and the extensor tendons, the principal steps of the operation are :—

1. *Freeing the palmar skin* as far as the head of the metacarpal bone.

2. *Separation of the metacarpal bone from the muscles which are attached to it.* This is done by *shaving the bone* with the knife, to save the muscles as far as possible and to avoid injury to the adjacent arteries. The metacarpal and metatarsal bones are shaped like a rod with flattened sides, and terminate in a head, the posterior part of which is nearly in line with the dorsal surface, while the 'chin' projects towards the palm. The heads of the bones are united by the *transverse intermetacarpal ligament*, which is continuous with the palmar portion of the capsular ligament and with the sheaths of the flexor tendons. It is always necessary to begin by dividing this ligament with the point of the scalpel, held vertically and cutting longitudinally, and an incision is next made transversely, under the 'chin' of the bone, with the blade perpendicular to the bone; *cutting the throat of the head*, so to speak, which has been already cleared on the palmar surface as well as the sides. It is then easy to pass in succession along each side of the metacarpal between bone and muscles (thenar, hypothenar, or interosseous), *from the distal end towards the proximal, and from left to right.* Except then for a special manœuvre which will be described for the first metacarpal, the rule is to *keep the end of the limb to the left during the enucleation.*

DISARTICULATION OF THE FIRST METACARPAL.

Anatomy.—The line of the trapezometacarpal joint is concave downwards on the dorsal surface, and its general direction is oblique, running downwards and inwards. The slight anteroposterior convexity of this saddle-shaped articulation is negligible.

The capsule is thin and weak, but a ligament is formed by the tendon of extensor ossis metacarpi pollicis, which is inserted into the external tubercle of the metacarpal bone to the outer side and behind.

The palmar surface of the metacarpal is flat (like a phalanx); it faces inwards, and is padded by the prominent muscles of the thenar eminence. The dorsal and external surface is superficial, separated from the skin by the tendons of extensor primi internodii and extensor ossis metacarpi pollicis externally, and extensor secundi internodii pollicis internally. These tendons diverge above to take up their position against the styloid process of the radius, leaving between them the anatomical snuff-box (*see* p. 17).

The radial artery crosses the snuff-box (*see Fig.* 22, p. 18) in close contact with the inner side of the capsule of the joint.

On the palmar surface at the root of the thumb *two folds of skin* are to be seen: the *fold of flexion*, which nearly corresponds with the line of the metacarpo-phalangeal joint, and to the inner side and above, the *fold of opposition*.

To find the line of the trapezo-metacarpal joint.—This can be done by pinching the articular swelling from below upwards; the external tubercle of the first metacarpal bone is then felt, and just above it runs the line of the joint. But it is more convenient to palpate the joint from above downwards (*Fig.* 269), pinching the base of the metacarpal bone between thumb and index finger of one hand while the patient's thumb is moved by the other. The level where the bone should be nipped is indicated by the upper extremity of the first interosseous space. In adduction the metacarpal bone projects on the outer side; in abduction the trapezium projects on the dorsal surface: the line of the joint is to be found between these two projections. If the snuff-box is palpated from above downwards, the trapezium is found about half an inch above the joint.

Fig. 269.

Line of Incision.—*A racket incision with a straight handle* should be used. Starting half an inch above the articulation (about one finger-breadth below the tip of the styloid process), over the tendon of extensor primi internodii pollicis, it follows this tendon along the dorso-external surface for rather more than an inch. The line then bends and runs downwards, half an inch below the fold of opposition, crossing the palm transversely to the point where the folds of flexion and opposition meet; it then passes symmetrically over the inner surface of the metacarpal bone to rejoin the handle of the racket (*Fig.* 270).

Fig. 270.

Fig. 271.

Division of the Skin.—Standing outside the limb, the assistant fixes the forearm with his left hand, and with his right grasps the ulnar border of the hand, his thumb and thenar eminence stretching the skin on the dorsal surface, while his fingers hold the patient's fingers flexed and out of the way. The hand is held horizontally, thumb uppermost.

Standing at the extremity of the limb, the operator seizes the thumb in his left hand, and passing the knife over it, pierces the skin at the upper extremity of the racket over the outer tendon of the snuff-box (*Fig.* 271); he draws the knife, turns at the right side of the head of the metacarpal bone (*Fig.* 272), and continues over the palm as far as possible towards the left (*Fig.* 273), exposing the palmar surface by bending back the thumb and supinating the hand.

Fig. 272.

Fig. 273.

Fig. 274.

Fig. 275.

Replacing the hand in pronation, and carrying the flexed thumb to the right, a second incision is now made by reversing, cutting the stretched commissure with the whole blade, the right hand fully extended and pronated (*Fig.* 274).

It will often happen that the extensor tendons have already been divided as they were lying stretched over the bone; if this has not occurred, they should now be divided by transfixion, the edge of the knife away from the operator (*Fig.* 275).

Division of the Muscles of the Palm.—Raising the thumb again, the head of the metacarpal bone must first be freed with one or two strokes of the knife on the flat round the bone from left to right and close to it. At the same time the thumb is kept raised, and carried alternately to the right and left to expose the surfaces as required; this process is discontinued when the red muscle mass under the articulation comes into view.

The operator next seizes the distal phalanx of the thumb from above in his pronated hand, holding it like a pen-filler, and raises it.

Fig. 276.

Fig. 277.

Fig. 278.

He carries the thumb to the right, and then thrusts about half an inch of the point on the flat under the palmar surface of the metacarpal bone, and draws the knife from left to right, sawing all the time, until arrested by the sesamoid bones (*Fig.* 276).

The thumb must now be held quite straight, neither adducted nor abducted, while the blade, applied on the flat, perpendicular to the bone below the sesamoid bones, cuts the throat of the metacarpal, so to speak, from left to right, until the edge reaches the bone. It should be remembered that the tough flexor tendon has to be divided in this stroke (*Fig.* 277).

When this section has been completed, it is easy to shave the right side of the metacarpal by reversing, the right hand flexed and pronated, the left raising the thumb and carrying it to the left (*Fig.* 278).

Disarticulation is completed (*Figs.* 279, 280) just as in the case of the middle finger, described on page 157.

Fig. 279.

Fig. 280.

DISARTICULATION OF THE FIFTH METACARPAL.

Anatomy.—The upper extremity of the 5th metacarpal bone articulates: (1) By its base, with the inner half of the unciform bone; (2) By its outer surface, with the 4th metacarpal.

1. *The unci-metacarpal articulation* is slightly saddle-shaped, the surface of the unciform being somewhat convex transversely and concave from before backwards. Seen from the dorsal surface, therefore, *the line of the joint* is slightly concave upwards, but from the operator's point of view it may be considered flat. It runs obliquely downwards and outwards from a point on the ulnar border of the hand 4 or 5 millimetres above the postero-internal tubercle of the 5th metacarpal bone.

The unci-metacarpal ligaments proper are weak; but the union of the bones is made secure anteriorly by the pisi-metacarpal ligament, a prolongation of the tendon of flexor carpi ulnaris; and behind and to the inner side by the tendon of extensor carpi ulnaris, which is inserted into the postero-internal tubercle.

2. *The intermetacarpal articulation* is a plane surface running obliquely upwards and outwards; with the wrist flexed, the line of this joint is directed from the upper extremity of the interosseous space towards the tip of the styloid process of the radius. It is supported by strong fibrous bands on the palmar surface.

Examination.—When the pronated hand is held straight, in a horizontal position, the projection formed by the *head of the ulna* is seen on the back of the wrist; if this is nipped between thumb and index finger, a depression will be noticed below it, about half an inch broad; lower down a bony mass is felt, formed by the superimposed cuneiform and pisiform bones. In the palm, at the internal border of the hand, the pisiform marks the root of the fleshy mass forming the hypothenar eminence. On the dorsum of the hand the surface of the cuneiform bone is continuous with the superficial dorsal surfaces of the unciform and the 5th metacarpal, to the outer side of which runs the extensor tendon. If the inner border of the hand is followed from below upwards, the finger is arrested by the projecting postero-internal tubercle of the fifth metacarpal, about half an inch below the pisi-cuneiform mass and about one inch below the head of the ulna (*Fig.* 281).

If the finger is now alternately adducted and abducted, the upper end of the metacarpal can be felt to move a little, and the line of the joint can easily be marked with the finger-nail.

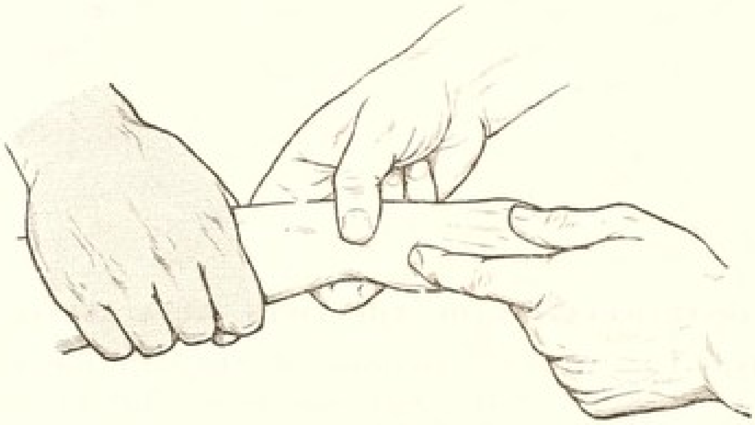


Fig. 281.

Line of Incision.—The incision is *racket-shaped, with the end of the handle curved forwards and the ring asymmetrical in order to form a flap shaped suitably for an end finger.*

It commences at the ulnar border of the hand, over the line of the joint (4 to 5 millimetres, therefore, above the tubercle of the 5th metacarpal bone), at the point where the fleshy mass in front reaches the bone, and it runs transversely outwards for rather more than half an inch. Over the dorsum of the metacarpal bone it turns in a rounded right angle, and continues straight along the inner border of the extensor tendon as far as half-way down the proximal phalanx. It then bends sharply on the inner surface of the phalanx, and crosses the palm obliquely to the interdigital commissure. The outer shoulder of the racket runs in a straight line from the commissure (over the finger to be removed) to rejoin the dorsal incision about an inch above the metacarpo-phalangeal articulation (*Fig.* 282).

The assistant stands on the outer side of the limb, and presents it with the forearm vertical and semipronated, the elbow flexed at a right-angle and resting on the table. With one hand he holds the middle of the forearm, with the other he grasps, and drags towards him, the three outer fingers.

Division of the Skin.—Stand facing the ulnar border of the hand, in front if it is the left hand (*Fig.* 282), behind if it is the right (*Fig.* 286). Hold the finger by the distal phalanx, as if it were a pen-filler; twist it a little to expose the palmar surface, and start from this surface, piercing the skin with the point of the knife at the commissural end

Fig. 282.

Fig. 283.

Fig. 284.

of the flap (*Fig.* 282, left ; *Fig.* 286, right). After crossing the palm in an oblique direction, the inverse to that of the digitopalmar fold, turn on the point over the side of the phalanx half an inch from this fold, and draw the knife from above downwards and from left to right over the back of the metacarpal (*Fig.* 283) ; then bend the tail of the incision towards the ulnar border at the level of the articulation, drawing on the left side (*Fig.* 284), reversing on the right. On both sides the *second commissural incision* is made similarly, by drawing the full blade from the palmar to the dorsal surface of the finger to be removed, the skin being kept tense by separating the finger from its fellows (*Figs.* 285 and 287).

Fig. 285.

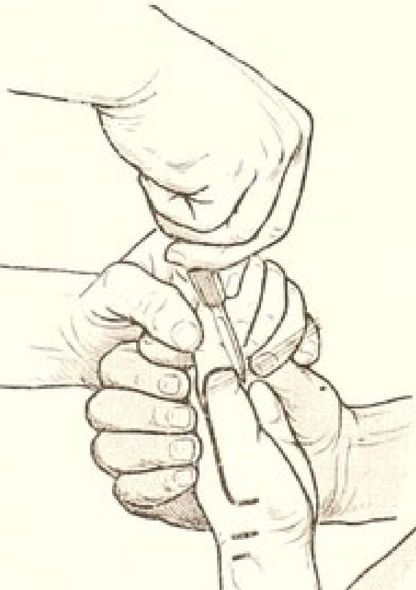


Fig. 286.

Fig. 287.

Clearing the Metacarpal Bone.—Entrust the finger to the assistant, who should hold it vertically, without hyperextension (in *Fig.* 288 the finger is shown in hyperextension in order better to display the field of operation, and moreover it represents the stage reached after the head of the metacarpal has been rounded, when this position is not disadvantageous), and commence by dissecting the palmar flap, from the distal end towards the proximal, holding the skin between

Fig. 288.

Fig. 289.

Fig. 290.

the left thumb and index finger, shaving the inner and lower surface of the phalanx, then the head of the metacarpal bone, with your scalpel held, according to taste, like a pen or a knife. When the red palmar muscles are seen appearing under the head, turn the knife through a right-angle and 'cut the throat' of the metacarpal; then follow the palmar surface of the bone from end to end (*Fig.* 288, right, starting beneath the head), shaving it closely for two or three strokes, and taking care at each stroke to divide the muscles right to the level of the curved tail of the wound (*Fig.* 289, left); otherwise the flap does not open sufficiently, and it is difficult to find the joint.

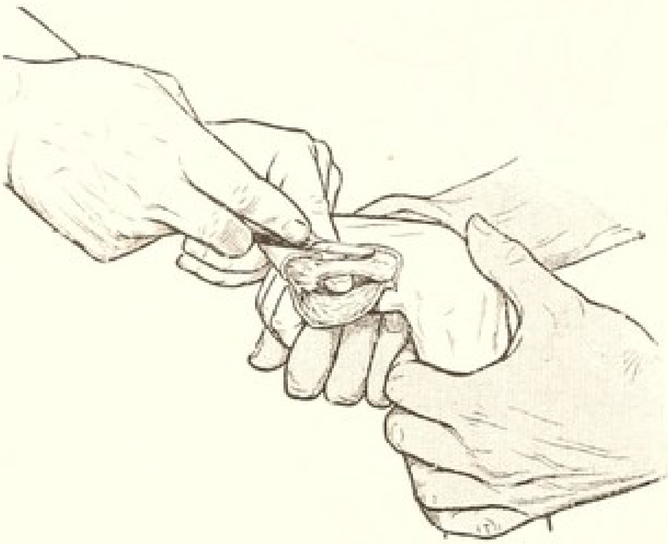


Fig. 291.

Fig. 292.

Fig. 293.

When this flap has been dissected up, the *interosseous surface of the metacarpal bone is next freed* by passing the knife along it from above downwards while the bones are held apart with a finger (thumb on the right side, *Fig.* 290; index finger on the left), slipped like a wedge between the heads of the 4th and 5th metacarpals as soon as the intermetacarpal ligament has been divided. By this means also the line of the intermetacarpal joint is made to gape, and the point of the knife can be passed into it when it has reached the base of the denuded bone.

Disarticulation.—The main joint is to be entered through the intermetacarpal joint, the obliquity of which must always be borne in mind. Direct the assistant therefore to flex the wrist to a right angle, and then—

A.—On the right side. Holding the knife in your right hand in extreme pronation, the edge towards you, pass half an inch of the point into the intermetacarpal joint at the upper extremity of the interosseous space, held apart as described (*Fig.* 290), aiming the blade at the tip of the styloid process of the radius.

As soon as the knife is felt to be engaged between the two bones and arrested by contact with the unciform, bring the flexed right hand forwards and downwards, so making the edge bite from below upwards, while the left hand twists the finger and dislocates it towards the ulnar border (*Fig.* 292). By this double movement the interosseous ligament almost may be said to divide itself, and the bone remains held by the tendon of the extensor carpi ulnaris alone. Apply the scalpel with the edge upwards and forwards over the dorsum of the hand, close to the metacarpal bone, which is now hanging; press the metacarpal towards the hand, back to back, and cut from below upwards the tendon beneath which the knife is now lying (*Fig.* 293).

B.—Left side. If the forearm is inclined towards the operator, the dorsum of the flexed wrist is placed horizontally, and he is in a position to enter the joint, with the edge of the knife away from him, by aiming at the styloid process of the radius, while with the left hand he dislocates and twists the finger (*Fig.* 291). This neat but delicate manœuvre may be avoided by taking the scalpel in hand like a pen, and moving to the outer side of the limb by a short step to the right. The operator then enters the joint as on the right side, shaving the bone, with the point held vertically and aimed towards the styloid process of the radius.

While carrying out this step the assistant retracts the skin, with a hook if needful.

DISARTICULATION OF THE THIRD METACARPAL.

Anatomy.—The upper extremity of the 3rd metacarpal bone articulates: (1) At its base, with the os magnum; (2) On either side, with the 2nd and 4th metacarpals respectively.

1. *The dorsal line of the carpometacarpal joint* is half an inch wide; in its inner two-thirds it is straight and transverse, on the outer side it is raised by the projection, 5 millimetres long, of the styloid process, into which is inserted the extenso carpi radialis brevior. It is joined perpendicularly at either end by—

2. *The vertical lines of the intermetacarpal articulations,* 5 millimetres deep. These joints are very narrow, and will hardly admit the point of a scalpel. On the dorsal surface they are both straight; the internal (4th metacarpal) remains flat throughout; but the outer (2nd metacarpal) is concave outwards, so that to enter it from the back of the hand the scalpel should first, and for the third of an inch, be directed obliquely downwards and inwards, then, in the palmar half, downwards and outwards.

The most powerful *ligaments* are on the palmar surface, where the crest of the third metacarpal is the meeting place of various intermetacarpal and interosseous fibres; but the union with the os magnum is weak.

The *deep palmar arch* lies about half an inch below the carpometacarpal articulation; it is separated from the bone by the palmar interosseous muscles only.

Fig. 294.

Examination.—The dorsal surface of the metacarpal bone should be followed from below upwards with the pulp of the index finger, and at its upper extremity the carpometacarpal depression and the styloid process are readily felt (*Fig.* 294).

Line of Incision.—The incision is a *symmetrical racket*, of which the handle commences half an inch above the line of the joint, while the ring passes over the sides of the head of the metacarpal and of the proximal phalanx, and crosses the palm in the digitopalmar fold (*Fig.* 295).

Fig. 295.

Fig. 296.

The assistant, standing on the outer side of the limb, grasps the borders of the hand longitudinally, thumbs uppermost, and flexes the patient's fingers in the palm to the maximum extent, excepting the middle finger, which remains free and projecting forwards. The skin on the whole dorsum of the hand is stretched between the thenar eminences of the assistant, and the hand is presented horizontally in pronation.

Division of the Skin.—Facing the patient, the surgeon seizes the finger, with his thumb above, at the level of the first interphalangeal joint, and pierces the skin at the upper extremity of the racket with the point of the knife, handle above (*Fig.* 295).

Dropping the handle of the knife, he then draws an incision along the handle of the racket, turns at the right shoulder, and passes transversely over the digito-palmar fold, blade horizontal, edge upwards, extending the incision as far to the left as possible, and crossing the hands at the finish to end with the point. The flexion of the fingers to a right-angle allows the knife to pass over the palmar surface without interruption (*Fig.* 296).

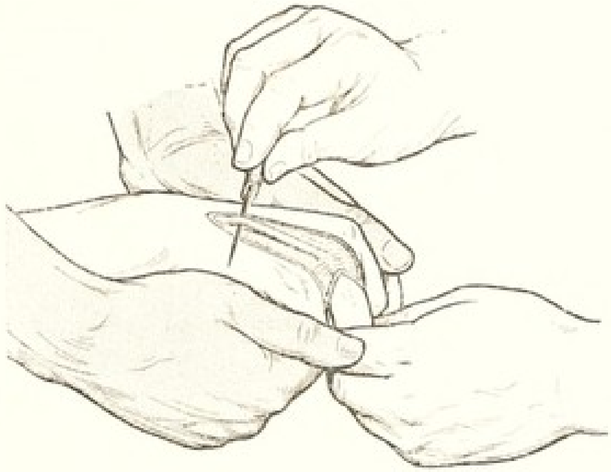


Fig. 297.

The left shoulder of the racket is made by a second incision, reversing, from heel to point of the knife, over the interdigital commissure while the finger is flexed and twisted to right left (*see Fig.* 274).

After freeing the dorsal skin, the extensor tendon is divided, either directly or by transfixion (*Fig.* 297), as high up as possible, while it is held tense by flexion of the finger.

Fig. 298.

Then, with his left hand holding the finger vertically from above by the distal phalanx, the operator shaves the bone from left to right with his blade flat to the bone (nearly vertical therefore), and in one stroke, or several, he carefully frees the phalanx from its attachments on the palmar aspect as far as the head of the metacarpal bone (*Fig.* 298). Without changing position he then performs what has been called 'the Liston stroke.'

Clearing the Bone by the Liston Stroke.—The finger being raised, hyperextended, and carried to the right, a *preliminary incision* is drawn along the left side of the bone, the right hand passing under the left; the incision is not ended until the ligament between the heads of the metacarpal bones has been completely divided (*Fig.* 299).

Fig. 299.

Now carrying the finger to the left, a *second incision* is drawn in the same way along the right side of the metacarpal bone, commencing as high up as possible, and again continuing until the intermetacarpal ligament on this side also has been completely divided (*Fig.* 300).

To follow the contour of the anterior surface of the bone the blade is first applied, edge downwards, in the incision to the right of the bone, and the point is then passed under the right side of the palmar surface of the bone, the heel lying between the two heads (*Fig.* 301).

Fig. 300.

The finger is now raised, while the assistant presses on the dorsum of the hand, and the heel of the blade is turned until it can be brought horizontally under the head of the bone, shaving it closely. The movement is continued, the point remaining stationary, until the heel appears to the left of the head, leaving it completely clear (*Fig.* 302).

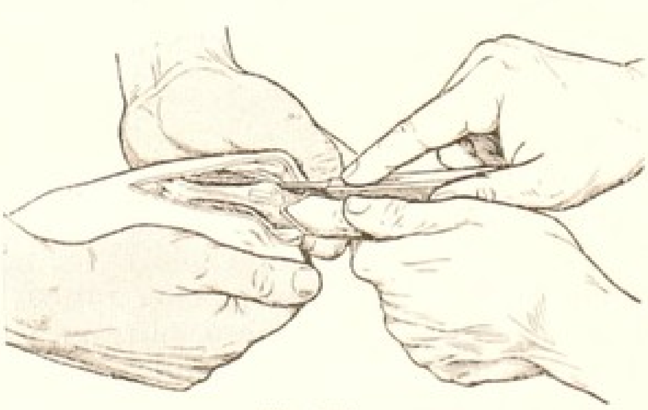


Fig. 301.

The heel of the blade is next brought back again a little to the operator's right, while at the same time, by raising the handle, the point is dropped slightly and passed under the palmar surface of the bone, reappearing as high as possible against the left side. The surgeon then draws the knife towards him, with sawing movements, dividing as he does so the tissues underneath the bone between the projecting point of the knife and the left side of the head of the metacarpal (*Fig.* 303).

Disarticulation. — The joint between the 3rd and 4th metacarpals must first be opened, because it is more easily done on that side; moreover, the joint between the 3rd and 2nd metacarpals can afterwards be made to gape and allow the passage of the knife more readily.

The 3rd and 4th metacarpals are therefore wedged apart with the left index finger (*Fig.* 304), and with the knife held in the right hand like a pen, one inch from the point, edge upwards, at an angle of 45°, the side of the 3rd metacarpal is shaved upwards, towards the wrist, until, at the apex of the interosseous space, the joint is opened. The surgeon now rests the tip of his middle finger against the back of the metacarpal bone, and pivoting around it raises the handle of the knife (*Fig.* 305). A little cracking sound announces that the palmar fibres of the interosseous ligament have been divided, and these are the only powerful fibres round the joint.

The 2nd and 3rd metacarpals are now in turn wedged apart with the index finger, and the procedure just described is repeated; this time in two steps. First, about a third of an

Fig. 302.

Fig. 303.

Fig. 304.

inch of the point is inserted from the dorsal surface (*Fig.* 306), then from the palm towards the dorsum rather less than an inch is inserted, and the handle is dropped so that the knife enters the palmar portion of the joint. The operator must not forget to incline the knife a little transversely in inverse directions when passing

Fig. 305.

Fig. 306.

through the two portions of the joint, for the first is directed obliquely downwards and inwards, and the second downwards and outwards (*Fig.* 308).

The metacarpal is now only held by the tendon of the extensor carpi radialis brevior. The assistant exercises pressure on the hand

Fig. 307.

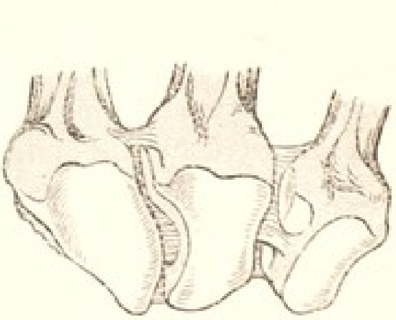


Fig. 308.

and holds it horizontal, while the operator applies his knife on the flat, over the handle of the racket, edge towards him; on to this edge the tendon is drawn by pulling the metacarpal bone backwards over the hand, dorsum to dorsum (*Fig.* 307); during this manipulation the few, weak, remaining fibres of the palmar ligament are also torn through.

DISARTICULATION OF THE WRIST.

Anatomy.—The bony surfaces in contact are: above, those of the bones of the forearm; below, those of the three first bones of the proximal row of carpal bones.

The forearm surface is concave transversely, and the posterior edge extends lower than the anterior; it is formed from without inwards by the internal surface of the styloid process of the radius, the horizontal portion of the lower extremity of the radius, and then, for about a third of its breadth, by the triangular cartilage over which the head of the ulna moves. In disarticulation, this cartilage should be left behind.

On the *carpal surface*, a semi-elliptical condyle is formed by the scaphoid, semilunar, and cuneiform bones.

At each border of the hand the entrance to the joint lies beneath the tip of the corresponding styloid process; the styloid process of the radius reaches about half an inch lower than the process on the ulnar side.

The horizontal level of the tip of the styloid process of the radius corresponds to the head of the os magnum on the dorsum of the hand, which is the highest point of the midcarpal joint, between the three bones of the proximal row and the four bones of the distal row (trapezium, trapezoid, os magnum, and unciform).

The anterior surfaces of all the bones which lie at the sides of the wrist are surmounted by projections on their outward margins. These bones are the scaphoid and trapezium outside, the cuneiform and unciform on the inner side. The projection of the cuneiform is surmounted and increased by the pisiform bone. A deep groove is thus formed on the front of the wrist, which is bridged over by the powerful *anterior annular ligament*, transforming the groove into the *carpal canal*, through which pass the flexor tendons and the median nerve. From the projecting bony and ligamentous margins of the canal the muscles of the thenar and hypothenar eminences take extensive origin; nearly in contact at the middle line, they diverge from above downwards. It is these muscles which form the fleshy heel of the hand, and between the two masses stretches the palmar fascia, in the form of a triangle, base downwards, below the annular ligament.

The *ligaments of the joint* consist of:—

1. *Two lateral ligaments*, passing from the corresponding styloid process above to the scaphoid on the outer side and to the cuneiform and pisiform on the inner side. They are superficial at the sides and posteriorly, and can be divided with certainty beneath the styloid processes.

2. *A posterior ligament*, running chiefly from radius to cuneiform bone, and covered only by the extensor tendons.

3. A strong *anterior ligament*, formed of fasciculi from the ulna and radius which descend towards the axis of the hand and cross obliquely over the os magnum, to which the majority of their fibres are attached. The radial ligament is a much stronger portion of the

anterior ligament which passes from the lower border of the radius to be attached firmly, by deep-seated fibres, to the semilunar bone.

Examination.—The wrist should be examined from the dorsum with the hand pronated, and it is best to begin by palpating *the styloid*

Fig. 309.

Fig. 310.

processes. With the patient's wrist extended, and supporting the palm on his three inner fingers, the surgeon passes the pulp of each index finger from below upwards along the corresponding border of the metacarpus until arrested by the projecting processes: above the anatomi-

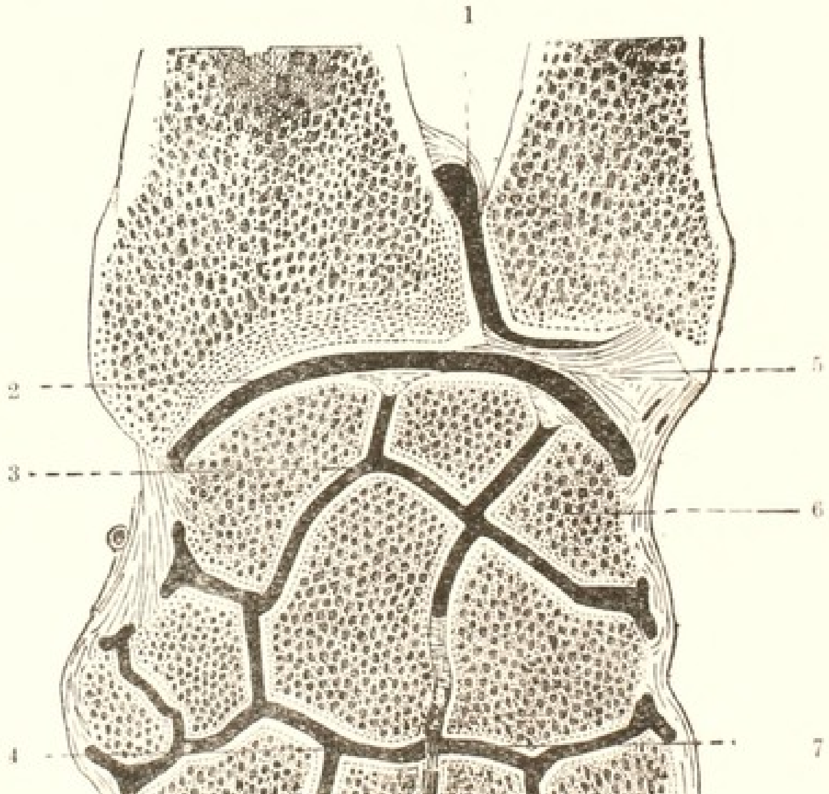


Fig. 311.—Coronal section through the radiocarpal, midcarpal, and carpometacarpal joints.

(1) Inferior radio-ulnar articulation; (2) Line of the radiocarpal joint; (3) Line of the midcarpal joint; (4) Line of the carpometacarpal joint; (5) Triangular cartilage; (6) Cuneiform bone; (7) Interosseous carpometacarpal ligament; (8) Intermetacarpal ligament.

cal snuff-box on the outer side, above the pisi-cuneiform mass on the inner side.

The index fingers remaining in place, marking therefore the two ends of the joint line, when the wrist is *extended*, or even in the normal position, the bones of the proximal row of the carpus disappear be-

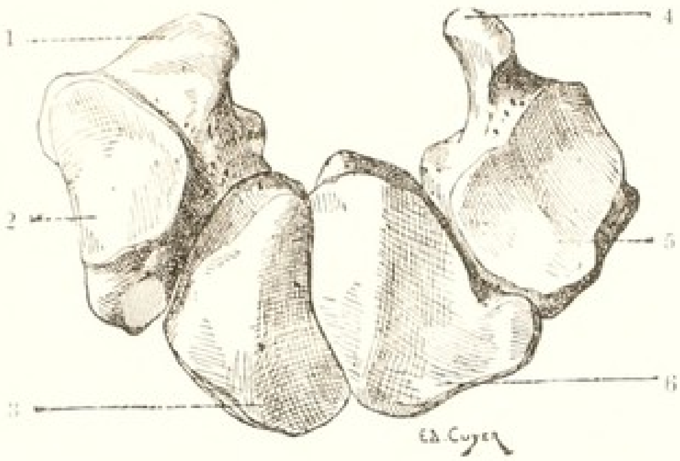


Fig. 312.—Carpal groove.

(1) Ridge of trapezium; (2) Trapezium; (3) Trapezoid; (4) Hook of unciform; (5) Unciform; (6) Os magnum.

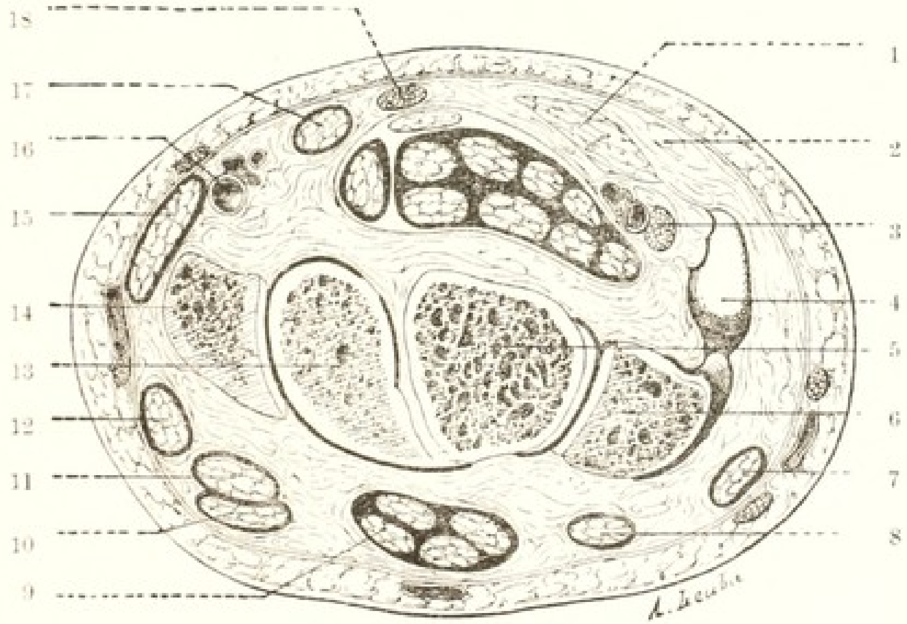


Fig. 313.—Transverse section through the wrist.

(1) Abductor minimi digiti; (2) Flexor carpi ulnaris; (3) Ulnar artery and nerve; (4) Pisiform; (5) Semilunar; (6) Cuneiform; (7) Extensor carpi ulnaris; (8) Extensor minimi digiti; (9) Extensor communis digitorum; (10) Extensor secundi internodii pollicis; (11) Extensor carpi radialis brevior; (12) Extensor carpi radialis longior; (13) Scaphoid; (14) Radius; (15) Extensor ossis metacarpi pollicis; (16) Radial artery; (17) Flexor carpi radialis; (18) Palmaris longus.

neath the posterior border of the radius, and it is the *midcarpal joint* (head of the os magnum) which lies in the line between the two fingers. In *flexion* of the wrist, on the other hand, the condyle formed by the proximal row of bones projects on the dorsal surface, and would be exposed by a transverse incision between the two fingers.

In the forearm the vertical line of the radio-ulnar articulation must also be noted ; it can be felt to move when the head of the ulna is grasped between thumb and index finger and pressed gently forwards and backwards.

In the palm, the upper border of the anterior annular ligament is shown by the *projection of the pisiform bone.* At this level, between the roots of the fleshy masses of the hand, and the forearm, a transverse cutaneous fold is noticed. When the wrist is extended, this

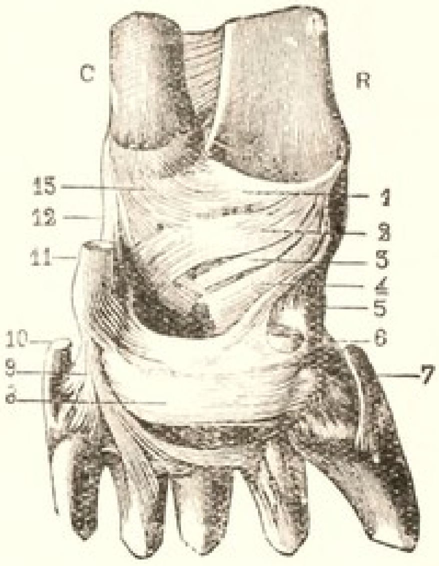


Fig. 314.—Anterior aspect of the left wrist-joint.

(C) Ulna ; (R) Radius ; (1, 2, 3, 4) Fibres of the anterior radiocarpal ligament ; (5) Very weak external lateral ligament ; (6) Tendon of flexor carpi radialis ; (7) Tendon of extensor ossis metacarpi pollicis ; (8) Anterior annular ligament ; (9) Pisimetacarpal ligaments, expansions from the tendon of flexor carpi ulnaris ; (10) Extensor carpi ulnaris ; (11) Flexor carpi ulnaris ; (12) Internal lateral ligament ; (13) Anterior radio-ulnar ligament.

line is about three-quarters of an inch below the line of the joint on the inner side, rather less than half an inch below on the outer side ; in flexion, the scaphoid and pisiform bones almost come into contact with the radio-ulnar margin.

The mid-line of the palmar skin is marked by a vertical fold.

Line of Incision.—The line for amputation by an *elliptical incision* is as follows :—

On the palmar surface (*Fig.* 316), exposed by supination, the line runs centrally from the edges of the hand near their dorsal surface, starting on the outer side a little below the first carpometacarpal joint, and on the inner side between the pisiform bone and the tubercle of the 5th metacarpal.

The length of the flap should be two good finger-breadths (three finger-breadths is too long) below the fold which marks, in flexion, the limit between the forearm and the lateral palmar eminences, and it should be symmetrical about the mid-line of the palm, marked in nearly all patients by a fold of the skin. It should be equal in breadth to the forearm, not to the hand ; so that starting from the edges at the points named, its radial border is traced by aiming at the outer side of the 2nd metacarpal bone, and its inner side by aiming at the commissure between the 4th and 5th metacarpals, rather more towards the 5th.

The angles of the flap should be rounded right-angles, and its two margins therefore must pass straight downwards almost to the line of the transverse portion.

On the dorsal surface (*Fig.* 315), the apex of the ellipse should be opposite the radio-ulnar articulation, half an inch below the joint, and not at the mid-point of the forearm. This point is united by a curved line with the two extremities of the palmar flap.

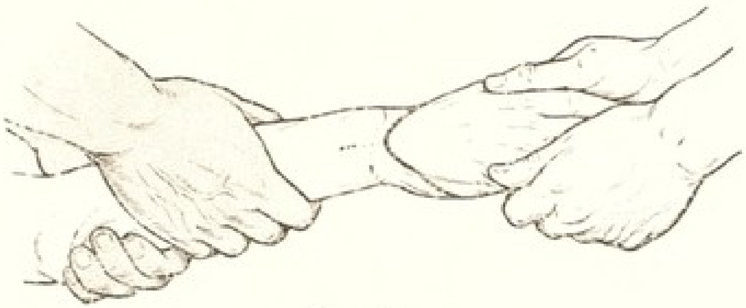


Fig. 315.

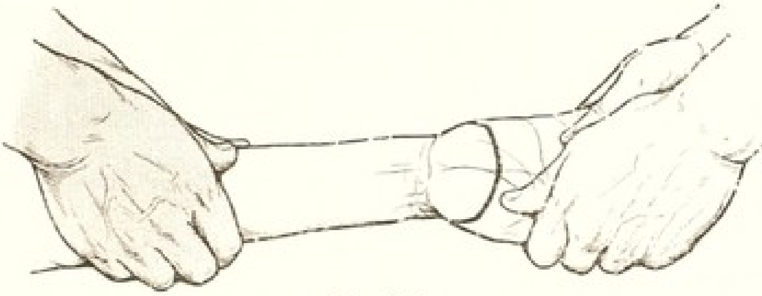


Fig. 316.

Two other incisions give excellent results :—

1. *An Anterior Flap.*—In this the palmar incision is exactly as described, but the dorsal incision simply unites the two heads of the U by a straight line running obliquely downwards and outwards as would a line joining the tips of the two styloid processes. This is carried out just as the elliptical incision.

2. *A Circular Incision.*—This is arranged somewhat obliquely about an inch below the joint ; passing on the inner side over the upper extremity of the 5th metacarpal bone, and on the outer side half an inch below the first carpometacarpal joint.

In this procedure the skin is first divided as in all circular amputations, and the palmar region is subsequently treated as after the elliptical incision ; but before disarticulation a dorsal cuff must be raised to expose the styloid processes. There are no special features about the disarticulation.

Principal Steps (elliptical incision or anterior flap) :—

1. Division of the palmar skin.
2. Division and liberation of the dorsal skin.

3. Opening the joint from the dorsal surface, with section of the tendons and ligaments at the same time.
4. Division of the fibres of the anterior ligament, the radiocarpal.
5. Opening the carpal canal, in succession on either side.
6. Division of the flexor tendons thus exposed.

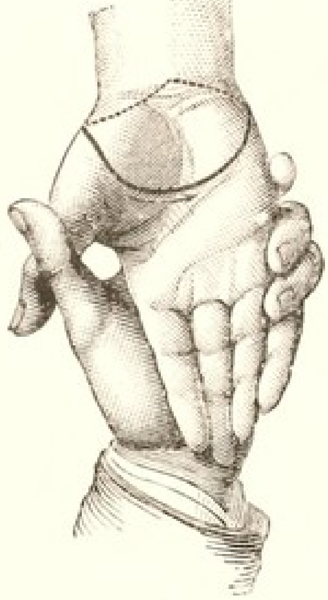


Fig. 317.

Fig. 318.

A *wrist knife*, which has a narrow blade four inches long, is used for the operation.

Fig. 319.

Fig. 320.

Division of the Palmar Skin.—The assistant grasps the forearm in both hands, presenting it horizontally and supinated.

The palm being flattened, as shown in *Figs.* 317–320, the heel of the blade, point downwards, is applied to the left border of the hand at the upper limit of the palmar **U**. By drawing the knife the tissues are now divided down to the bone (*Fig.* 319), the corner is turned on the point, and the palmar skin is divided transversely with sawing movements of the point, the handle raised (*Fig.* 320). The right corner of the flap is then turned, after which the handle is again dropped and the blade made to cut again right down to the bone while reversing along the right branch of the **U** (*Fig.* 321).

Fig. 321.

Fig. 322.

The muscles of the thenar and hypothenar eminences must be completely divided to the bone, but between them the knife should not do more than divide the palmar fascia transversely.

Before leaving the palm it is best to widen the opening in the divided fascia by extension of the wrist, and to free the fascia from the tendons for about half an inch with little strokes of the point, the blade nearly flat to the hand (*Fig.* 322).

Dorsal Incision.—The hand is pronated, the assistant stretches the skin with his two thumbs, while the operator grasps the left border of the hand with his left hand, thumb above. If the muscles of the thenar and hypothenar eminences have been completely divided, the ends of the palmar incision will be close to the dorsal surface. Twisting the hand a little to the right to see clearly the left extremity of the **U**, and flexing the wrist slightly, the operator applies the heel of the blade at that spot, point downwards (*Fig.* 323); the first half of the incision is made by reversing, the second by drawing the knife, after turning on the point at the apex of the ellipse (*Fig.* 324); and the incision is ended with the point, handle below, at the right border of the hand, which has now been rotated slightly towards the left (*Fig.* 325).

The skin must be carefully freed, so that when the assistant retracts it, the styloid processes and the line of the joint will be well exposed.

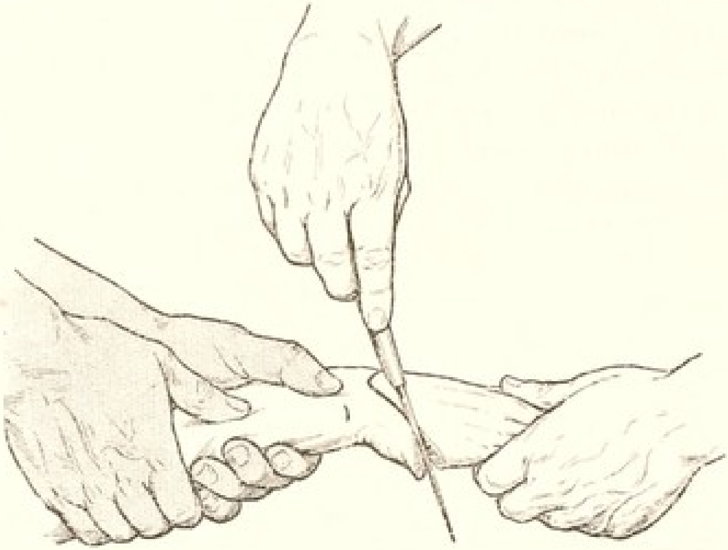


Fig. 323.

Fig. 324.

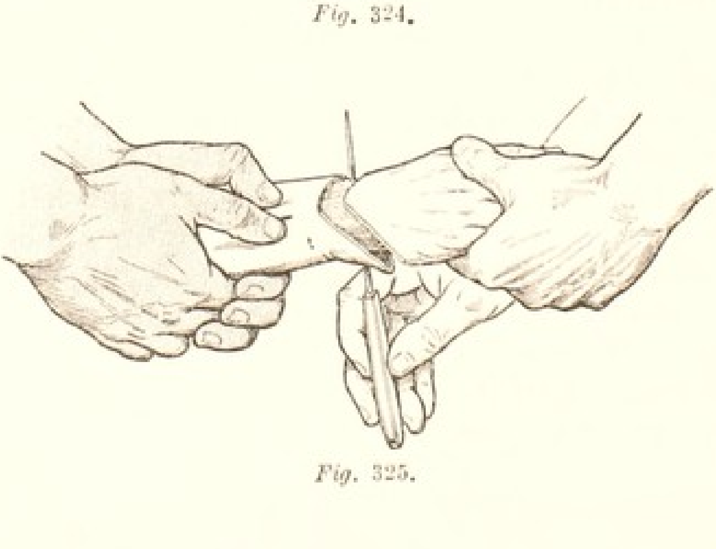


Fig. 325.

Disarticulation.—The pronated forearm is inclined upwards at an angle of about 45°, and the wrist is flexed to the maximum; the operator feels the styloid process to his left with the pulp of his index finger, and then brings the finger towards him until a space a few millimetres broad is left between the nail and the tip of the process. To this interval the blade is applied transversely, hand uppermost (*Fig.* 326), and the dorsal tendons and ligaments are divided completely, from left to right, on to the projecting condyle of the carpus; the edge is directed downwards, as if the carpal bones were to be divided coronally, parallel to the surface of the palm, but it is made to follow approximately the upward convexity of the joint line.

Fig. 326.

Fig. 327.

Fig. 328.

The cartilaginous upper surfaces of the carpal bones now appear, and the hand becomes dislocated backwards (*Fig.* 327). The stroke is terminated to the right, with the hand below, to make sure of dividing the left lateral ligament.

The *powerful anterior radiocarpal ligament may next be divided* from left to right against the anterior border of the radius, with the point of the knife, blade horizontal; but it is neater to follow tradition and *divide the ligament against the carpus* (*Fig.* 328). For this purpose the tissues at the extreme left of the carpal canal are pierced with the point for about one and a half inches, blade vertical, edge to the right, and the knife is passed to the right with sawing movements until arrested by the bony projection to the right of the carpal canal. When operating on the left side, this projection will be the pisiform bone, and care must be taken not to open the articulation between it and the cuneiform.

Freeing the Palmar Flap and Opening the Carpal Canal.—After division of the ligament as just described, the wrist is still held by: (1) The connections between the anterior annular ligament and the palmar flap; (2) The flexor tendons as they pass beneath this ligament. Two steps must therefore be taken at both sides of the flap: (1) The detachment of the muscles, thenar or hypothenar, from their origin; (2) The division of the annular ligament close to its lateral insertions, thus liberating the flexor tendons. These steps are carried out, first, by dividing the muscles close to their origin, with the blade flat to the bones, until the resistance of the projecting bones has been passed; then, by turning the blade through a right-angle, slipping the point under the projection, and dividing the annular ligament. This movement is facilitated by twisting the flexed wrist with the left hand.

Fig. 329.

The bony projections on the radial side (tubercle of the scaphoid and ridge of the trapezium) are solid, and can be rounded without special precautions; but care must be taken on the ulnar side in rounding the pisiform bone, or it may be left in the flap.

After the joint is opened, the hand is left hanging in pronation. The carpal canal should always be attacked first on the side to the right of the operator; the radial side, therefore, when operating on the right hand, but the ulnar side in the case of the left hand.

Radial Side.—Grasping the patient's hand as it hangs before him in his semipronated left hand, fingers over the dorsum, thumb over the metacarpal bone on the right border of the palmar incision, the operator twists the hand to the left until the palm faces to the right, by supinating his own left hand.

The cut surface of the palmar muscles now comes into view, and they can be detached by two or three strokes of the knife, held on the flat (*Fig.* 329), drawn from heel to point of the blade, from carpus to metacarpus.

When the carpal projection is passed, the operator turns the edge towards him, and, with the point beneath the projection, drawing the knife towards him from carpus to metacarpus, divides the annular ligament against the bones, at the same time twisting the hand still further by a movement of his left hand. (This second step is shown, for the ulnar side only, in *Fig.* 332, in which three points may be noted: (1) A tendon which marks the upper border of the annular ligament; (2) The position of the blade: (3) The divided annular ligament).

Fig. 330.

Ulnar Side.—The operation figured in the text is performed on the right wrist, and the ulnar side, therefore, which lies to the operator's left, is reached last.

Fig. 331.

The pisiform bone must first be freed.

For this purpose the hand is grasped as it hangs by the operator, thumb above, the index finger stretched beneath it, feeling with the pulp the pisiform bone. He now pulls the hand a little towards him, at the same time lowering the wrist so that the dorsum of the carpus rotates a little towards him; then twisting the hand a little to the right, he clears the pisiform bone with two or three strokes of the point from left to right, the flat of the blade against the bone, the point directed downwards and towards him, his right hand pronated, the elbow above (*Fig.* 330).

Fig. 332.

The operator next alters the position of his left hand, placing his thumb on the palmar surface of the metacarpo-phalangeal articulation of the patient's little finger, his fingers over the dorsal surface of the wrist, which is now twisted to the right until the palm faces to the left. The divided surface of the palmar muscles on this side is now seen, and they are divided close to the bone, cutting from left to right, from metacarpus to carpus, the edge of the knife away from the operator, until the bones have been cleared (*Fig.* 331). Finally, the annular ligament is divided against the bone, the blade again pointed towards the operator (*Fig.* 332).

The hand is now held by the tendons only ; the surgeon pulls it towards him, while he holds the flap with the other hand and drags it away from the tendons (*Fig.* 333). These are held firmly on the hand

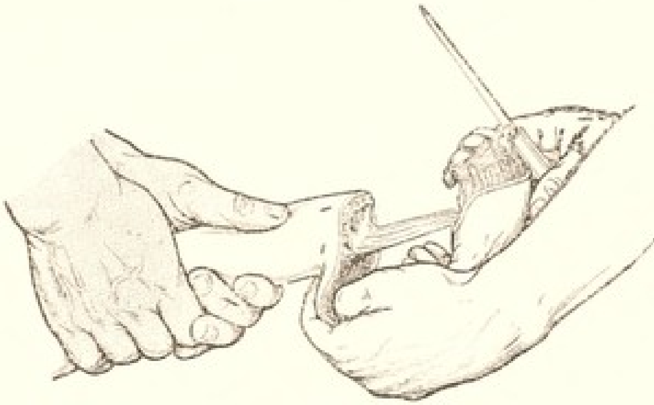


Fig. 333.

Fig. 334.

side between the left index finger and thumb (*Fig.* 334), and are divided transversely with the blade vertical, about an inch from the bones of the forearm.

Circular Amputation of the Wrist.—This is generally performed for practice in the dissecting-room on hands which have already been used for enucleation of the metacarpal bones. On the living, also, it is an excellent method, for the dorsal skin retracts considerably, and the final result is much the same as that left after an elliptical amputation or one by an anterior flap. The only difference in the operation lies in the *division of the skin* (see the line of incision in *Figs.* 317 and 318) ; this is carried out by the surgeon holding the patient's hand horizontally and pronated in his left hand, so that by untwisting little by little, the palm is brought uppermost, and the skin is easily divided in one step. The palmar tissues are freed just as in the flap operation, the bones are disarticulated from the dorsum, and the carpal canal opened exactly as above described.

Chapter XV.

DISARTICULATIONS OF THE ELBOW AND SHOULDER.

DISARTICULATION OF THE ELBOW.

Anatomy.—*The articular surfaces* are formed above by the lower extremity of the humerus, below by the upper extremity of the two bones of the forearm: the radius on the outer side, lying under the spherical capitellum; the hook-shaped upper extremity of the ulna on the inner side, fitting the trochlear surface.

The *line of the joint* is practically horizontal on the outer side and in front; but posteriorly it is raised nearly two finger-breadths by the olecranon process.

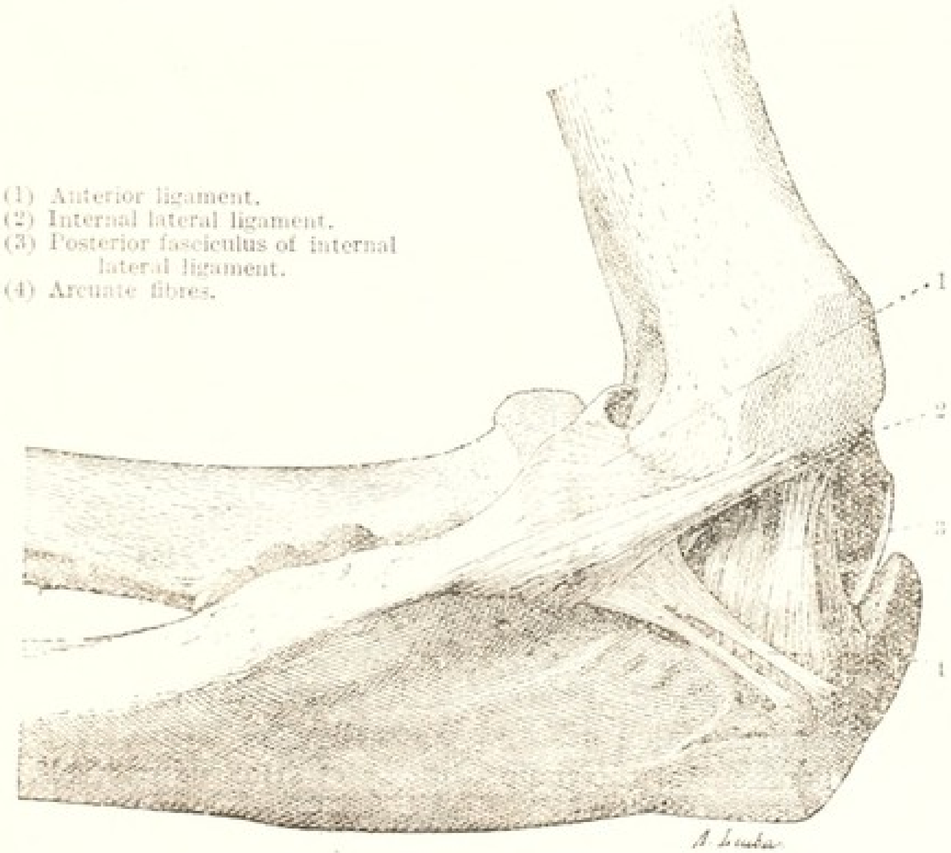


Fig. 335.—Ligaments on the inner side of the elbow.

In semiflexion, a line joining the two epicondyles, of which the internal projects sharply, touches the tip of the olecranon; but in extension, the tip of the olecranon reaches above this line.

The shape of the line of the joint viewed from in front may well be described as a *hyphen* two-thirds of an inch long over the head of the radius on the outer side, and a *circumflex accent* one and a quarter inches long over the coronoid process of the ulna on the inner side. *In flexion*, the beak of this process and the radius pass in front of the corresponding articular surfaces of the humerus, and the plane of the supinated bones of the forearm cuts the lower extremity of the humerus from before backwards. *In extension*, the capitellum and trochlea become free, and the plane of the supinated forearm bones cuts them coronally at the junction of their anterior third with the posterior two-thirds.

It is in extension and supination that the joint gapes and becomes accessible from in front. In order to enter it in this position, the ligaments to be divided are the *anterior ligament*, reinforced by the tendons of brachialis anticus and biceps, and the two *lateral ligaments*, which pass downwards from the epicondyles to the corresponding

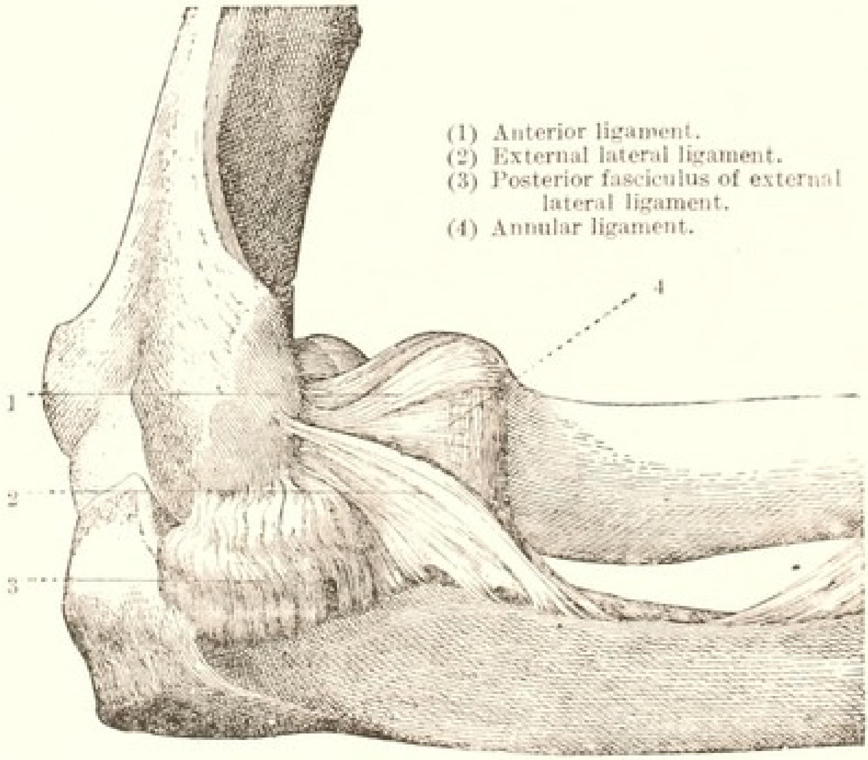


Fig. 336.—Ligaments on the outer side of the elbow.

borders of the coronoid process. The external lateral ligament is attached, by fibres which descend vertically, to the upper border of the annular ligament of the radius, but not to the radius itself, so that on this side the joint is loose.

The lateral ligaments have also a strong *posterior fasciculus* which passes from each lateral eminence to the corresponding border of the olecranon, to the whole length of which it is attached.

Finally, to the posterior surface of the olecranon process, the bulky *tendon of the triceps* is attached. It is divided at the end of the operation, after opening the joint from in front.

Landmarks.—The line of the epicondyles must first be ascertained. This is done by grasping the supinated forearm near the wrist in the left hand and slightly flexing the elbow, while the supinated right hand grasps the posterior surface of the elbow. The projection to the right is now felt by the thumb, that to the left by the middle finger, while the flexed index-finger palpates the summit of the olecranon process. In semiflexion these three points are in line with one another; in extension the olecranon reaches above the inter-epicondylar line.

A director is then taken, and applied transversely to the bend of the elbow, grooved surface towards the skin. The bend can now be

Fig. 337.—Marking the bend of the elbow.

marked by flexing the joint while pressing on the director (*Fig.* 337). The transverse portion of the articulation lies two finger-breadths below the upper limit of the epicondyles, one finger-breadth below the fold of the elbow. Its exact position can easily be determined by rotating the wrist with one hand while the head of the radius is felt to turn between the thumb and forefinger of the other hand.

The *muscular prominences* to note are the biceps tendon, the supinator longus, and the muscles arising from the internal epicondyle; behind these last the *posterior border of the ulna* can be felt, continuous with the olecranon.

Line of Incision for an Anterior Flap.—This flap is **U**-shaped, as broad below as above, and the two branches should be a little

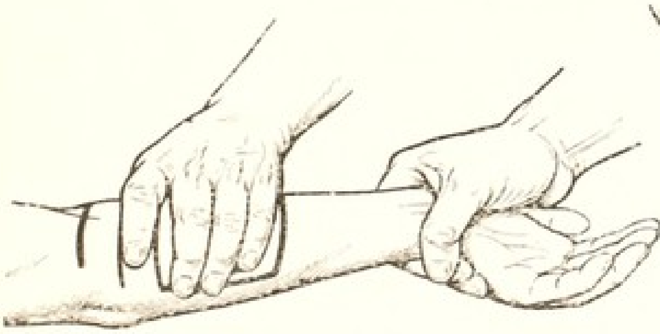


Fig. 338.

Fig. 339.

behind the median coronal plane of the limb; the external over the outer surface of the radius, the internal on a level with the anterior surface of the ulna.

The internal branch starts one finger-breadth below the line of the joint, the external two finger-breadths below, because the skin retracts much more on the outer side. The flap must extend at least four finger-breadths below the line of the joint (*Fig.* 338).

The heads of the two branches of the U are united posteriorly by a straight line (*Fig.* 339).

Line of Incision for an Elliptical Flap.—The summit of the ellipse lies over the olecranon, the lowest point over the prominence of supinator longus, a little below the middle of the forearm. By grasping the side of the limb to his left, thumb over the ulna below, fingers above, the surgeon can mark the lowest point of the ellipse by stretching upwards his little finger (*Fig.* 340).

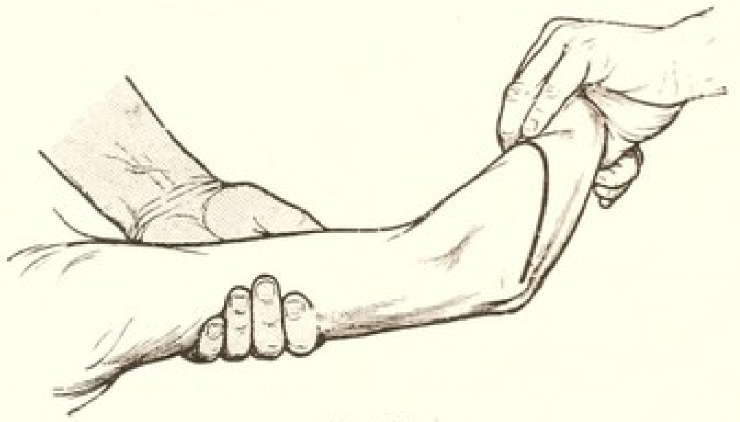


Fig. 340.

The movements for dividing the skin are the more graceful in this operation, but if the posterior skin can be preserved, we think the anterior flap gives better results.

Line of Incision for a Circular Flap.—If the condition of the soft parts allows of it, *a circular amputation* also gives excellent results. The line is an oblique one ; it should lie four finger-breadths below the joint on the antero-external border of the arm over the supinator longus, and only two finger-breadths below the joint line on the postero-internal border over the crest of the ulna.

Principal Steps of the Operation :—

1. Division of the skin.
2. Division of the tissues anteriorly.
3. Disarticulation.

If the anterior muscles are divided by transfixion, the last two steps are the same, whether the incision be elliptical or with an anterior flap.

In the *circular amputation*, the forearm is carried away from the body to a right-angle, and is held by an assistant standing on the outer side. The surgeon, standing so that the hand is to his left, seizes the forearm above the wrist, and makes the incision in one step or two (the first behind and below the limb, the second in front) according to his ability. The difficulty is to retract the skin at the sides above the level of the joint, so that it will not be injured when the muscles are divided or when disarticulation is being performed. The liberation of the posterior skin (*Fig.* 345) should be carried out most carefully, and must extend to the summit of the olecranon. The section of the anterior muscles is better accomplished by dissection than by transfixion. The method of disarticulation is the same in each procedure. The nerves should always be resected as high as possible.

The assistant stands opposite the shoulder, the surgeon at the end of the limb, slightly to the right.

Division of the Skin.

Anterior Flap.—The operator grasps the lower part of the supinated forearm with his pronated left hand, thumb below, and

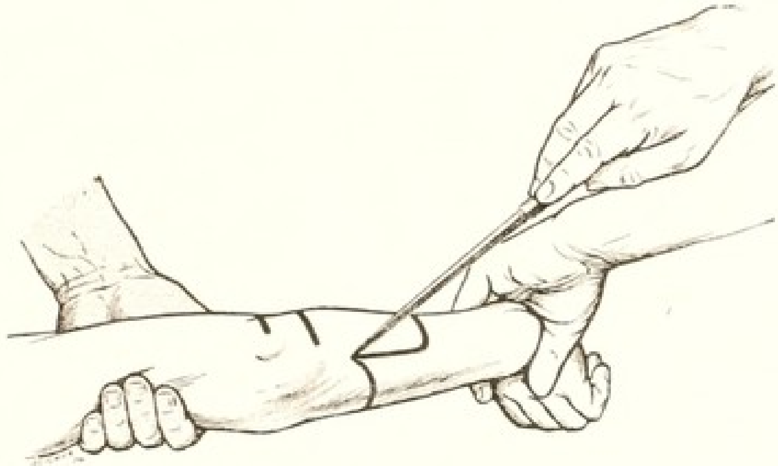


Fig. 341.

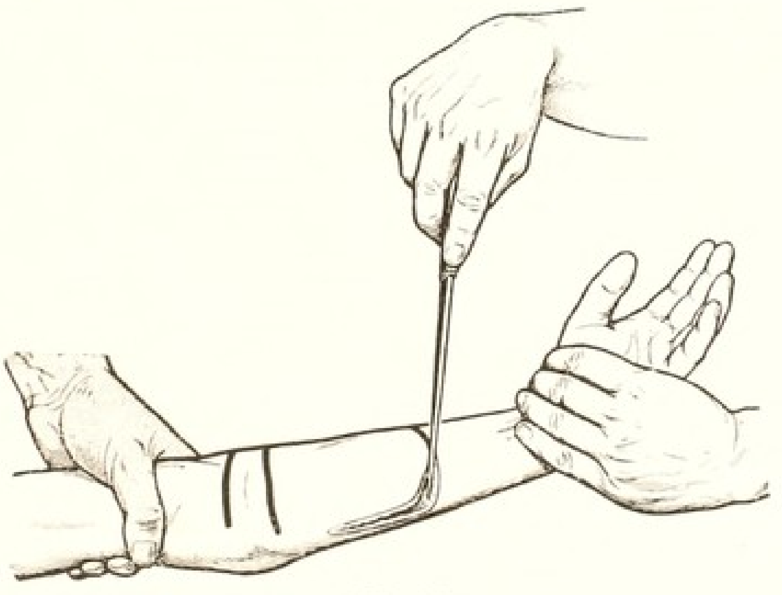


Fig. 342.

carries it to the right in extreme supination, slightly rotated to the right, extended, and horizontal. Along the left branch of the U, which is thus exposed, the knife is now drawn towards the operator (*Fig.* 341). After turning on the point, the front of the forearm is crossed transversely, cutting with the full blade, the arm now in simple supination without torsion (*Fig.* 342). On reaching the right-angle of the flap, a second turn on the point is made, the limb is placed in pronation, and the knife ascends along the right branch of the **U**, while the surgeon rotates on his right leg so as to face this branch at the end of his incision (*Fig.* 343).

Fig. 343

After liberating the skin, together with which the deep fascia may be taken, the forearm is flexed to a right-angle until it is nearly vertical and the operator faces the posterior surface. The knife is now passed under the left hand, and divides the posterior skin from left to right (*Fig.* 344).

Fig. 344.

Fig. 345.

The forearm is next entrusted to an assistant, who holds it still vertically, at a right-angle (or better perhaps at an obtuse angle), while the operator takes the posterior skin between finger and thumb and frees it as far as the olecranon, the blade passing beneath it parallel to the bone (*Fig.* 345).

Care must be taken that the skin is completely liberated at the angles of the wound.

Elliptical Incision on the Right Side.—The limb is grasped as described on page 194 (*Fig.* 340). It is

Fig. 346.

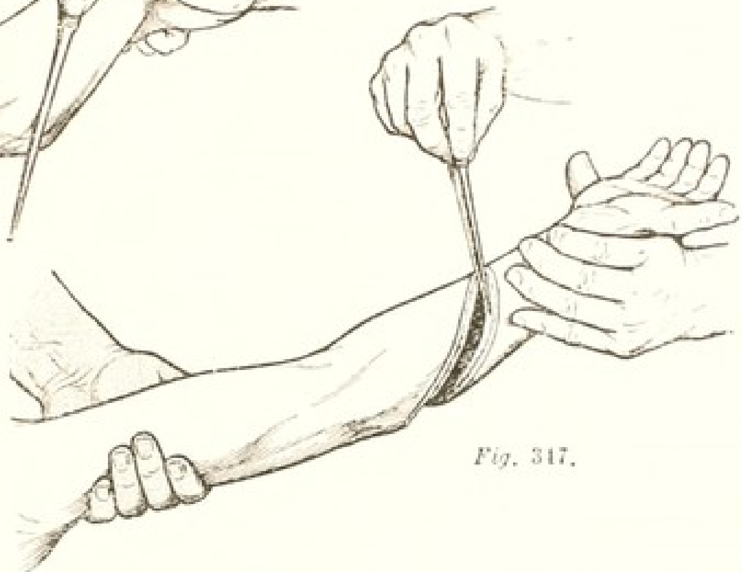


Fig. 347.

Fig. 348.

Fig. 349.

then flexed slightly, pronated, and rotated to the right. The wrist is lowered, so raising the elbow and displacing it to the left. The olecranon can now be seen by the operator ; over it he applies the heel of the blade, and then draws the knife towards his little finger, which is marking the lowest point of the ellipse (*Fig.* 346).

Turning on the point, while the left hand untwists the limb until it reaches a position of supination and extension, the anterior surface is crossed obliquely as far as the internal border (*Fig.* 347).

The elbow is then flexed by the surgeon extending his own left arm, and a nearly horizontal incision is drawn along the postero-internal border of the forearm thus exposed, ending with the point of the knife over the olecranon, whence the incision started (*Fig.* 348).

The arm is then entrusted to an assistant, who holds it supinated and almost vertical whilst the surgeon takes the skin of the posterior surface, now before him, between thumb and index finger, and frees it with one or two strokes of the knife, blade parallel to the olecranon (*Fig.* 349).

Elliptical Incision on the Left Side.—Holding the limb as before in his left hand, the surgeon stands definitely on its outer side and a little behind it.

Flexing the elbow at a right-angle, and pressing the strongly supinated forearm well to the right, the humerus is also rotated strongly to the right, and the point of the elbow comes to be in front of the surgeon and to the left. The heel of the blade is now applied over the olecranon, and drawn as before towards the operator's little finger (*Fig.* 350). As the incision passes towards the right, the limb is carried to the left with the left hand, so that it lies straight when the point of the knife has reached the outer border.

Fig. 350.

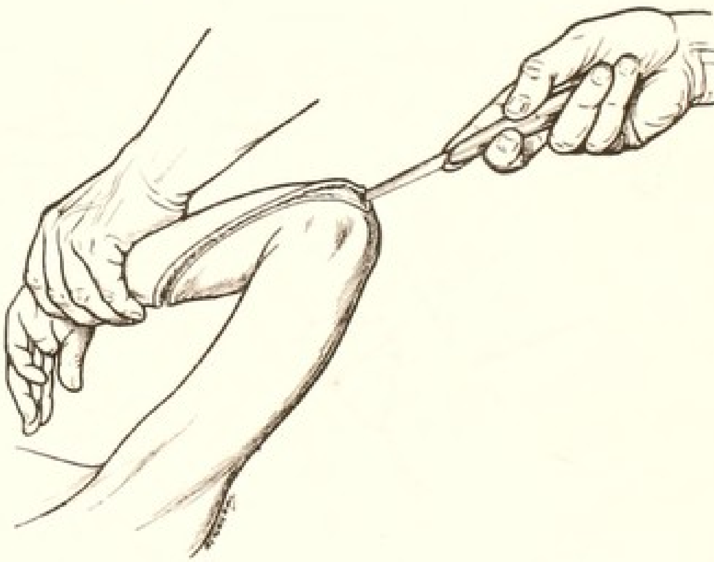


Fig. 351.

The corner is turned on the point ; the forearm is then flexed at an acute angle, and carried as far as possible forwards and to the left, first a little pronated as the corner is being turned, then in supination and the knife is drawn over the postero-external surface, which lies before the operator, until it rejoins over the olecranon the point whence it started (*Fig.* 351).

The freeing of the skin behind the olecranon, not so important here as in the operation with an anterior flap, but a wise step none the less, is carried out as on the right side.

Whatever the procedure adopted, the *skin must be completely* *freed* all round the limb, and it is possibly advantageous to reflect the deep fascia with it.

Transfixion of the Anterior Flap.—The arm is supinated, slightly flexed, and placed so that the hand lies to the operator's left; he then pinches the flap transversely in his pronated left hand, and passes the blade horizontally and on the flat through the limb, the

Fig. 352.

edge to his left, from a point as high as possible on the right branch of the **U**, to emerge as high as possible on the left side; the skin is retracted meanwhile by dragging it upwards and towards the axis of the limb. While the point is traversing the tissues, the assistant should flex the wrist to relax the muscles; but when the point has emerged, they must be made tense by extension of elbow and wrist.

Fig. 353.

The knife then cuts its way downwards on the flat (*Fig.* 352) as far as the level of the retracted skin; the operator's left hand pinching the flap and raising it.

At this level the blade is turned through a right-angle until the edge looks upwards, when it is brought out (*Fig.* 353), while the assistant momentarily increases the extension of the wrist.

Transfixion is carried out in the same way after *an elliptical incision*. It is only necessary to retract the skin at the edges more energetically when piercing the base of the flap and when bringing the knife out.

After transfixion, the flap is entrusted to an assistant, while the surgeon, moving to the extremity of the limb, seizes the wrist, fingers below, and maintains it in supination, the elbow extended.

Disarticulation.—The assistant takes the flap in both hands, and raises it as far as possible ; the surgeon first makes sure that the skin

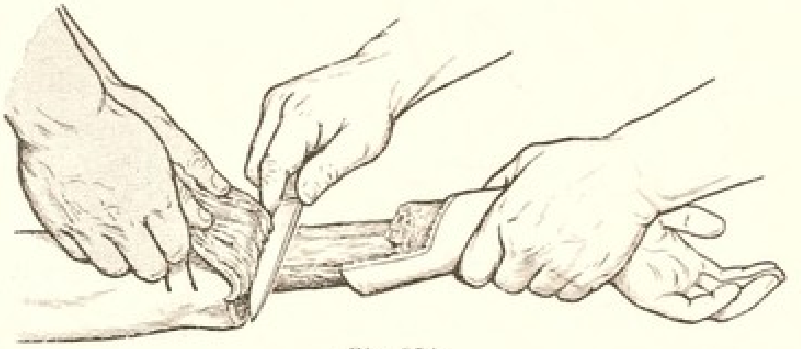


Fig. 354.

posteriorly is retracted as far as the angles of the wound, then applies the blade flat to the bones of the arm, edge towards the elbow, and cuts upwards until the knife is arrested, after passing the bicipital tuberosity, by the inner lip of the trochlea (*Fig.* 354) ; this is the level of the articulation.

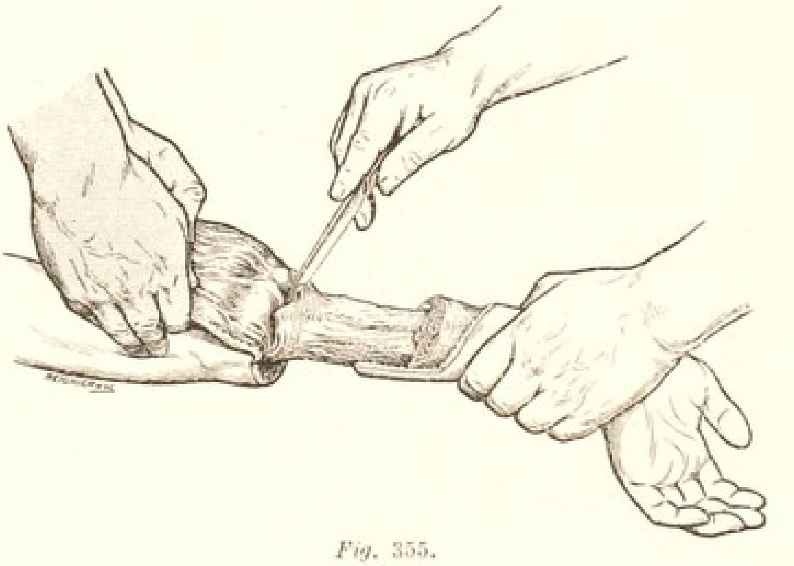


Fig. 355.

The point of the knife is now made to follow the line of the joint anteriorly, in shape like a circumflex accent over the coronoid process and a hyphen over the radius (*Fig.* 355). This movement takes place from left to right ; the coronoid process, therefore, is first attacked on the left side, the radius on the right.

The line of the joint thus manifest, it is easiest to continue disarticulation by dividing *the external postero-lateral* ligament, where there is more space: the ligament to the right, therefore, in the case of the left limb (*Fig.* 356), but to the left in the right limb (*Fig.* 359).

Left Side.—The forearm, still extended and supinated, is placed in a position of cubitus varus (pressed to the left, therefore, in the case of the left arm), the assistant resisting the movement by a firm

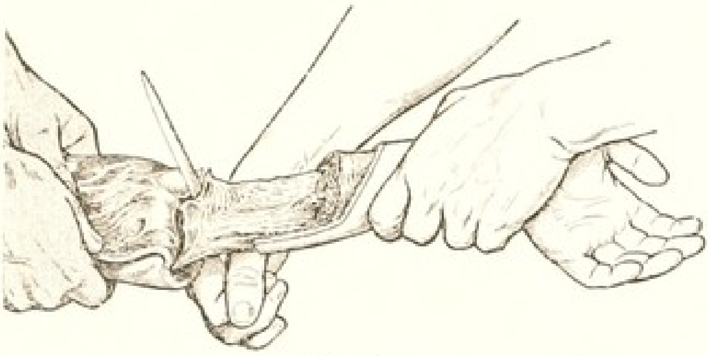


Fig. 356.

Fig. 357.

Fig. 358.

hold on the upper arm. The surgeon then applies the heel of his knife transversely, handle below, to the right side of the joint line which has thus been made to open (*Fig.* 356), and cuts with the whole blade from above downwards, ceasing only when the border of the olecranon is reached; he passes the knife vertically through the joint again until the heel bites in the angle between radius and olecranon, then turns the blade upwards through a right-angle, edge towards the humerus, and at the same time by moving the left hand he increases the extension and varus. In this way the posterior external ligamentous fibres of the olecranon almost divide themselves, and the joint gapes widely (*Fig.* 357).

Liberated thus on the outer side, the *inner side of the joint* also gapes a little and can be attacked similarly.

Bending the limb into a position of cubitus valgus (to the right, therefore, on the left side), the heel of the knife is applied transversely to the ulnar side of the joint, handle above, and the ligaments are divided from below upwards (*Fig.* 358).

When the inner border of the olecranon is reached, the blade is turned through a right-angle until the edge is towards the humerus, and the valgus position is exaggerated while the knife is passing upwards.

Right Side.—The joint is attacked from the radial border, which is to the operator's left, with the knife vertical, handle above (*Fig.*

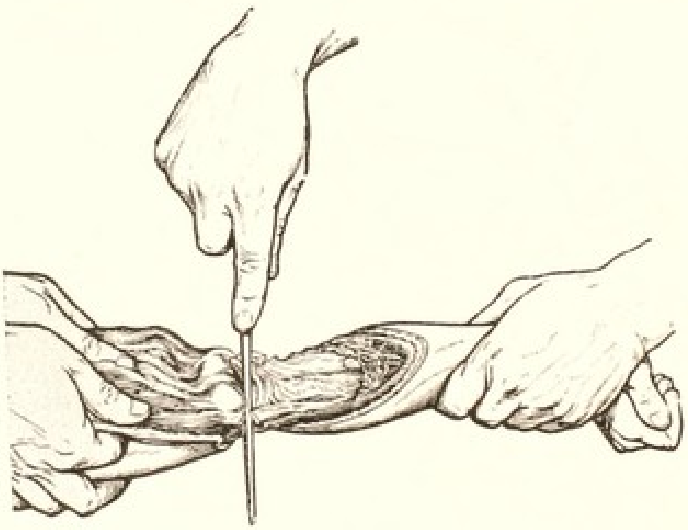


Fig. 359.

359), the joint being made to gape as already described, while the blade is passed first inwards, then upwards, as before. When the inner

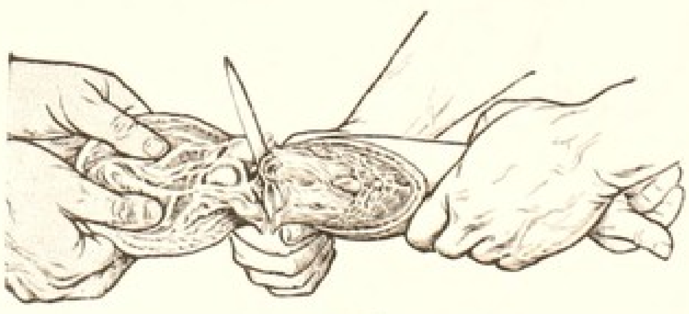


Fig. 360.

side is attacked, which now lies on the operator's right, the knife cuts from heel to point, the handle below; when the edge reaches the olecranon process, the knife is pushed back, and cuts again from heel to point and from above downwards, as before (*Fig.* 360).

An experienced operator can always start to the left, handle above, and finish to the right, handle below.

The forearm is now held by the triceps tendon only.

Fig. 361.

To complete the disarticulation, the surgeon passes his left hand upwards until it grasps the middle of the forearm; he then pulls (*Fig.* 361), at the same time placing the wrist against his abdomen to increase the leverage. The head of the ulna becomes dislocated

Fig. 362.

forwards, exposing the triceps tendon, which is now divided transversely by repeated semicircular movements of the knife, the edge towards the bone, cutting from edge to edge of the tendon from the heel to the point of the blade—a common movement when playing the violin (*Figs.* 361, 362).

DISARTICULATION OF THE SHOULDER.

Anatomy.—The shoulder is a *ball-and-socket joint* (enarthrosis) between the small glenoid cavity of the scapula, almost flat, and the large head of the humerus (the third of a sphere).

The bones are united by a cone-shaped capsule, attached above to the sides of the glenoid cavity and to the glenoid cartilage, below to the humerus—to the anatomical neck in front, behind, and on the outer side, but to the surgical neck internally. The capsule is continuous with the *muscular cone which covers it*, formed on the outer side by the muscles from the dorsal surface of the scapula which are inserted into the great tuberosity, and to the inner side by the subscapularis muscle, inserted into the lesser tuberosity.

Inside the articulation is the *long tendon of the biceps*, which arises just above the glenoid cavity, winds round the head of the humerus, and leaves the joint in the *bicipital groove* between the tuberosities.

The *junction of the acromion process and the clavicle* overhangs the joint, while underneath this the *coracoid process* projects, united to the acromion by the *coraco-acromial ligament*. From the coracoid process descends the *large fleshy body of the coracobrachialis* muscle, behind which lies the axillary vasculo-nervous bundle.

The bony plane formed by the spine of the scapula, the acromion, and the clavicle, gives origin to a *sheet of muscle fibres* (deltoid and pectoralis major) which is attached below to the upper third of the humerus. *The tendon of pectoralis major* is inserted into the outer lip of the bicipital groove, and therefore binds down the long tendon of the biceps, behind and to the inner side of which are the superimposed tendons of latissimus dorsi (at the bottom of the groove) and teres major (inner lip).

Examination.—The *bony landmarks* are very easily felt. Following with the finger from within outwards the spine of the scapula posteriorly and the clavicle anteriorly, the acromio-clavicular joint is reached at the acromial angle, where also the shoulder projection begins. Two finger-breadths to the inner side of this point, and one finger-breadth below it, the outer portion of the anterior wall of the axilla is raised by the coracoid process.

The cavity beneath the coraco-acromial ligament is filled by the *head of the humerus*. When the arm hangs alongside the body, without rotation, the bicipital groove runs almost vertically downwards beneath the tip of the acromion ; on the inner side of the groove, projecting forwards, lies the lesser tuberosity ; on the outer side, projecting outwards, the great tuberosity.

If the humerus is moved, it will be noticed that the head disappears under the coraco-acromial arch in flexion, but projects in extension. The great tuberosity is brought forwards by internal rotation, and with it the posterior part of the capsule of the joint, which is thus made tense. In external rotation the lesser tuberosity becomes definitely anterior, and the antero-internal portion of the capsule is stretched and becomes accessible (together with the accessory ligaments).

Line of Incision.—The line of incision (*Fig.* 363) is a racket with a straight handle. It commences midway between the coracoid and acromion processes, and follows vertically the anterior profile of the limb for about two and a half inches. The ring surrounds symmetrically the posterior and lateral surfaces of the limb, crossing the posterior surface about two and a half inches below the bifurcation of the racket. So that if a line five inches long is traced on the anterior surface of the arm, the handle of the racket will bifurcate half-way down the line, while the lowest point of the ring posteriorly will be level with the lower end of the line.

Principal Steps:—

1. Division of the skin.
2. Dissecting the two deltoid lips.
3. Division of the pectoralis major tendon.
4. Disarticulation.
5. Division of the muscles and vessels on the inner side.

A knife with a blade five or six inches long should be used.

Fig. 363.

The patient is placed at the edge of the table, the shoulder reaching beyond the edge. The assistant stands behind the shoulder, between it and the head, and marks with his two thumbs the coracoid process and the tip of the acromion, at the same time stretching the skin. (In *Fig.* 363 he is shown standing on the other side of the head, so that the field of operation is not hidden.)

Division of the Skin.—The surgeon grasps transversely the posterior surface of the arm, below the middle, in his supinated left hand, and by drawing his fingers together makes the skin tense. He then abducts the limb slightly in the horizontal plane, and with the knife grasped fully in the right hand, the index finger stretched along the back of the blade, pierces the tissues to the bone midway between the two landmarks, handle above, blade nearly vertical (*Fig.* 364).

When the bone is felt, he inclines the blade at an angle of 45°, and draws it towards him, along the bone, as far as the lower extremity of the handle of the racket (*Fig.* 365). Turning on the point, he then passes downwards along the right shoulder of the racket (*Fig.* 366), while with the left hand he twists the limb to the left and raises it

Fig. 364.

Fig. 365.

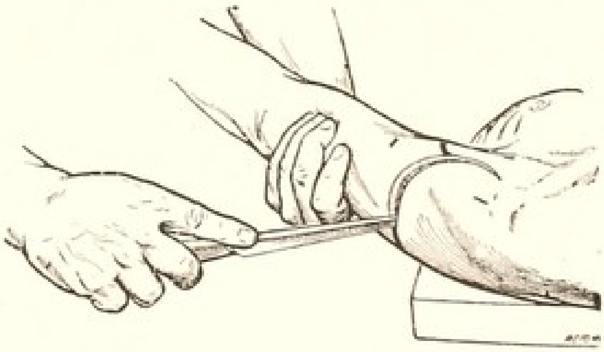


Fig. 366.

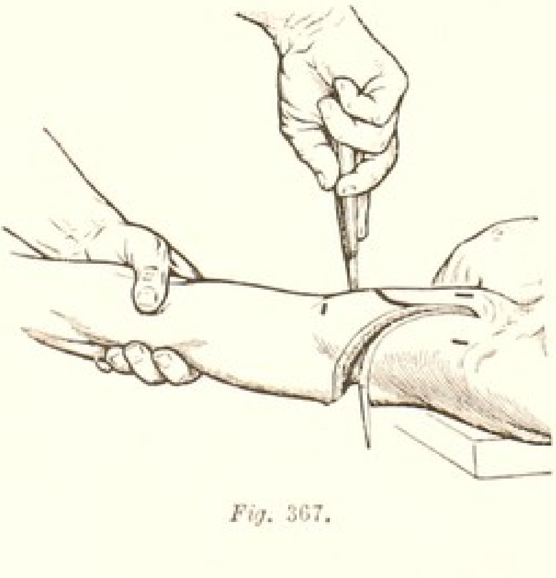


Fig. 367.

Fig. 368.

a little to see the posterior surface, which in turn is crossed transversely, and the incision carried as far as possible to the left.

After making sure that the skin has been completely divided, the limb is abducted nearly to a right angle, and twisted to the right (*Fig.* 367), to expose the left posterior surface and the termination of the first incision; the heel of the blade is then applied transversely, handle above, at that point, and an incision is made by reversing along the left shoulder of the racket, from heel to point, while with the left hand the arm is lowered and rotated to the left in order to stretch the skin (*Fig.* 368).

In disarticulation of the *right shoulder*, the first part of the incision is made exactly as on the left side, but the right shoulder of the racket leads the operator to the axilla, which he crosses transversely from heel to point, the arm in abduction, sawing lightly with the blade to avoid injuring the vessels (*Fig.* 369). During this step the knife should lie horizontally, held like a violin bow, and should rotate little by little towards the back of the operator's wrist, edge upwards, point to the right; with the knife in this position the skin is divided as far as possible to the outer margin of the limb (*Fig.* 370).


Fig. 369.

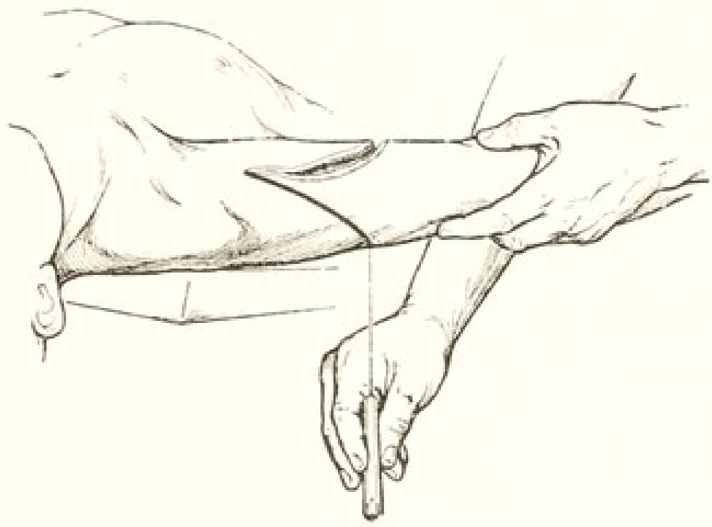


Fig. 370.

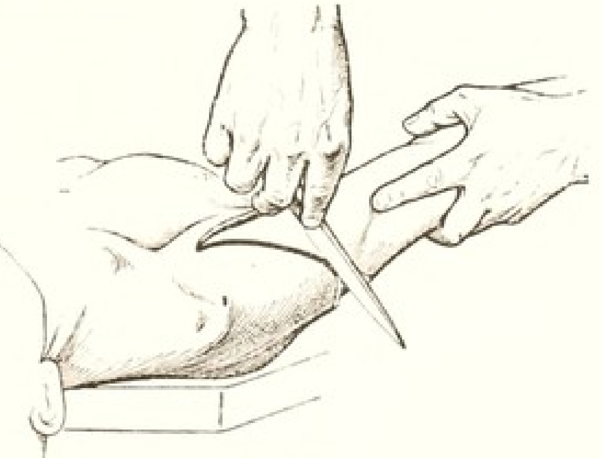


Fig. 371.

Fig. 371 shows how the incision is completed on this side by a second cut, upwards from the postero-external surface, the limb being raised, adducted, and rotated to the right.

Division of the Muscles.—The following structures must now be divided: (1) The tendon of pectoralis major, on the inner side

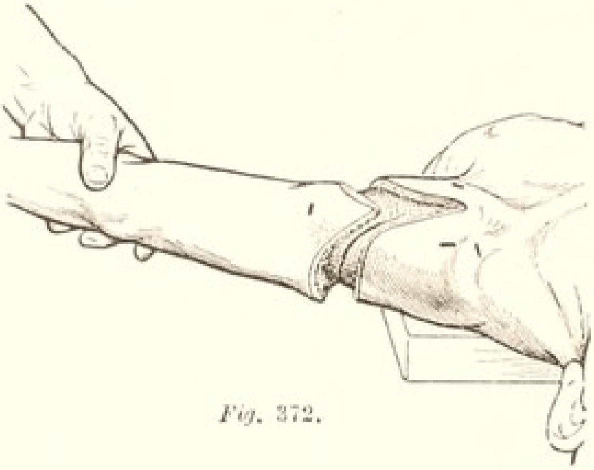


Fig. 372.

Fig. 373.

at the level of the bicipital groove; (2) The deltoid muscle, on the outer side and behind at the level of the retracted skin. This is done by a cut shaped like a very pointed circumflex accent, angle above, the knife first passing away from the operator, then towards him again after turning on the point. On the left side, therefore, the cut starts from the axilla and ends posteriorly on the outer part of the shoulder; while on the right side the knife is passed in the reverse direction.

Before proceeding to this step, the surgeon slips his left hand downwards along the arm until it grasps the limb transversely, thumb in front, at the level of the lower end of the humerus. This hold is maintained to the end of the operation, giving as it does great power to rotate the limb (*Fig.* 372).

Left Side (*Fig.* 373).—The assistant separates the lips of the wound with his thumbs, and the surgeon, twisting the limb to the right, and holding it horizontally alongside the trunk, applies the point of his knife over the stretched and visible tendon of pectoralis

Fig. 374.

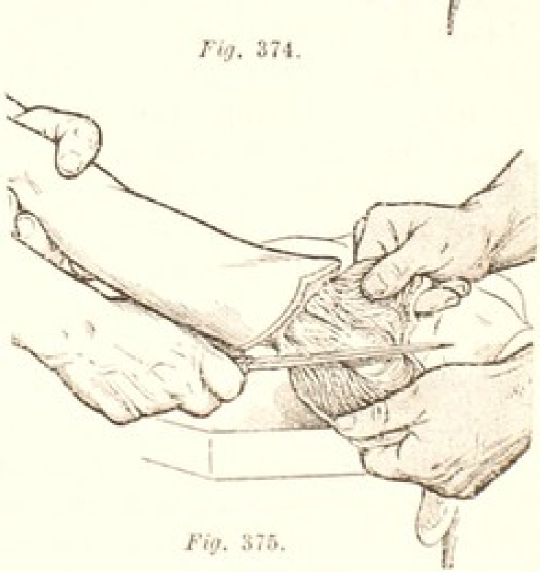


Fig. 375.

major, handle above, edge towards the shoulder. He then divides the tendon with the point by reversing along the bicipital groove between the tuberosities of the humerus, without leaving the bone, as far as the coraco-acromial arch (*Figs.* 373, 374). The biceps tendon now appears from end to end of the incision. After turning on the point, the blade next follows the obliquity of the skin incision to the right, the operator raising the limb and twisting it to the left with his left hand, while he drops the right and divides the deltoid obliquely, cutting with the whole blade (*Fig.* 375).

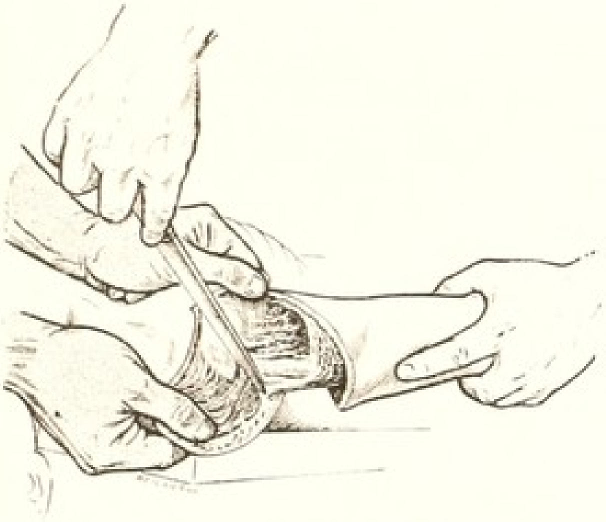


Fig. 376.

Fig. 377.

Right Side.—The assistant retracts the flaps as already described, holding them between index fingers and thumbs, while the surgeon first attacks the deltoid flap by reversing, using the whole edge of the knife, and cutting down to the bone, with the limb rotated inwards (*Fig.* 376); he then turns on the point between the tuberosities (*Fig.* 377), notes the line of the bicipital groove, and divides the pectoralis major tendon with the point of his knife along the whole length of the biceps tendon (*Fig.* 378).

Fig. 378.

An inexperienced operator (or an experienced, when a good assistant is not available to retract the edges of the wound and seize the vessels) may divide the postero-external fibres of the deltoid as described without danger, but he *should divide the anterior muscles in several successive strokes*, pinching them up between index finger and thumb before each stroke. The tissues to be

14

divided in this manner are: (1) The anterior fibres of the deltoid at the level of the skin until the pectoralis major tendon is laid bare; (2) This tendon itself close to the bicipital groove; (3) The coraco-brachialis after its sheath has been opened with a longitudinal stroke of the point.

The vascular bundle now comes into view. The artery is sought for beneath the median nerve, the first nerve to be seen, and tied below the origin of the circumflex arteries.

Freeing the Head of the Bone (*Fig.* 379).—The operator now pulls on the limb, insinuates the point of the knife on the flat beneath the coraco-acromial arch, and rounds the head of the bone from left to right, holding the limb horizontally and twisting it from right to left.

Fig. 379.

Fig. 380.

Disarticulation.—The limb is replaced alongside the trunk, twisted vigorously to the right, and the heel of the knife is applied to the left side of the head of the humerus, blade parallel to the bone, handle over the shoulder (*Fig.* 380). With little sawing movements the knife is now made

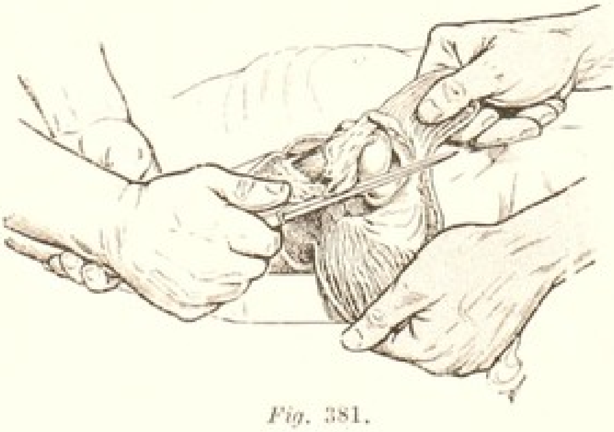


Fig. 381.

Fig. 382.

to cut forcibly on to the head of the bone, while the surgeon twists the limb to the left, exposing the capsule gradually over about three-quarters of the circumference of the head ; in this process the biceps tendon is also divided. The tissues are divided from left to right, or towards the operator, always with the heel of the blade, until a position of extreme left rotation is reached (*Fig.* 381).

Dropping the left hand, the head is next levered forwards, and behind it the operator passes his knife transversely, shaving the bone closely to divide the remainder of the posterior portion of the capsule. Transfixion is then completed, the assistant seizing the vessels at the back of the blade before they are divided. If the bone has been closely shaved posteriorly, the circumflex vessels and nerve will be uninjured behind the capsular collar.

Chapter XVI.

DISARTICULATIONS OF THE FOOT AND ANKLE.

DISARTICULATION OF THE TOES.

Anatomy.—The metatarso-phalangeal articulations are constructed on the same plan as the corresponding joints in the hand. They are situated one good finger's breadth behind the digito-plantar fold, and their normal position is slight hyperextension, so that the heads of the metatarsal bones (on which we walk) project towards the sole. On the dorsum of the foot, the joint is felt at the bottom of an angular hollow when the toe is pulled upon and moved slightly in different directions.

The *metatarso-phalangeal articulation of the great toe* is quite analogous to that of the thumb. The size of the *sesamoid bones* in the glenoid pad is noteworthy, and it must be remembered that the outer bone, which is very prominent, passes beneath the head of the second metatarsal.

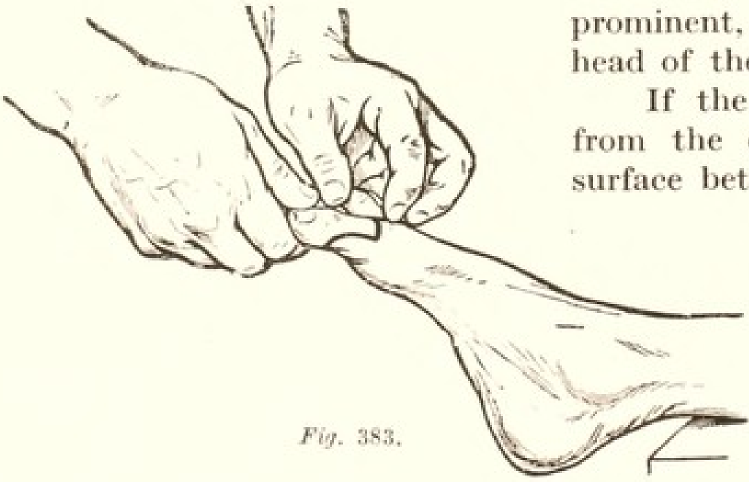


Fig. 383.

If the great toe is pinched from the dorsal to the plantar surface between thumb and index finger, and the fingers are then slipped backwards towards the heel, they are arrested by the projection of the sesamoid bones. The line of the joint lies just in front of this projection. It may be sought for also on the inner side with the finger-nail while little movements of the toe are made—flexion, extension, and especially adduction ; in this manner the line between the lateral tubercles of the phalanx and metatarsal bone (of which the metatarsal tubercle is the more prominent) is made to gape.

The operative procedure for disarticulation of the great toe will alone be described.

DISARTICULATION OF THE GREAT TOE.

Line of Incision (*Fig.* 383).—This resembles that already described for *end fingers* (see *Fig.* 252). On the left side the skin must be divided with the hands crossed (see *Fig.* 255).

The assistant, standing on the outer side, holds the base of the thigh, with the knee flexed, between his arm and side, and thus presents the foot nearly in a horizontal position.

Division of the Skin.—The surgeon, standing opposite the toes, seizes the distal phalanx of the great toe in his pronated left hand, thumb beneath the pulp of the toe, and starting with the point at the posterior extremity of the line of the dorsal incision, draws the knife along the outer side of the tendon of extensor longus hallucis as far as the middle of the dorsal surface of the proximal phalanx (*Fig.* 384).

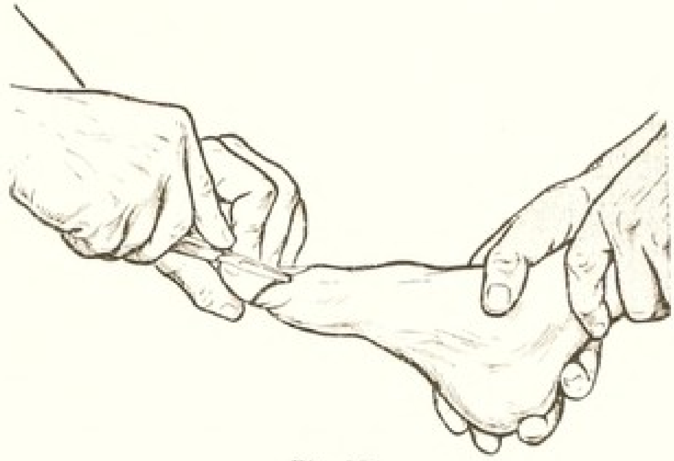


Fig. 384.

Turning then on the point, the knife is passed with little jerking movements, over the inner side of the phalanx and beneath the callosity on the distal phalanx; the assistant is asked to raise the toes by flexing the ankle-joint, and the surgeon crosses the plantar surface obliquely, as it stands vertically before him, still with little movements of the knife-point, as far as the interdigital commissure, while the foot is rotated slightly to the left (*Fig.* 385).

Fig. 385.

Second Incision.—The foot is next held by the assistant in a horizontal position, inclined to the right of the operator, who grasps the toe in the semipronated left hand, thumb over the nail, index finger beneath the pulp, the back of his middle finger pressing the second toe outwards and so stretching the commissure. He then applies the blade of the knife near its point, handle above, at the left extremity of the plantar incision (*Fig.* 386), and dropping the handle, cuts away from him from the commissure to the joint line, where he rejoins the first incision.

Fig. 386.

Dissection of the Flap.—The leg being horizontal, the foot at a right-angle to it, the sole facing the operator, the assistant holds the distal phalanx *vertically* in his right hand, like a pen-filler, without flexion or extension; the surgeon then pinches the plantar flap between the nails of his left thumb and index finger (thumb above), and dissects it backwards as far as the articular swelling, holding the scalpel like a pen, the blade parallel to the bone (see *Figs.* 139 and 140).

Fig. 387.

The *flexor tendon is next divided.*

Disarticulation. — The leg remaining horizontal, the front of the foot is dropped into a position of equinus, the assistant retracts the left lip of the incision with his right thumb, while the surgeon passes about an inch of his blade vertically into the wound, flat to the left lateral surface of the phalanx, edge towards the metatarsus, and reverses until he has felt, and passed just beyond, the tubercle at the base of the phalanx (*Fig.* 387).

Fig. 388.

The tubercle of the phalanx being cleared, the surgeon next flexes the toe a little, carries it to the right to make the joint gape on the left, and turning the blade transversely, edge to the right, he cuts towards the right with vertical sawing movements, using about an inch of the blade, dividing as he goes both dorsal ligaments and the extensor tendon, the latter fixed by the pressure of his left thumb against its right border (*Fig.* 388).

Fig. 389.

After dividing the lateral ligament, the surgeon flexes the toe still more, and twists it to the left, while with the point of the knife, blade almost horizontal, he shaves the palmar border of the posterior surface of the phalanx with several little strokes from right to left, in order to leave behind the glenoid cartilage and the sesamoid bones (*Fig.* 389).

The head of the first metatarsal bone is very bulky, and projects both downwards and forwards. It must therefore be covered by supple and mobile skin, with neither a plantar nor a dorsal cicatrix. The procedure just described, with an infero-internal flap, is much to be preferred; a symmetrical racket incision is most undesirable.

If, in the living, the skin is insufficient to cover the head of the bone, it is better to resect the head. A certain amount of support is lost, no doubt, but the inconvenience is much less than might be anticipated.

OPERATIONS ON THE TARSUS AND METATARSUS.

General Anatomy of the Bones of the Foot.—Whatever operation is to be performed on the tarsus or metatarsus, the same bony landmarks are used. These will be described in detail before each operation.

The *posterior portion of the foot* is formed by two superimposed bones, the astragalus and os calcis; their anterior extremities are in

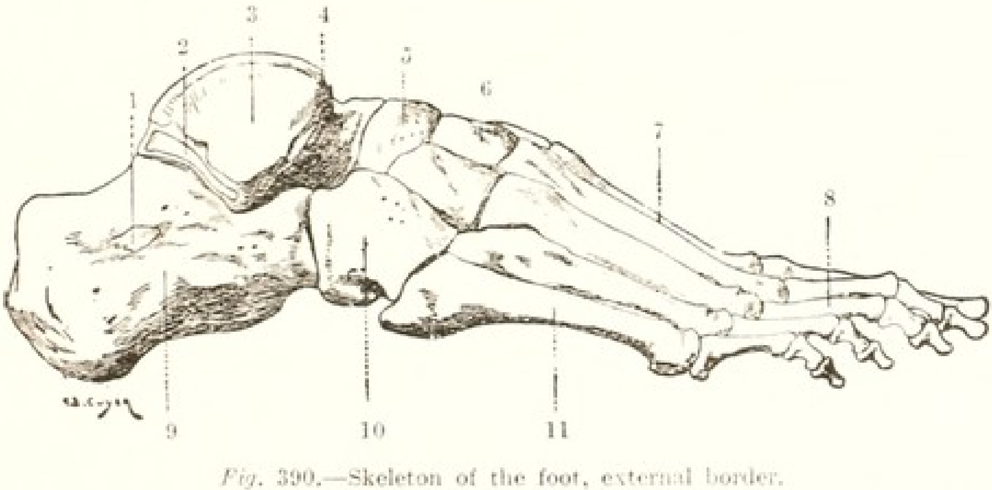


Fig. 390.—Skeleton of the foot, external border.

(1 and 9) Os calcis; (2) Posterior joint between astragalus and os calcis; (3) Surface of the astragalo-fibular articulation; (4) Neck of the astragalus above the sinus tarsi; (5) Scaphoid; (6) Middle cuneiform, to the inner side of which the internal cuneiform can just be seen; (7) Second metatarsal; (8) Phalanges; (10) Cuboid, showing the groove for the peroneus longus tendon; (11) 5th metatarsal, with its tuberosity posteriorly.

the same coronal plane, the astragalus above and to the inner side, the os calcis below and to the outer side. The posterior extremity of the os calcis, to which is attached the tendo Achillis, projects backwards for about an inch and a half, forming the heel. The astragalus is held above in the socket formed by tibia and fibula, and on either side of it descend the malleoli; the external malleolus (fibula) is more pointed, it reaches lower, and lies further behind. With the foot at a right-angle to the leg, the anterior extremity of the astragalus reaches one finger-breadth in front of the anterior border of the tibia.

The *anterior part of the tarsus* contains a single bone on the outer side, and four bones in two rows on the inner side.

On the outer side, the cuboid forms an anterior prolongation of the os calcis, and bears distally the bases of *two metatarsal bones*—the 4th and 5th. The 5th projects behind the articulation in a strong tuberosity into which is inserted the tendon of peroneus brevis. This tuberosity, often marked by a callosity, is the only projection to be found on the outer side of the foot towards the sole.

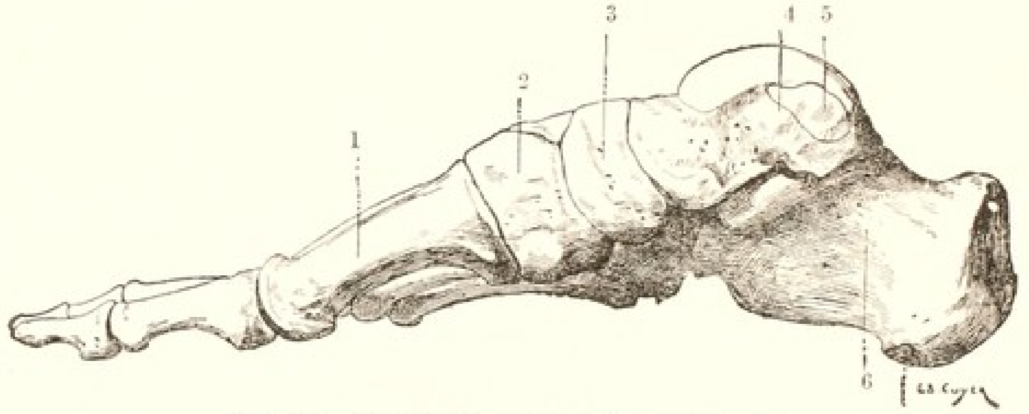


Fig. 391.—Skeleton of the foot, internal border.

(1) 1st metatarsal. Note the tubercle on the plantar aspect at the posterior extremity, situated at the mid-point of the side of the foot; (2) Internal cuneiform; (3) Scaphoid; (4) Astragalus; (5) Facette for the internal malleolus, overhanging the sustentaculum tali. This articulates anteriorly with the head of the astragalus, and the joint formed is continuous in front with the astragalo-scaphoid joint. Between the sustentaculum tali and the tuberosity of the scaphoid the head of the astragalus articulates with the very powerful calcaneo-scaphoid ligament, which completes the articular socket in the fresh state. (6) Os calcis.

On the inner side, the scaphoid bone, about one finger-breadth in width, is placed between the astragalus and the three *cuneiform bones, each of which bears the base of a metatarsal.*

Behind and towards the sole, the scaphoid forms a very marked projection at the summit of the internal arch of the foot (*tuberosity of the scaphoid*).

The internal cuneiform does not project; in front of it the 1st metatarsal bone forms the inner border of the foot, bearing at its posterior extremity *a tubercle*, which projects towards the sole and is the most prominent portion of the junction between the shaft and base of the bone.

Examination of the Foot.

1. *Line of the First Cuneo-metatarsal Joint.*—The leg being presented horizontally by an assistant, the surgeon takes the fore-part of the foot in one hand, fingers below, while he pinches the root of the great toe between thumb and forefinger of the other hand, placed outside the axis of the foot. The foot is now slightly plantar flexed, and inclined a little outwards, to render visible from above the junction of the plantar and internal surfaces of the metatarsal bone. The plantar surface of the bone is then followed from before backwards by the index finger of the hand which lies internal to the axis of the foot, and in this way the *tubercle of the first metatarsal bone* is reached (*Fig.* 392). The line of the joint lies two or

three millimetres behind this, and into the groove it forms the nail can be passed.

The line of this joint also lies at the *mid-point of the inner side of the foot*, as measured from the point of the heel to the end of the great toe. This measurement can be made with a tape (*Fig.* 393) folded in two ; if the centre of the tape and the line of the joint are marked, it will be seen that the marks are at the same level.

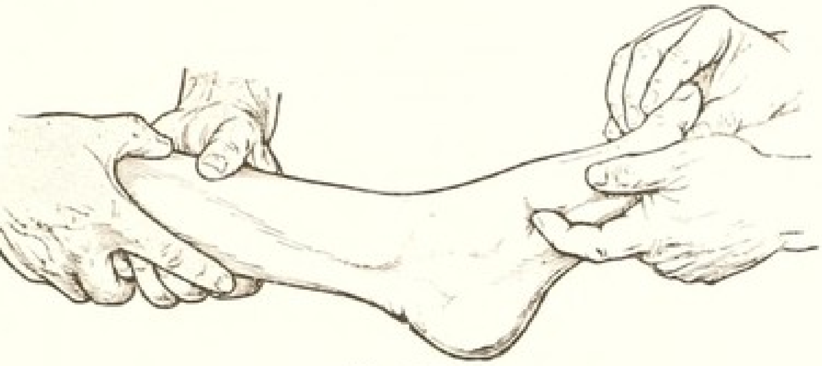


Fig. 392.

2. *Articulations of the Scaphoid.*—If the pulp of the finger is passed backwards, beneath the arch of the foot, behind the first cuneo-metatarsal joint, the under surface of the internal cuneiform is felt, then the tuberosity of the scaphoid, then, at a higher level, the internal malleolus, the last overhanging the anterior calcaneo-astragaloid joint and the fore part of the os calcis.

Fig. 393.

In adduction of the foot, the tuberosity of the scaphoid disappears, sinking into the sole towards the anterior extremity of the os calcis, while the head of the astragalus becomes prominent on the dorsum of the foot.

In abduction, on the other hand, the space between the internal malleolus and the tuberosity of the scaphoid increases, and the head of the astragalus comes to project between these two.

The line of the astragalo-scaphoid joint lies in front of the tuberosity of the scaphoid, which reaches half an inch below it towards the sole.

The articulation between the scaphoid and cuneiform bones lies about a finger-breadth in front of the astragalo-scaphoid joint.

3. *The Intermetatarsal Joints.*—In a general way the posterior extremities of the metatarsal bones are wedge-shaped, with the apex of the wedge downwards. They articulate with one another, except the 1st and 2nd, the latter of which articulates with the internal cuneiform instead of the 1st metatarsal (see Lisfranc's disarticulation, p. 227). The joints run antero-posteriorly, with a very slight obliquity downwards and outwards. In a transverse section, they radiate from the sole like the spokes of a fan; the first (between the 2nd meta-

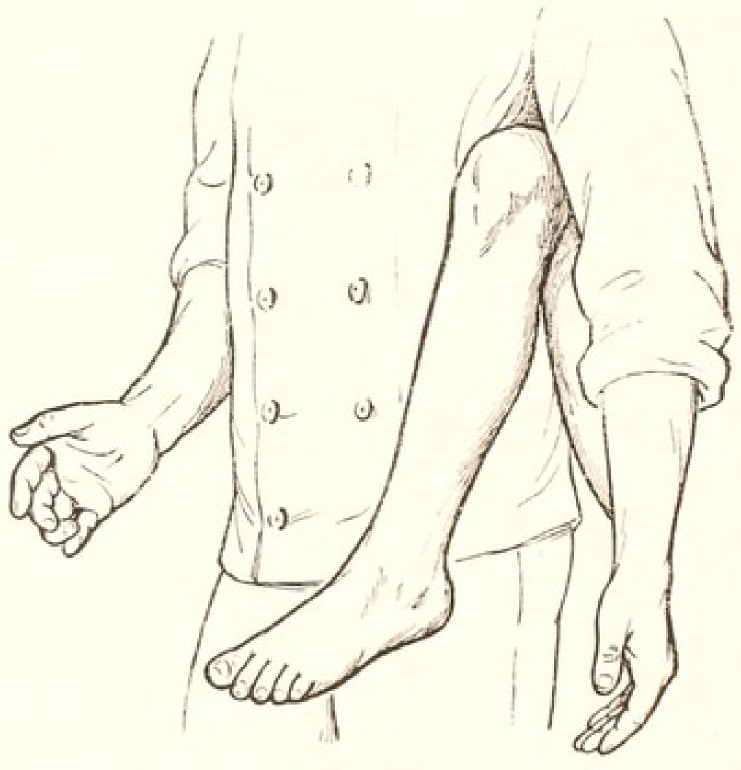


Fig. 394.

tarsal and internal cuneiform) being vertical, the last (between the 4th and 5th metatarsals) inclined at an angle of 45° to the horizontal (*Fig.* 438).

4. *The Inter-cuneiform and Cuneo-cuboid Joints.*—In a vertical direction the lines of these joints radiate like those just described; but antero-posteriorly they run obliquely backwards and inwards.

5. *The Tuberosity of the 5th Metatarsal Bone on the Outer Border of the Foot* (see p. 225).

6. *Dorsum of the Foot.*—The prominences caused by the tendons must be noted: the *tibialis anticus tendon*, running obliquely downwards and inwards, crosses the scaphoid to reach the inner side of the internal cuneiform; while the *tendon of extensor longus hallucis* is seen over the dorsum of the 1st metatarsal.

7. *The Malleoli.*—At the sides of the foot posteriorly the malleoli may be felt, the external reaching lower and lying slightly behind the internal. Between them lies the line of the tibio-tarsal joint.

Position of Assistant and Patient.—The patient is placed so that the leg and lower two-thirds of the thigh project beyond the table ; the assistant stands to one side of the limb, which is flexed at the knee, and squeezes the thigh between his elbow and trunk, at a greater distance from the knee the less the joint is flexed. In this manner both his hands and forearms are left free to support the leg or the ham, to hold the foot, retract the skin, or present the limb in whatever position the operator may wish (*Fig.* 394).

DISARTICULATION OF THE FIRST METATARSAL.

Anatomy.—The internal cuneiform presents to the 1st metatarsal bone an oval surface, practically flat, with the long axis vertical. The posterior extremity of the metatarsal bone ends in two projections, a small internal *tubercle* (see page 216), and a large external tubercle, which is a continuation of the external border of the bone, and reaches obliquely backwards under the 2nd metatarsal. Into this is inserted the tendon of the peroneus longus.

On the back of the foot the line of the joint runs obliquely forwards and outwards ; if continued, it would cut the 5th metatarsal bone about the middle.

The *ligaments* are not very strong. On the inner side they are strengthened by an expansion of the tibialis anticus tendon ; to the outer side, on the plantar surface, the tendon of peroneus longus, and its expansion to the internal cuneiform, have to be divided.

Examination.—See page 216.

General Instructions.—As previously stated, in order to lay bare and to disarticulate the bone, the extremity of the limb should lie to the operator's left, and he should therefore stand on the inner side for the right limb, on the outer side for the left. In this position it is easy to 'cut the throat' of the metatarsal—that is, to divide the short muscles and the flexor tendon—then to shave the bone from before backwards.

The surgeon may stand as described above *throughout the operation*, commencing the incision at the commissure on the plantar aspect of the foot, as represented for the 5th metacarpal bone on page 169.

Or he may stand at the end of the limb to commence with, this being held straight before him on the right side and to his left on the left side. This is the method represented here. The surgeon *then passes to the side of the limb* for the second part of the incision, and there he remains.

The assistant stands on the outer side, and presents the foot as described above.

It is possible to complete the operation from the end of the limb, clearing the bone by the Liston stroke (see p. 175) ; but the considerable projection of the head of the bone makes this difficult, and it is better to proceed with enucleation in the usual way.

Line of Incision.—The line of incision is a racket, with the extremity of the handle turned inwards, and with the internal shoulder shaped anteriorly to form a flap, as usual for ead toes or fingers.

The incision commences close to the sole, over the inner tubercle of the metacarpal bone—two or three millimetres, therefore, in front of the joint—and passes nearly vertically over the inner border of the foot (sloping just a little forwards and outwards, like the joint), as far as the extensor tendon, alongside which it then runs as far as half-way down the proximal phalanx. The incision then turns bluntly towards the sole, which it reaches about one finger-breadth beyond the digito-plantar fold, and crosses the plantar surface obliquely to the interdigital commissure, over which it passes, remaining on the toe to be removed. Finally, it rejoins the handle of the racket, in a very pointed **V**, rather more than an inch in front of the point where it first bent forwards (*Fig.* 395).

Division of the Skin.

Right Side.—Exposing the internal border of the foot as already described, and standing at the extremity of the limb, commence the incision with the point of the knife perpendicular to the border of the foot, edge to the left, handle above, right hand flexed and pronated (***Fig.*** **396**).

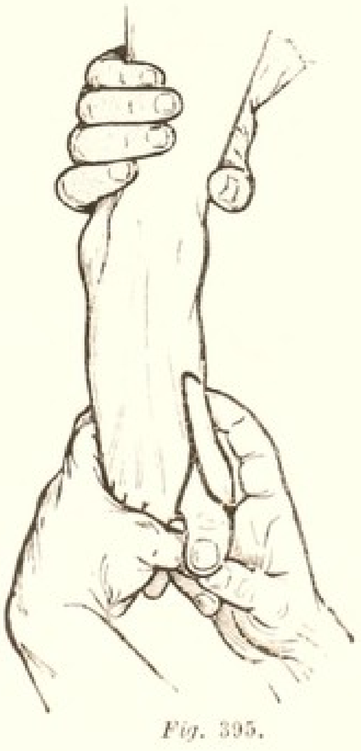


Fig. 395.

Fig. 396.

After turning on the point, draw the incision straight forwards as far as the middle of the proximal phalanx (*Fig.* 397).

The division of the internal and plantar skin, and the second incision on the dorsum, along the outer shoulder of the racket, are carried out as for disarticulation of the great toe (see p. 212).

Left Side.—The operator, seizing the great toe in his pronated and flexed left hand, his left elbow raised, exposes the inner border of the foot by carrying and bending it outwards (towards his right). Then, with the pronated right hand crossing beneath the left wrist, he applies the point of his knife at the end of the curve of the handle of the racket (*Fig.* 400).

On this side as on the other, after turning on the point at the rounded angle of the handle, the surgeon draws a straight incision as far as the middle of the proximal phalanx, which is held quite straight, without flexion or extension (see *Fig.* 397).

Fig. 397.

Fig. 398.

Fig. 399.

Then, raising the foot until the sole faces him, he turns, and crosses the plantar surface as in disarticulation of the great toe (*Fig.* 401).

The incision is repeated as before, in order completely to liberate the skin ; the assistant then drops the foot to a horizontal position, and the operator moves to the outer side of the limb, so that the toes lie to his left. Now with his left hand, which has never released the toe, in supination, he flexes the toe and moves it to the left, while with the tip of his middle finger he presses against the inner surface of the second toe, so keeping the commissure tense, and allowing it to be divided easily along the outer shoulder of the racket, reversing with the blade from heel to point (see *Fig.* 398).

Fig. 400.

During this stroke, or in a second over the same ground made to free the skin, *the extensor tendon is divided at the level of the skin* (see *Fig.* 399), stretching it over the bone by flexion of the toe. If necessary, it can be divided by transfixion (see *Fig.* 297).

Fig. 401.

Clearing the Metatarsal Bone.

Left Side.—Standing on the outer side of the limb, begin by clearing the interosseous border from end to end. First divide the intermetatarsal ligament between the heads of the 1st and 2nd metatarsals ; then, wedging apart the heads of the bones with the thumb, free the outer sesamoid bone. This lies partly beneath the head of the 2nd metatarsal; the blade must therefore pass in that direction,

Fig. 402.

Fig. 403.

while the handle of the knife is inclined away from you (see *Fig.* 403, right side). Then, with a stroke of the knife from left to right, the tissues are separated from the bone by shaving the interosseous side of the metatarsal with an inch of the point.

The inner surface of the bone has next to be freed. To achieve this, the toe is entrusted to an assistant, who holds it horizontally in his left hand, while the operator raises the digito-plantar flap as far as the head of the metatarsal bone, the blade on the flat between skin and bone (*Fig.* 402, right side). Having reached the insertion of the muscles to the inner sesamoid bone, turn the knife against the bone, and *cut the throat* of the

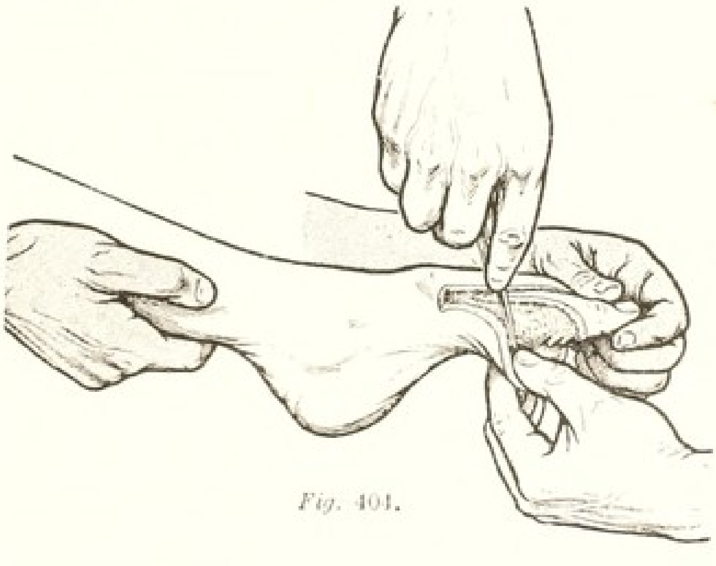


Fig. 404.

Fig. 405.

metatarsal (*Fig.* 404). Taking the flap again between the finger and thumb, strip the tissues from the plantar surface of the bone with one or two strokes of the knife, using about an inch of the point, the blade again flat against the bone (*Fig.* 405). On reaching the joint, enter it from within outwards (*Fig.* 407).

Fig. 406.

Right Side. — The steps are similar, but the operator begins by raising the plantar flap, and standing on the inner side of the limb, he enters the joint from without inwards (*Fig.* 406).

Fig. 407.

Disarticulation.—The rules for this step are the same as in metacarpo-phalangeal articulations. The blade is applied against the base of the metatarsal, and the line of the joint is followed transversely (or with a slight obliquity, if the line is to be followed accurately). Finally the bone is twisted well to the left, and the plantar ligaments and the tendon of peroneus longus are divided with little strokes of the point (*Fig.* 408). The leverage for the requisite torsion is much increased if the toe is held flexed to a right-angle in the operator's left palm.

Fig. 408.

On the left side (*Fig.* 407), the joint is entered perpendicularly to the edge of the foot ; but *on the right side*, in order to enter the joint from its outer aspect, the blade must first be applied obliquely against the outer side of the 1st metatarsal, so as to engage the point beneath the 2nd metatarsal (see *Figs.* 415, 416).

DISARTICULATION OF THE FIFTH METATARSAL.

Anatomy.—The 5th metatarsal bone articulates: (1) With the cuboid behind; (2) With the 4th metatarsal on the inner side. Both these joint surfaces are flat.

The *articulation with the cuboid* lies in a vertical plane. It runs obliquely forwards and inwards at an angle of about 45° to the axis of the foot, and the line of the joint, if prolonged, would cut the 1st metatarsal bone about the middle.

The tuberosity of the 5th metatarsal overlaps the outer border of the joint for half an inch; into this is inserted the strong tendon of peroneus brevis, forming the only *ligament* of importance to the surgeon. The plantar ligaments are strong, and the weak dorsal ligaments are strengthened by the tendon of peroneus tertius, but their division presents no difficulty.

The *line of the intermetatarsal joint* is practically antero-posterior as seen from the dorsal surface, but slightly oblique backwards and outwards. From below it passes upwards and outwards at an angle of 45° with the horizontal. As the removal of the middle metatarsal bones will not be described, and the posterior articulations of the metatarsals will be considered with Lisfranc's disarticulation, it may here briefly be explained that the posterior extremities of the metatarsal bones are wedge-shaped, with the apex downwards, and that the lines of the joints radiate from the sole of the foot like the spokes of a fan. The joint between the 2nd metatarsal and internal cuneiform is vertical (see Lisfranc's operation); the succeeding joints tend more and more to the horizontal, until the last, between the 4th and 5th metatarsals, is inclined at an angle of 45° with the vertical.

These articulations are supported by some unimportant dorsal fibres, and by stout *plantar interosseous ligaments*, situated below and in front of the articular surfaces.

Examination.—The dorsal surface of the 5th metatarsal bone

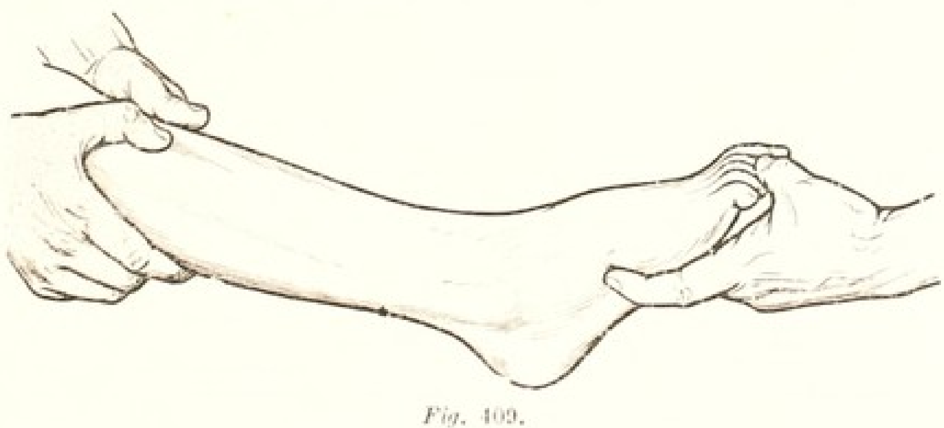


Fig. 409.

can be directly palpated from the outer side; it lies superficially on the dorsal aspect of the outer border of the foot, separated from the skin by the extensor tendon only. The plantar muscles (short muscles of the little toe) cover it, forming a pad along the line where the thick plantar skin joins the thin dorsal skin. If the bone is followed with the pulp of the index finger from before backwards, the prominent tuberosity of the metatarsal is reached, often marked by a callosity, and behind this the finger falls into a depression corresponding to the external surface of the cuboid (*Fig.* 409).

Line of Incision.—A straight-handled racket incision is used, with a little internal flap over the dorsum of the proximal phalanx.

Fig. 410.

Starting from a point half an inch behind the tuberosity, over the palpable bony surface (towards the back of the foot, therefore), the line of the incision runs straight along the dorsum of the foot as far as the first interphalangeal joint. Turning thence inwards in a rounded right-angle, the commissure is soon reached, and the racket is closed by passing backwards and outwards along the digito-plantar fold, and rejoining the straight portion of the incision about the middle.

Fig. 411.

The handle of the racket must lie *over the bone*, towards the dorsum of the foot, as shown in *Fig.* 410, so that the skin is divided above the plantar tissues, which will otherwise project and give a result that is most ugly.

The bone may be cleared by the Liston stroke, or enucleated. An ordinary scalpel is the best to use.

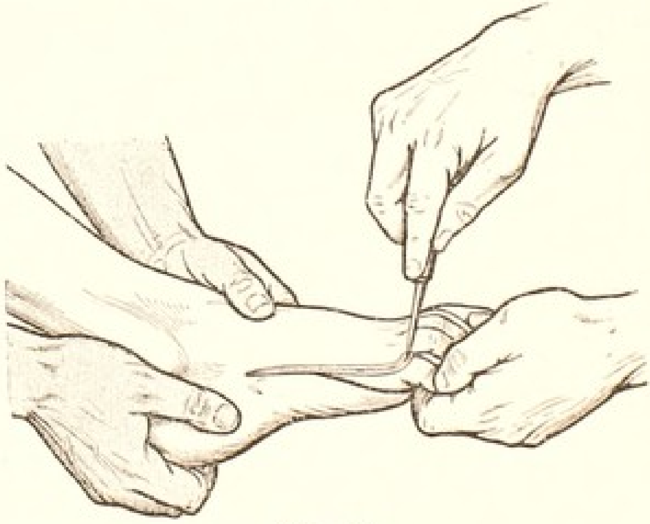


Fig. 412.

Division of the Skin.—The operator stands at the end of the limb, and commences with hands parallel on the right side, but crossed on the left, in order to cut the flap without interruption. He then moves so that the extremity of the toe lies to his left (standing on the inner side for the right toe, therefore, on the outer side for the left), and divides the external skin together with the extensor tendon. This position enables the surgeon subsequently to *clear the sides of the metatarsal and cut its throat*, exactly as represented for the great toe.

Disarticulation.—The knife, directed away from the operator obliquely towards the tarsus, is passed between the 4th and 5th metatarsals. The plane of the joint is inclined to the horizontal at an angle of 45° (see *Fig.* 438), so that the joint is made to gape, and the passage of the knife facilitated by pressing with the thumb on the

Fig. 413.

Fig. 414.

flexed and abducted metatarsal bone (*Fig.* 413). In this manner the interosseous fibres almost divide themselves; the blade is then pushed onwards a little, and the line of the cuboid-metatarsal joint, running obliquely at an angle of 45° backwards and outwards, is entered without difficulty. The bone is then only held by the tendon of peroneus brevis, and this is divided by bending the metatarsal backwards over the dorsum of the foot, while the operator directs the blade towards himself (*Fig.* 414).

TARSOMETATARSAL DISARTICULATION
(Lisfranc's Disarticulation).

Anatomy.—The two important points to know are: (1) The exact position on the dorsum of the foot of the line of the articulations; (2) That in addition to the dorsal ligaments, there is a powerful ligament between the external lateral surface of the internal cuneiform and the internal lateral surface of the base of the 2nd metatarsal bone (Lisfranc's ligament).

The first step in disarticulation is to cut the dorsal ligaments, and thus to enter the joint; the second is to divide Lisfranc's ligament; the fore part of the foot can then be depressed and the plantar tarsometatarsal ligaments easily detached.

1. *The Dorsal Line of the Joints.*—The metatarsal bones articulate: the two outer with the cuboid, the three inner with the three cuneiform bones.

The cuboid bears the 4th and 5th metatarsals. The line of the 5th joint, which is about half an inch broad, runs obliquely forwards and inwards at an angle of about 45° with the transverse diameter of the foot ; if prolonged, this line would cross the first metatarsal bone about the middle. The tuberosity of the 5th metatarsal bone, into which is inserted the tendon of peroneus brevis, projects beyond the joint posteriorly for a distance of half an inch. The line joins that

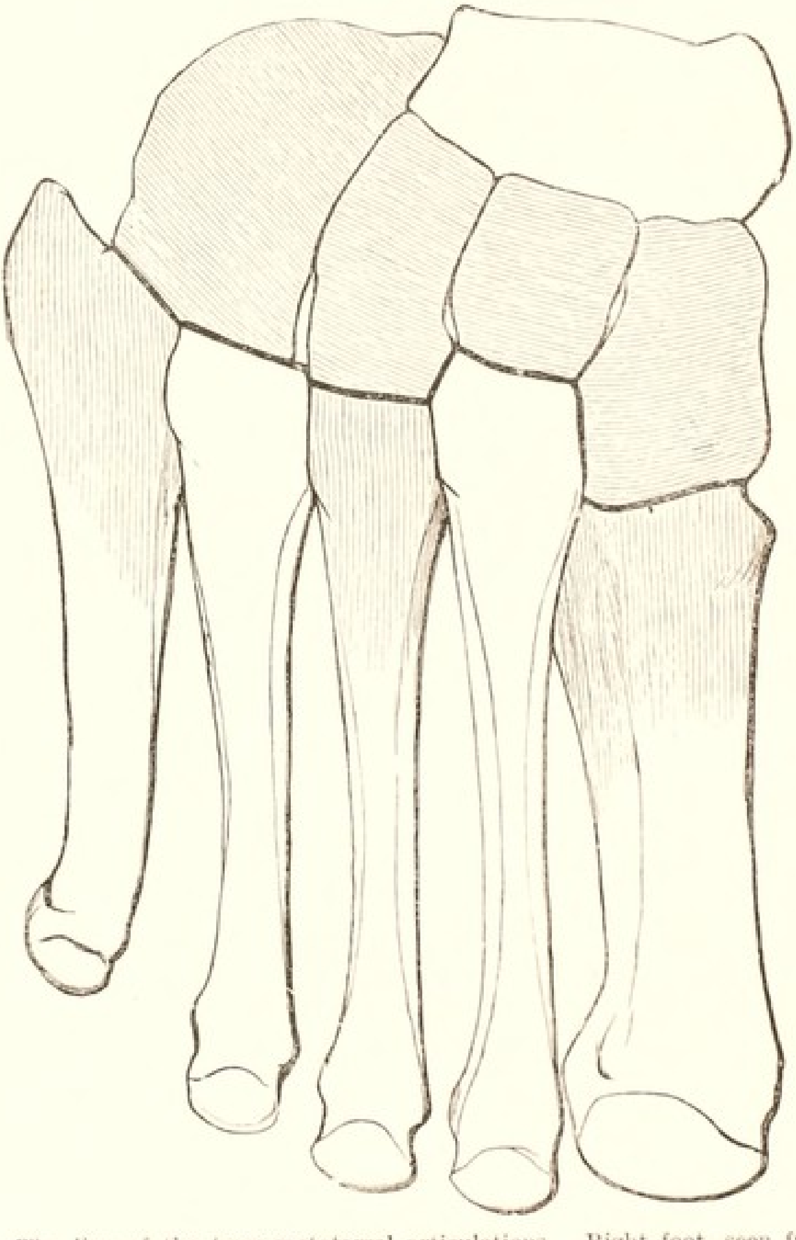


Fig. 415.—The line of the tarso-metatarsal articulations. Right foot, seen from above. (The reader should follow the interline in both directions with a dry pen or a pencil.)

of the 4th joint, which is more transverse and slightly posterior, at a very obtuse angle.

The line of the 4th joint, if prolonged, does not pass over the 3rd joint (between the 3rd metatarsal and the external cuneiform), but cuts the side of the cuneiform two to three millimetres behind its anterior extremity, which projects to this extent beyond the cuboid. At the point of contact between the 4th metatarsal and the external cuneiform there are a few weak ligamentous fibres.

The line of the 3rd joint, which is half an inch broad, is transverse; a prolongation of it would cut the base of the 2nd metatarsal.

The 2nd metatarsal is imprisoned by the three cuneiform bones as follows: The three bones form a socket, the floor of which is formed by the middle cuneiform, the inner side—anteroposterior and half an inch long—by the internal cuneiform, and the outer side—a quarter of an inch long and oblique forwards and outwards—by the external cuneiform. The length of the outer side is less constant than that of the inner. The dorsal half of the surfaces forming the socket is articular, the plantar half is fixed to the metatarsal bone by interosseous fibres. The external ligament is weak, but the internal (Lisfranc's ligament) is very strong.

The line of the 1st tarso-metatarsal joint has already been considered (p. 219); it is situated two or three millimetres behind the tubercle on the inner side of the plantar surface of this bone. As

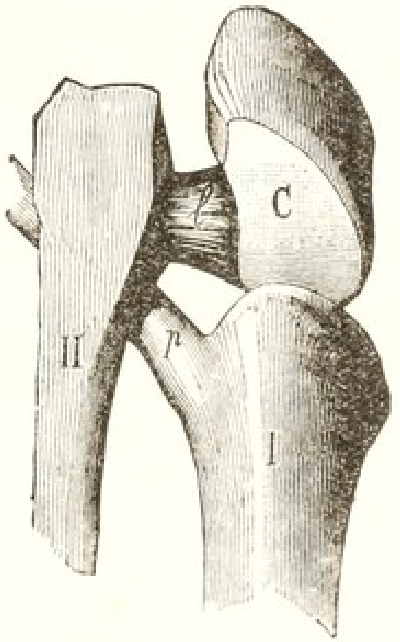


Fig. 416.—Diagram of the inner portion of the 1st *right* tarso-metatarsal joint, with the bones separated.

C. Internal cuneiform; I. 1st metatarsal; II. 2nd metatarsal; *p*. Tendon of peroneus longus attached to the outer tubercle of the 1st metatarsal; *l*. Lisfranc's ligament, lengthened by the diagrammatic separation of the bones. The back of the point of the knife should rest against *p*, so that the edge may divide *l*.

seen from the dorsum of the foot, the line is slightly oblique forwards and outwards, and would, if prolonged, reach the 5th metatarsal bone about the middle.

Apart from Lisfranc's ligament, it is unnecessary to study in detail the ligaments of these joints. On the dorsum of the foot they are weak, and should be divided by the surgeon transversely. On the sole, however, they form a thick fibrous cushion connected with the sheath of the peroneus longus tendon. The plantar surface of the metatarsal bones must be shaved closely in order to leave this cushion in the flap, as will be described on p. 246.

For a description of the tendons of peroneus brevis and tibialis anticus, see pp. 218, 219, and 227.

2. *Lisfranc's Ligament.*—It is necessary to know exactly the *mode of union between the base of the 2nd metatarsal bone and the outer surface of the internal cuneiform.* The dorsal half of the surfaces in

contact is occupied by articular cartilage, the plantar half by a powerful transverse ligament. Until this ligament is divided, the metatarsus cleaves solidly to the tarsus. It can only be divided from below upwards, the dorsal joint surfaces being too closely in contact to allow the blade to pass from above downwards. The division is carried out by what is known as the *coup de maitre*, and this can only be done correctly if the operator remembers accurately the connections of this ligament with the base of the metatarsal bone and the tendon of peroneus longus.

The outer surface of the 1st metatarsal bone is nearly vertical; posteriorly, as it reaches the enlarged base of the bone it becomes oblique from above on the inner side, downwards and outwards, and it terminates below in the tubercle to which is attached the tendon of peroneus longus. This tendon enters the groove under the cuboid at the outer border of the foot, and passes obliquely forwards and inwards, beneath the posterior extremities of the 3rd and 2nd metatarsals, to its attachment. The process into which it is inserted, and

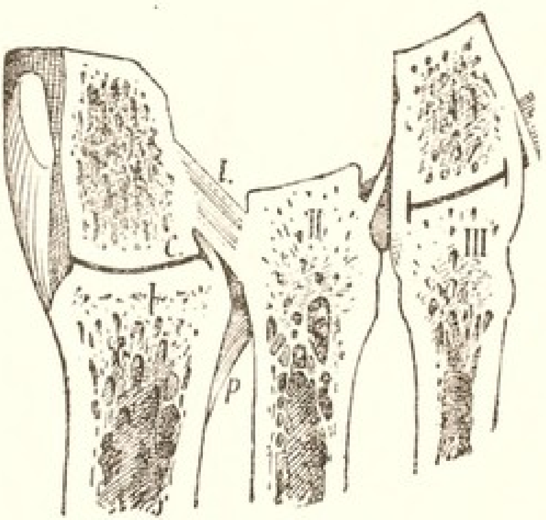


Fig. 417.—Horizontal section of the 1st and adjoining tarso-metatarsal joints on the *left* side.

The letters and figures correspond to those in *Fig.* 416. Note that a few fibres only, surgically unimportant, pass from *l* to the 1st metatarsal. Note also that fibres pass from the external cuneiform to the 2nd and 4th metatarsals as well as to the 3rd. These are sometimes strong enough to require a special stroke of the knife.

the adjoining portion of the outer surface of the 1st metatarsal bone, lie beneath the plantar surface of the 2nd metatarsal; this may be understood if the reader imagines the bones, which are represented separate in *Fig.* 416, replaced in position.

It is only exceptionally that a real articulation exists between the 1st and 2nd metatarsal bones, but the bones are in contact nevertheless for a length of about three-quarters of an inch. The line of contact on the dorsal surface runs obliquely backwards and inwards from the upper extremity of the first interosseous space to the antero-external angle of the internal cuneiform.

To enter this space with the knife, it is necessary:—

1. To direct the point, with the edge uppermost, along the outer side of the first metatarsal, the axis of the blade running obliquely backwards and outwards towards the external malleolus.

2. To incline the edge inwards towards the internal malleolus.

Examination.—The *bony landmarks* are:—

1. On the inner border of the foot, the tubercle of the 1st metatarsal bone, found as described on p. 216 (*Figs.* 392, 393).

2. On the outer border of the foot, the tuberosity of the 5th metatarsal bone, found as described on p. 225 (*Fig.* 409).

These points may be palpated simultaneously with the two index fingers, in the following manner. The foot being presented in a horizontal position, the surgeon grasps the fore-part of the foot in his two hands, thumbs across the dorsum over the heads of the metatarsal bones, the three outer fingers beneath the sole; the index fingers, flexed slightly, are then made to follow with the pulp the corresponding metatarsal bones from head to base, at the junction of the bone with the soft parts of the sole.

Fig. 418.

In *Fig.* 418 the fingers are seen placed on these landmarks, and it will be noticed that the inner finger is about two finger-breadths in front of the outer. It must however be remembered that the tubercle of the 1st metatarsal bone is one or two millimetres in front of the joint line on that side, while the tuberosity of the 5th metatarsal projects for half an inch behind the outer extremity of the 5th tarso-metatarsal joint.

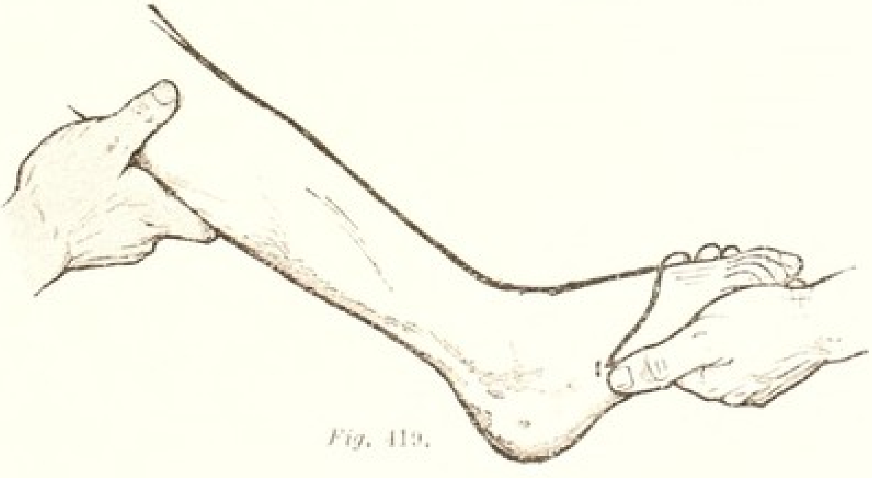


Fig. 419.

Line of Incision.—A *plantar flap* is to be made. On the *dorsum of the foot*, the line of the incision starts from the inner border, one inch in front of the tubercle of the first metatarsal, nearer to the dorsum than the sole, and a little inside the tendon of extensor longus hallucis. From this point it runs transversely outwards to the middle of the 2nd interosseous space, then curves gently backwards to reach the outer border of the foot approximately over the tuberosity of the 5th metatarsal (or half an inch in front of this if the operator is an expert ; the final result is better). This end of the incision also should lie more on the dorsum than on the sole of the foot, over the palpable surface of the bone, and should not reach the plantar muscles (*Fig.* 419).

Between these two extremities, the *plantar incision* follows longitudinally from end to end the metatarsal bone at each border of the foot, and crosses the foot at the anterior extremity of the sole, reaching nearly to the digito-plantar folds.

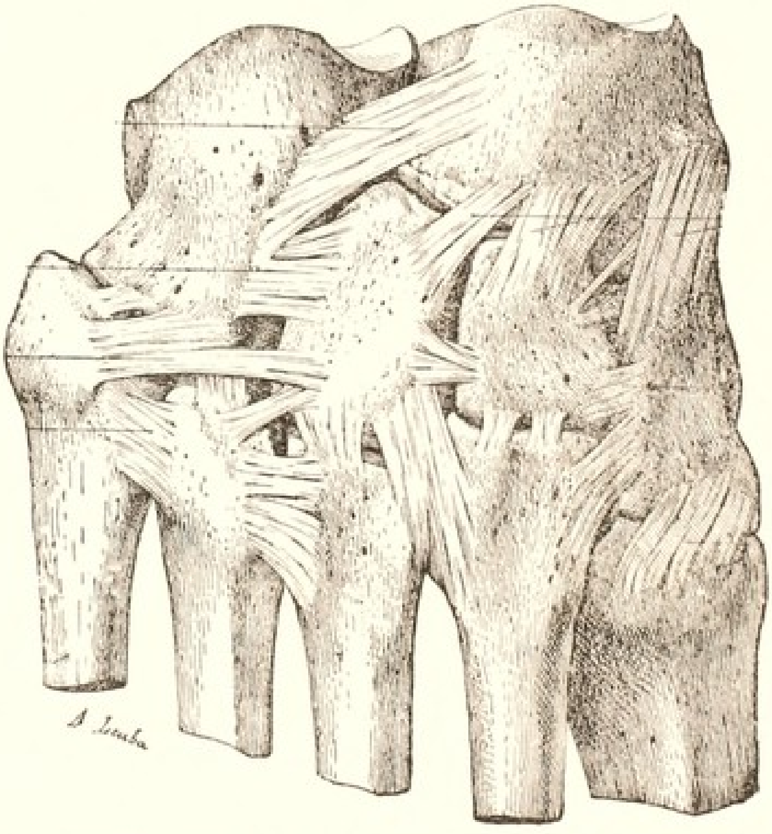


Fig. 420.—Dorsal view of the tarsus and tarso metatarsal articulations.

Principal Steps of the Operation :—

1. Division of the dorsal skin.

2. Division of the plantar skin, followed by dissection of the flap as far as beneath the heads of the metatarsal bones.

3. Disarticulation.

4. Transfixion of the plantar flap.

The knife used should be six inches long, half an inch broad, and *the point on a level with the rest of the edge*, this being essential for the performance of the *coup de maitre*.

The limb is dragged beyond the table, and the assistant, placed on the outer side, presents it as described on p. 219.

Division of the Dorsal Skin.—The surgeon, placed at the extremity of the limb, grasps the sole of the foot in his supinated left hand, thumb over the left landmark, index finger over the right landmark, the pulp of the fingers towards the dorsal surface, so that the dorsal skin is made tense when the fingers are approximated. The forefinger remaining in place, the thumb is withdrawn an inch (*Figs.* 419, 421).

Fig. 421.

Fig. 422.

The assistant applies the palm of one of his hands over the ankle and stretches the skin with the ulnar border of his hand, while with the other hand under the calf he supports the limb and maintains the foot in a horizontal position (*Fig.* 421).

Beginning at the left border of the foot with the heel of the knife, point downwards, handle above, index finger stretched along the back of the blade, the surgeon draws the knife from left to right over the dorsum of the foot, ending at the right border with the point, knife vertical, handle below (*Fig.* 422). At the commencement of this incision he twists the limb somewhat towards his right, and at the end towards the left. The knife is held lightly as it crosses the back of the foot, so that the handle can turn a little between the fingers, until at the end it is held like a violin bow and the index finger is no longer stretched along the blade (*Fig.* 422).

If possessed of sufficient dexterity, the surgeon can next reverse over the same incision, still holding the knife like a violin bow, passing from right to left, from the point to the heel of the knife, while the assistant retracts the skin. In this way the connective tissue, and the dorsal tendons even, may be divided.

Division of the Plantar Skin.—The assistant removes the hand previously placed over the ankle, and places it instead a little above the malleoli, behind the leg, which is thus presented in a horizontal position.

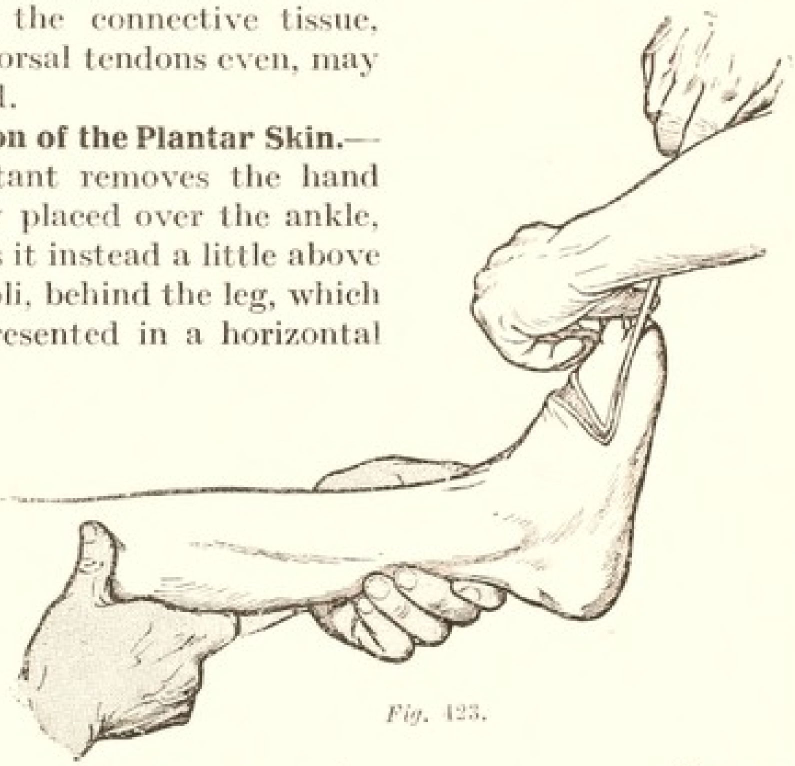


Fig. 423.

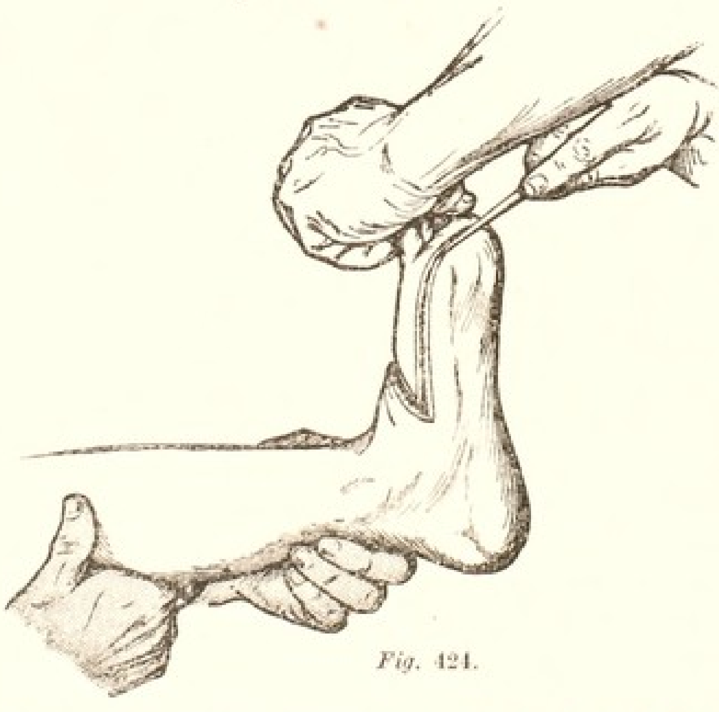


Fig. 424.

The surgeon takes the toes in his flexed and pronated left hand, the thumb on the plantar surface, the fingers over the dorsum, and, with the foot vertical, dorsiflexes the toes and carries them upwards. Then, raising the left elbow, he inclines the foot towards the right, and with his right hand under the left, draws an incision along the left border of the foot as far as the digito-plantar groove (*Fig.* 423). He now turns on the point of the knife, at the same time bringing the foot back to a vertical position, and divides the plantar skin somewhat obliquely with the point of his knife in little sawing movements (*Fig.* 424).

Arrived at the right border of the foot, he inclines it to the left by dropping his elbow again, and reverses along this border until he rejoins, with the point of the knife, the corresponding extremity of the dorsal incision (*Fig.* 425).

Fig. 425.

Special attention must be paid to the angle where the palmar and dorsal incisions meet, to see that the skin is completely divided. The flap must be very broad in front ; it is important, therefore, that the incision should not turn to cross the sole at the neck of the bones, but should continue forwards until the side of the head of the metatarsal has been reached.

Dissection of the Plantar Flap.—The assistant takes the toes in the hand which was supporting the lower part of the leg, thumb above, and presenting the leg horizontally, keeps the toes vertical—

Fig. 426.

without hyperextension, which would make the heads project towards the sole. The foot is then inclined to the right.

The operator now having the sole of the foot directly in front of him, hooks open the lower lip of the plantar incision with his finger-

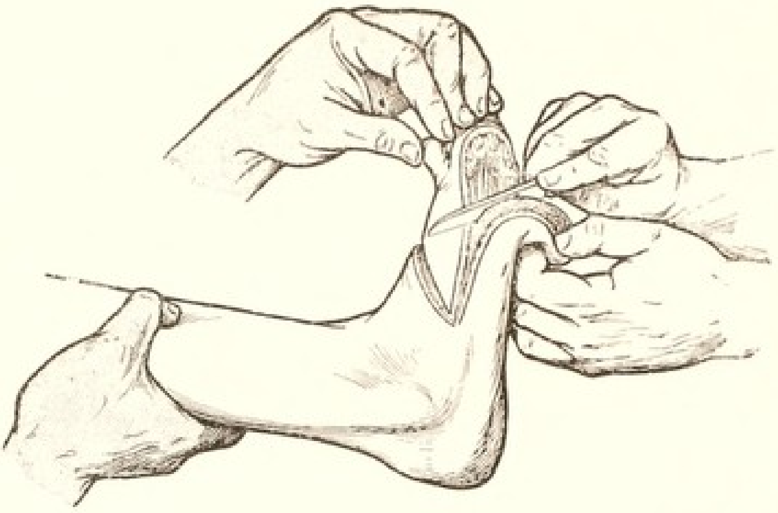


Fig. 427.

Fig. 428.

Fig. 429.

tips, thumb under the sole; then raising his right elbow, the right hand pronated, he thrusts the point of his knife under the body of the metatarsal bone, the blade flat between the bone and the short muscles. He then draws the knife towards him, using about two inches of the blade, until the head of the metatarsal is reached (*Fig.* 426).

Turning on the point of the knife, and holding down the plantar flap with the thumb, he next divides the plantar fat, cutting with the whole blade, until a point is reached well behind the heads of the metatarsal bones. It must not be forgotten that the head of the 1st metatarsal projects strongly towards the sole, and is considerably in front of the head of the 5th metatarsal (*Fig.* 427).

The blade is next inclined so that the edge is towards the bones, and with sawing movements of the whole blade, following also the obliquity of the metatarso-phalangeal line, the throats of all the metatarsal bones are cut; special care being taken to divide the muscles attached to the 5th and 1st bones. This stage is ended by reversing beneath the body of the metatarsal to the right, the blade flat beneath the bone, while the assistant exposes the spot by inclining the foot to the left (*Fig.* 429).

Right Side.—The incision commences beneath the 5th metatarsal, and after turning on the point at the side of the head of this bone, the surgeon raises his elbow and directs the blade obliquely upwards and to the right from the head of the 5th to that of the 1st metatarsal. The knife is then passed: (1) Obliquely towards the ankle until the heads of the bones are felt (*Fig.* 427); (2) Perpendicular to the necks when the heads have been passed (*Fig.* 428).

In carrying out this procedure the whole of the blade should be used, with sawing movements, the point reaching beyond the left border and the heel beyond the right border of the flap, which is retracted by the left thumb.

The short muscles must be detached carefully from the two outside metatarsal bones, especially from the first, from end to end, and close to the bone; otherwise, when the operation has been completed by plantar transfixion, two ugly tongues will remain at the edges. Some surgeons advise dissecting the flap right under the plantar surface of the articulations, so that there is no necessity for transfixion; but by so doing the fibrous tissues which form a musculo-tendinous pad posteriorly are sacrificed (less important, it is true, in this operation than in a Chopart); moreover, the procedure is not so neat.

Left Side.—The incision commences beneath the 1st metatarsal, and it must be remembered that the head of this bone is very large, and more difficult to round with the knife than the head of the 5th metatarsal. After reaching the head of the bone, the operator lowers his elbow so that the heel of the knife lies opposite the head of the 5th metatarsal and the direction of the blade is obliquely upwards and to the left (*Fig.* 429). This position must be maintained while the heads of the bones are being rounded, and afterwards in the action of cutting their throats.

Beginners make this liberation in several strokes, experienced operators in a single stroke. It is the same movement as that made use of to free the head of the 1st metacarpal bone.

Before proceeding to disarticulate, the *dorsal skin must be completely freed*, and attention must be directed to two points: (1) That all the tendons are divided; (2) That the skin is so well retracted at the two extremities of the wound, especially over the 1st metatarsal, that ready access is possible to the joints on the dorsum and *at the borders of the foot*. If the skin is not supple, or the assistant is not sufficiently adroit, beginners would act wisely to turn back a cuff, half to one inch in length, over the internal cuneiform and at the angles of the dorsi-plantar junction.

The liberation of the skin must obviously be easier to carry out if the dorsal incision begins near to the sole, at the appropriate border of the foot, But this is likely to give an unsatisfactory result, especially on the inner side, where the internal cuneiform bone is very prominent: the bone is not adequately covered, and the plantar flap is narrow at the base, and very ugly. On the outer side, where the tuberosity of the 5th metatarsal bone projects behind the obliquely sloping anterior end of the cuboid, the drawbacks of the method are not so marked. The cutaneous angle should be arranged to form a tiny pocket, in which the projecting bone can be hidden.

To retract the skin, the assistant may use the ulnar border of his hand, applied transversely over the dorsum of the foot as shown in *Fig.* 421, when the incision is being made; or, as represented in *Figs.* 430–436, he may use the two thumbs applied over the dorsum of the foot, the fingers beneath the os calcis. He should hold the base of the femur between one of his arms (left for the right side, right for the left side) and his trunk, as shown in *Fig.* 394, so that his hands are free. The knee is flexed at an acute angle; the leg, therefore, hangs nearly vertically, and the dorsum of the foot projects nearly horizontally before the operator. The knee is a very mobile joint, so the obliquity of the leg can easily be altered.

Fig. 430.

Disarticulation.

Right Side.—With the foot at right angles to the leg, and lowered to a convenient position, the operator grasps the fore-part of the foot in his left hand, thumb above, marking with his index finger the dorso-external surface of the 5th metatarsal. He then applies the flat of the blade, using about an inch of the point, edge away from him, against the outer side of the tuberosity of the metatarsal, just beyond the index finger-nail, and follows the bone backwards with the knife, the foot placed slightly in the varus position, until the resistance of the tuberosity has been passed (*Fig.* 430). The knife is then turned through a right-angle, edge to the right, and the tendon of peroneus brevis divided.

Fig. 431.

Now, pressing with the left hand on the front of the foot, and maintaining it in the same position, the surgeon enters the joint between the cuboid and 5th metatarsal bone, the knife sloped somewhat towards him, the edge aiming for the middle of the 1st metatarsal (*Fig.* 431). The point is moved to the right with slight jerking movements, in contact with the metatarsal, until arrested by the very slight projection (about one millimetre) of the 4th metatarsal ; round this it is carried without effort, and continues transversely until again arrested, this time by the external cuneiform. To round this the blade is brought two millimetres towards the operator, and then proceeds transversely again until the base of the 2nd metatarsal is reached (*Fig.* 432). At this point the knife is withdrawn, and the first tarso-metatarsal joint is next attacked. During the whole of this movement no force must be used ; the blade is held nearly vertical, and follows lightly the line of the joints, cutting almost by its weight alone, while the line is made to gape by maintaining a position of equino-varus.

Fig. 432.

To make sure of the position of the 1st tarso-metatarsal joint, the left thumb is placed on the infero-internal tubercle of the 1st metatarsal bone, and the heel of the blade is applied flat against the thumb, the edge away from the operator, the point above, while the foot is held in the valgus position to make the joint gape on this side. Two to three millimetres behind the tubercle the blade is turned through a right-angle and cuts on the line of the joint, thus dividing the internal lateral ligament and some fibres of the tibialis anticus tendon. The line of the joint is then followed on the dorsum of the foot by raising the handle of the knife a little, so lowering the point, and aiming for the middle of the 5th metatarsal bone (*Fig.* 433).

Fig. 433.

The joint between the 2nd metatarsal and the middle cuneiform bone must now be opened. It is made to gape by pressure on the front of the foot; the surgeon seeks for it about half an inch behind the prominent anterior extremity of the internal cuneiform, a quarter of an inch behind the anterior extremity of the external cuneiform (but this distance is much more variable), and opens it with a transverse stroke of the full blade from left to right, the knife held like a violin bow, or the point of the knife may be used, as shown in (*Fig.* 434). A beginner may with advantage ascertain the exact position of the joint before opening it, by making two or three *light* antero-posterior strokes of the point, drawn from the middle cuneiform over the base of the 2nd metatarsal. The little depression between the bones is felt, and its exact position can thus be determined.

Fig. 434.

The dorsal ligament between the middle cuneiform and the 2nd metatarsal is weak, and can be torn through without much violence when the front of the foot is lowered after the *coup de maitre*, so that a novice may be forgiven for not opening it beforehand as described; but it is a step always taken by an expert operator.

Left Side.—The incision should commence to the left of the operator, at the *first tarso-metatarsal* joint.

A beginner should verify the position of the tubercle of the first metatarsal towards the sole with his left thumb-nail, and apply the point of his blade against the nail; but a practised operator finds his position with the point of the knife without using the thumb.

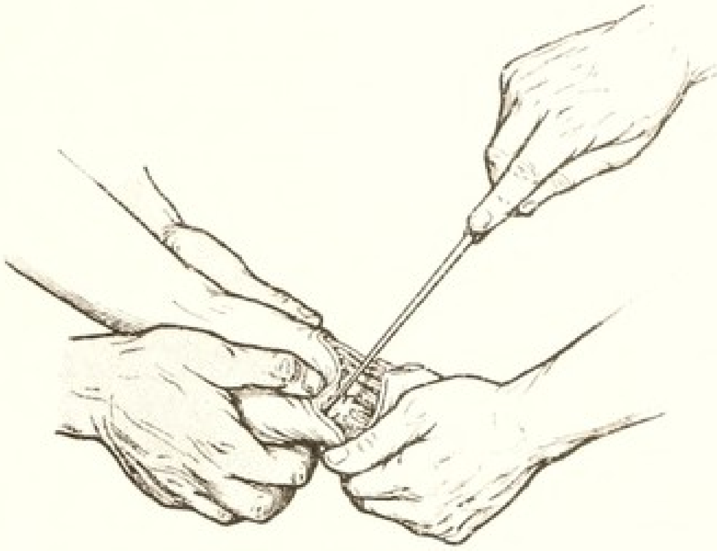


Fig. 435.

The point is applied to the left surface of the metatarsal, handle above, the edge away from the operator. The tubercle is felt, and beyond it a depression, where the blade is turned through a right-angle, and the joint is entered transversely at the border of the foot, held slightly in the valgus position to widen the interval. The internal ligament and some fibres of tibialis anticus tendon are first divided, and then the dorsal ligament, the edge being aimed for the middle of the 5th metatarsal bone, while the front of the foot is depressed, until the blade is arrested by the 2nd metatarsal bone (*Fig.* 435).

Fig. 436.

Passing transversely over the base of the 2nd metatarsal, and scratching the dorsal surface of the bones beyond with the point of the knife at the level of the retracted skin, in the direction of the tuberosity of the 5th metatarsal, an experienced operator will nearly always find the lines of the *three outer* joints, widened above by holding the foot in equino-varus.

In any case the joints may be found by reversing with the blade from before backwards at the edge of the foot, as follows (see also p. 238). The fore-part of the foot is depressed into a position of equino-varus, whilst the surgeon, holding the knife in his flexed and pronated right hand, edge towards the tarsus, pierces the tissues vertically with the point against the outer surface of the 5th metatarsal (*Fig.* 436) and reverses, with jerking movements of the wrist, until the bony prominence has been passed. He then turns the blade through a right-angle until it is perpendicular to the outer border of the foot, and,

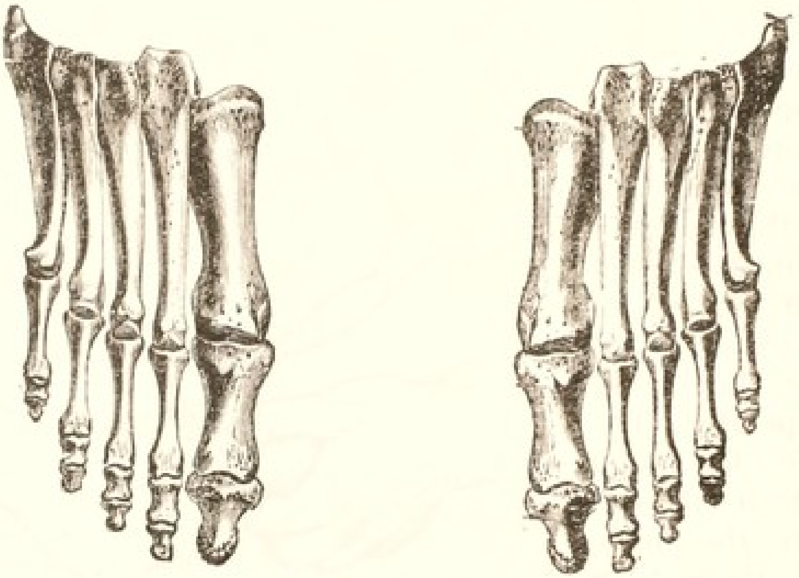


Fig. 437.—Skeleton of the metatarsus, showing the direction and sinuosities of the joint lines.

continuing the little sawing movements, divides the peroneus brevis tendon. Once the tendon is divided, the blade is turned still further forwards, through an angle of 45°, and aimed towards the middle of

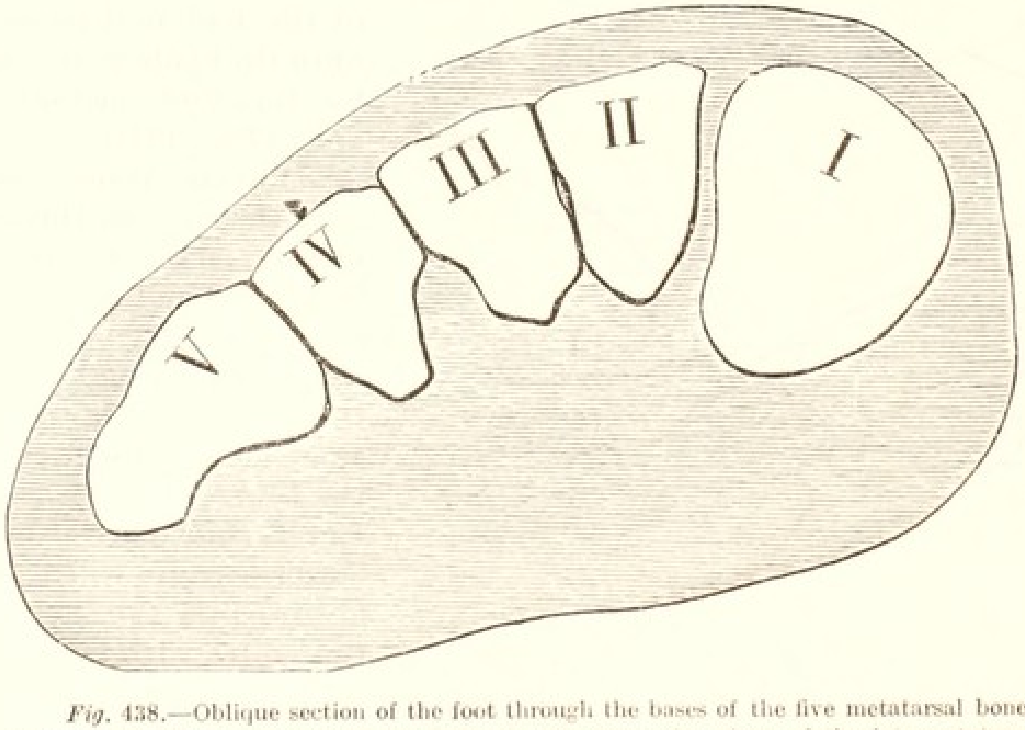


Fig. 438.—Oblique section of the foot through the bases of the five metatarsal bones, showing the transverse arch of the foot, and the increasing slope of the intermetatarsal joints from the 1st to the 4th.

the 1st metatarsal bone ; the surgeon then follows the line of the joint lightly from right to left. Turning the blade rather more transversely, the line of the 4th joint is followed ; when the point reaches the slightly projecting external cuneiform, it is brought a little towards the operator, and the line of the 3rd joint is similarly followed until the blade reaches the outer surface of the 2nd metatarsal.

The interline of the 2nd joint is opened, as on the right side, by a transverse stroke of the full blade.

The Coup de Maitre.—The lateral and dorsal ligaments and the tendons of peroneus brevis and tibialis anticus being divided, the tarsus and metatarsus are still held together by the rather weak interosseous fibres which unite the sides of the external cuneiform to the 2nd and 4th metatarsal bones, and by the very strong fibrous union between the internal cuneiform and the 2nd metatarsal: the latter is divided from the sole towards the dorsum of the foot by the *coup de maitre*.

The anatomy of this region having been already described, I have only to remind the reader that the bases of the 1st and 2nd

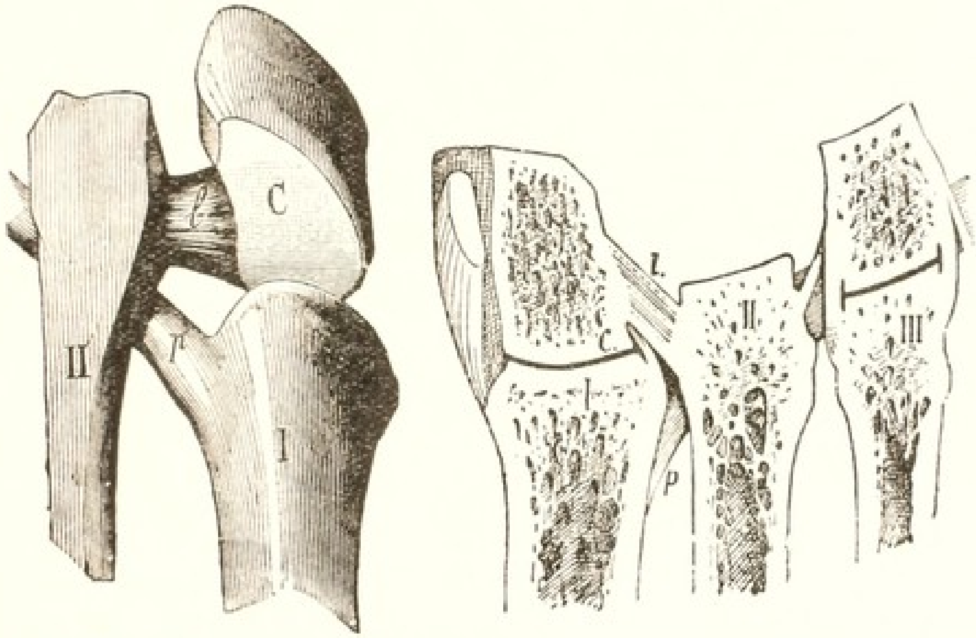


Fig. 439.—On the left is seen the inner portion of the right tarso-metatarsal joint, with the bones dislocated to show the structures concerned in the *coup de maitre*. The figure on the right shows a horizontal section through the same articulation on the left side.

p, Tendon of peroneus longus; *l*, The ligament to be divided in the *coup de maitre*; *c*, Internal cuneiform.

metatarsal bones are in contact along a plane which runs obliquely upwards and inwards, because of the projection to which peroneus longus is attached on the outer side and below.

Fig. 439, with the bones separated, shows clearly the interval through which the point must pass in performing the *coup de maitre*. If the back of the blade is supported by the tendon of peroneus longus (*p*), and the edge bites consequently on the plantar border of Lisfranc's ligament (*l*), while the point lies between the internal cuneiform and the 2nd metatarsal, it is evident that when the handle of the instrument is raised, Lisfranc's ligament will be divided from below upwards and from before backwards, because the back of the blade is held in position by the peroneus longus tendon and cannot recede. It is essential that the point should be on a level with the rest of the edge, or it might penetrate downwards and divide the peroneus tendon instead of Lisfranc's ligament.

The interval described is best reached by following the outer surface of the 1st metatarsal from before backwards, commencing close to the head, the axis of the knife as nearly as possible in line with the axis of the bone, the flat of the blade against the bone.

The outer surface of the bone, however, does not lie in the sagittal plane for its whole length. It is exactly sagittal anteriorly, but posteriorly it inclines from above outwards and downwards, to become continuous with the process to which is attached the peroneus longus tendon; so that if the flat of the blade is applied against the surface anteriorly, edge upwards, and the knife is then pushed backwards without losing contact with it, the point becomes directed outwards towards the external malleolus as it nears the base of the bone, and the edge turns a little inwards. The point must be dropped a little to pass beneath the base of the 2nd metatarsal, and the blade must be directed along the side of the base in a practically horizontal direction, otherwise it may pass under the peroneus longus tendon instead of over it.

It is useful to practise this stroke on the skeleton of a foot with the ligaments preserved. The knife is applied against the outer surface of the metatarsal, and passes backwards three-quarters of the way in the sagittal plane, but after this the edge inclines inwards. This inclination is accentuated if the heads of the metatarsals are wedged apart, for the head of the 1st metatarsal is thus depressed and pushed inwards, and the joint between the internal cuneiform and the 2nd metatarsal bones is made to gape; but at the same time the peroneal process is displaced inwards and upwards, increasing the obliquity of the posterior quarter of the surface.

To pass the knife securely into the proper position, the tissues of the 1st interspace should *first* be divided from end to end, and the heads of the corresponding metatarsal bones wedged apart with the thumb as near to the toes as possible.

The knife should next be grasped like a trocar, edge upwards, the index finger extended, the end of the handle resting against the operator's palm, and the tissues are pierced horizontally, the blade against the bone close to the nail of the left thumb, which is wedging the bones apart. The blade is then pushed onwards, the point aiming for the external malleolus, the edge turned towards the internal malleolus. The point will be arrested when caught between the internal cuneiform and the 2nd metatarsal (*Fig.* 440); and if the back rests properly against the peroneus tendon, the knife will maintain its position when no longer held by the surgeon (*Fig.* 441).

The surgeon therefore releases the handle to make sure of this, then grasps it again like a dagger, and raises it, at the same time depressing the front of the foot by pressure from the base of his left hand (*Fig.* 442).

During this step the inclination of the edge towards the internal malleolus must be corrected, because the line of the joint is antero-posterior, or even slightly oblique backwards and outwards (see *Fig.* 415).

If the *coup de maitre* is properly carried out, Lisfranc's ligament may almost be said to divide itself; and after further dividing with

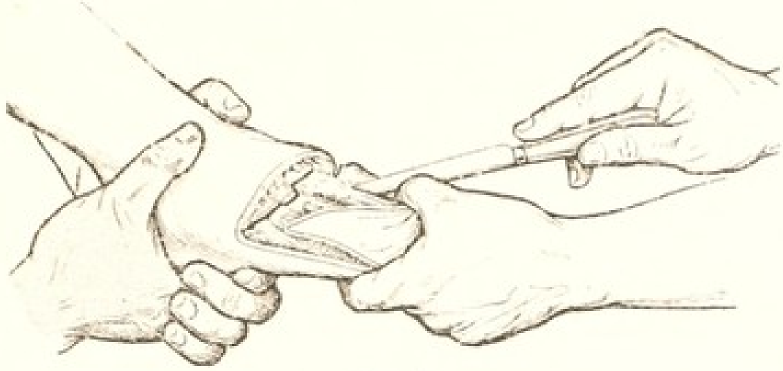


Fig. 440.

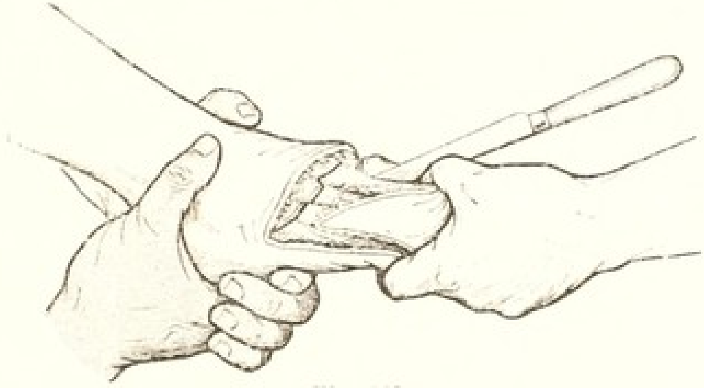


Fig. 441.

Fig. 442.

a stroke or two of the point any fibres of the interosseous ligaments attached to the external cuneiform bone which have not already been torn through by the pressure of the left hand, the front of the foot becomes nearly vertical.

The deep surface of the metatarsal bones is next shaved from left to right, with the blade vertical, in order to *detach the plantar ligaments* (*Fig.* 443), special care being taken to free completely the end metatarsals where they are attached to the flap.

Fig. 443.

Transfixion of the Plantar Flap.—Having thus prepared a path for the blade, the surgeon passes it transversely, on the flat, beneath the metatarsals, edge towards him ; he then re-articulates the bones,

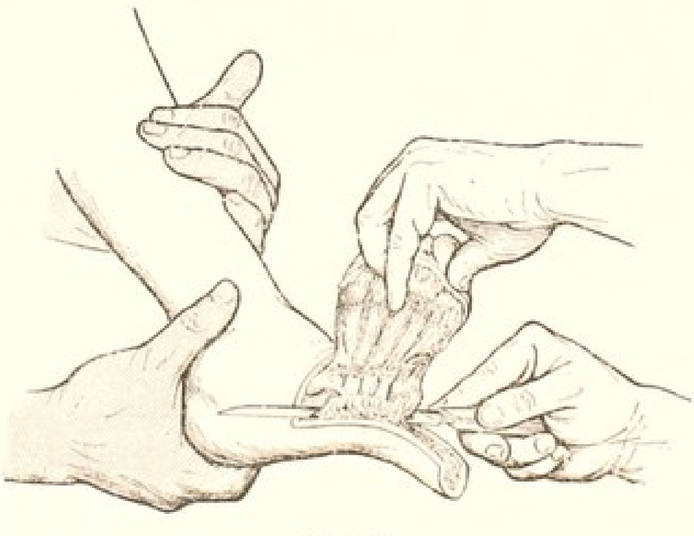


Fig. 444.

and places the toes in extension (holding them like a pen-filler) to stretch the plantar muscles, and finally completes the transfixion with little sawing movements (*Fig.* 444).

A very experienced operator can rely entirely on transfixion, without troubling to dissect the flap from the plantar surface, having only divided the plantar skin beforehand. The prominent heads of the metatarsals make this procedure difficult, however, and it has neither the advantage of rapidity or of neatness, for in any case it is necessary to free the skin as far as beneath the heads of the metatarsal bones.

MIDTARSAL DISARTICULATION
(Chopart's Disarticulation).

Anatomy.—The midtarsal joint lies between the os calcis and astragalus behind and the cuboid and scaphoid in front. The os calcis and cuboid are situated below and on the outer side, resting on the ground; the astragalus and scaphoid lie to the inner side and above, forming part of the internal arch of the foot.

The *astragalus* ends anteriorly in a rounded head, which is capped by the concavity of the scaphoid. *The line of this joint is therefore concave backwards*; the bulky tuberosity of the scaphoid overlaps it behind and below. The head of the astragalus has no bony support to the inner side and below, but rests on the powerful, fibrous *calcaneo-scaphoid ligament*, passing from the sustentaculum tali to the plantar border of the scaphoid, and reinforced on its inner side by the strong *tendon of tibialis posticus*, which is inserted into the tuberosity of the scaphoid.

The *calcaneo-cuboid joint* is saddle-shaped, concave forwards transversely, convex forwards from above downwards. On the dorsum of the foot the *line of the joint is slightly concave forwards*, but practically straight; on the sole of the foot a projection of the cuboid extends to a greater or less extent beneath the os calcis, and is sometimes embarrassing to the surgeon.

With the foot at right angles to the leg, both joints are in the same transverse plane; in the equinovarus position the os calcis passes 3 to 4 millimetres in front of the astragalus.

The *dorsal ligaments* are weak, and can be divided transversely without the necessity of a detailed knowledge of their arrangement. The same may be said of the very powerful *plantar ligaments*, which are detached by shaving closely the lower surface of the cuboid and scaphoid after depressing the fore-part of the foot. The tuberosity of the scaphoid must be rounded with care, in order to divide the tendon of tibialis posticus and the calcaneo-scaphoid ligament. But the foot can only be depressed after section of the *Y-shaped ligament*, a strong partition placed nearly vertically between the calcaneocuboid and astragalo-scaphoid joints. This ligament arises from the antero-superior portion of the os calcis, and sends one branch outwards to the cuboid, the other inwards to the scaphoid; its thick lower border is continuous with the plantar ligaments.

Examination.—The bony landmarks to determine the transverse line of the midtarsal joint are:—

1. *The tuberosity of the scaphoid*, on the inner border of the foot towards the plantar surface.

2. *The tuberosity of the 5th metatarsal bone*, on the outer border of the foot.

They may be palpated as described on pages 217 and 225.

It must be remembered that : (1) The tuberosity of the scaphoid reaches a quarter of an inch behind the line of the joint ; (2) The tuberosity of the 5th metatarsal is about a finger-breadth in front of the joint.

When these landmarks have been noted with the foot in the normal position, it must further be remembered that in the *valgus* position the scaphoid passes obliquely upwards and outwards over the head of the astragalus, and the tuberosity becomes less prominent as it passes away from the sustentaculum tali, while the astragalus projects on the inner border of the flattened foot.

In *equino-varus*, on the other hand, the scaphoid moves backwards, downwards, and inwards, and the tuberosity nearly comes in contact with the sustentaculum tali. The infero-internal portion of the head of the astragalus can then no longer be palpated, but the upper and outer portion, uncovered by the scaphoid, projects markedly at the middle of the dorsum of the foot.

Line of Incision.—A gaiter-like dorsal incision is made, and a plantar flap is cut, the general form of the incision being similar to that for Lisfranc's disarticulation (*Fig.* 445).

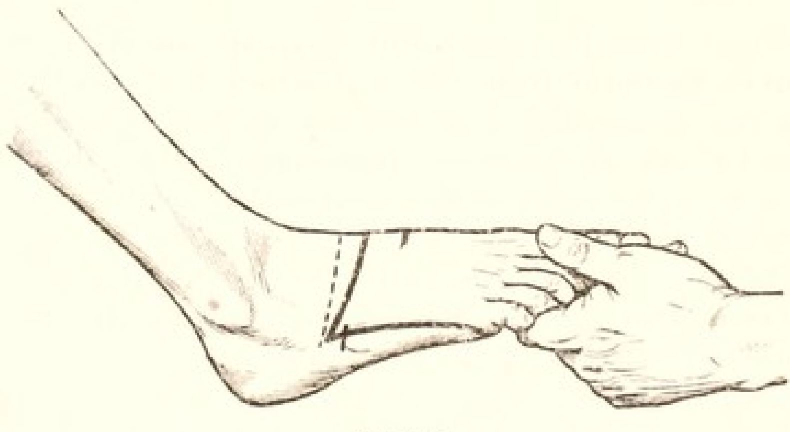


Fig. 445.

The *dorsal incision* passes from the outer border of the foot, one finger breadth behind the tuberosity of the 5th metatarsal, to the anterior part of the tuberosity of the scaphoid on the inner border. It starts from a point nearer to the dorsum than to the sole of the foot, especially on the inner side. It is not straight, but slightly convex forwards, passing one finger-breadth in front of the line of the joint at the mid-point of the foot.

The *plantar flap* is bounded laterally by two longitudinal lines following the corresponding borders of the foot, over the palpable surfaces of the metatarsal bones, above the tissues of the sole ; and in front by a curved line parallel to the metatarso-phalangeal joints, reaching a little further forwards on the inner side than on the outer. It is sufficient to pass beneath the heads of the metatarsal bones ; but on an intact foot in the dissecting-room, the incision is made to reach nearly as far as the digito-plantar folds, just as in Lisfranc's disarticulation.

Principal Steps of the Operation.—These are the same as for Lisfranc's disarticulation, and are carried out in the same order :—

1. Division of the dorsal skin.
2. Division of the plantar skin and dissection of the muscles.
3. Disarticulation.
4. Transfixion of the plantar flap.

A knife with a blade 6 inches long should be chosen ; Lisfranc's knife is convenient.

Division of the Skin and Muscles.—The soft parts are divided just as in Lisfranc's operation. The sole is grasped in the same way, thumb over the left landmark, index finger over the right ; the skin is stretched and incised similarly, and in the same way also the plantar flap is cut and dissected backwards (see p. 233 et seq.).

It is neater perhaps to divide the dorsal tendons at once, by passing the blade back from right to left, and to enter the joint directly at the same time. But if the disarticulation is to be continued in this way, the dorsal incision must reach nearer towards the sole, and the resulting flap is ugly and too narrow at the base.

The skin must be liberated with especial care at the dorsi-plantar angles of the wound.

Disarticulation.

1. *Entering the Line of the Joint from the Dorsal Aspect.*—There is a tendency among beginners to cut perpendicularly to the bones at

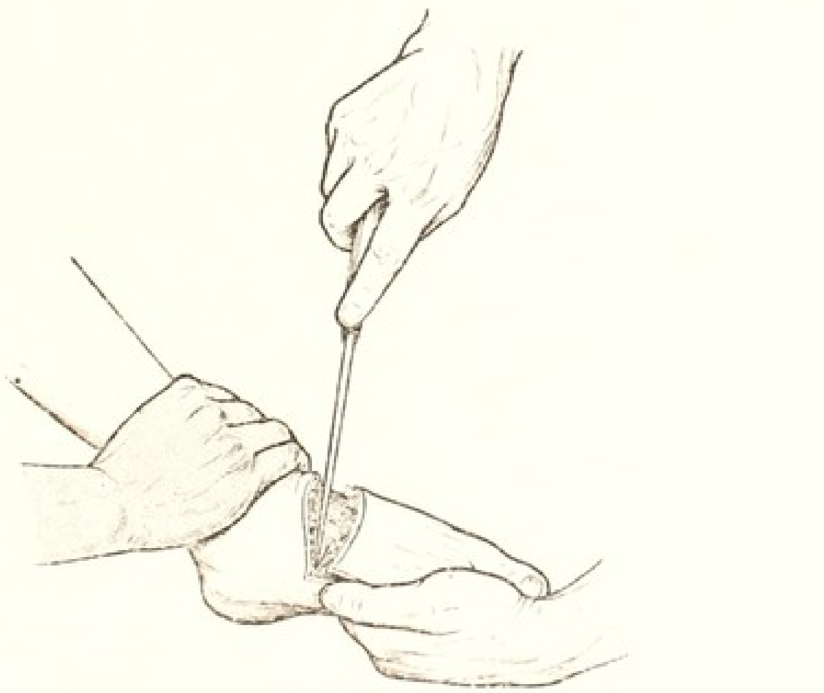


Fig. 446.

the level of the retracted skin (*Fig.* 446), and in this way the scapho-cuneiform articulations are frequently entered by mistake ; or else they scratch a bony surface, the scaphoid or the neck of the astragalus according to whether the incision is correctly placed or too far back, the latter being a common fault.

Fig. 447.

It must be borne in mind that if the *front of the foot is twisted into a position of equino-varus*, the head of the astragalus becomes uncovered and projects on the dorsum of the foot above and outside the scaphoid. If therefore the blade is applied edge towards the leg, flat to the external surface of the dorsum of the foot—handle above for the right side (*Fig.* 447), below for the left — and then pushed onwards without losing contact with the bones, the edge will be arrested by the head of the astragalus. The blade is now turned through a right angle, and the dorsal ligaments are divided transversely with the point, from left to right, handle above: the joint, stretched by the equino-varus position, opens immediately (*Fig.* 448).

Fig. 448.

2. *Division of the Y-shaped Ligament.*—In *Fig.* 448 the insertion of this ligament on the dorsum of the foot is clearly shown between the two joints, the astragaloid joint supero-internal and convex forwards, the calcaneal infero-external and concave forwards. It forms a partition which passes from the

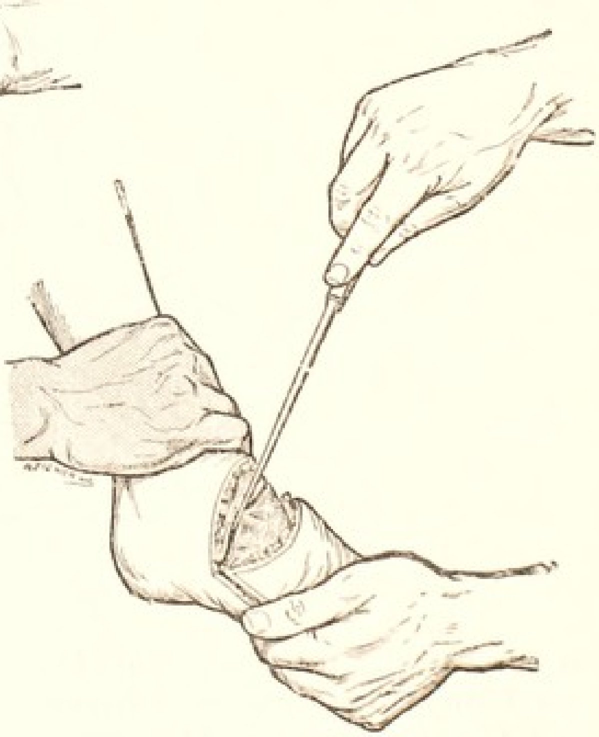


Fig. 449.

os calcis to the adjacent surfaces of the scaphoid on the inner side of the foot and the cuboid on the outer side, and may be considered the key of the joint. It is divided by applying half an inch of the edge of the point to its left margin, blade vertical, handle above, then pressing the knife to the right with little sawing movements. Two or three strokes will suffice to divide it, each one deeper than the last until the plantar surface of the joint is reached, while the foot is held in equino-varus (*Fig.* 449).

Division of the Plantar Ligaments.—When the Y-shaped ligament is completely divided, the foot drops into a position of extreme plantar flexion under pressure of the operator's left hand, and across the joint the powerful plantar ligaments are seen, the calcaneo-cuboid and calcaneo-scaphoid. The foot is also held at the sides by the peroneus brevis tendon attached to the tuberosity of the 5th metatarsal, and the tibialis posticus attached to the scaphoid. The front of the foot is now pressed downwards until its posterior surface faces slightly forwards, and with the point of the knife, held vertically, the ligaments and fibrous tissue, which must remain in the flap, are divided close to the bone in several strokes from the extreme left to the extreme right, following the plantar concavity (*Fig.* 450). On the inner side of the foot the projecting tuberosity of the scaphoid must be carefully rounded in order to divide the tibialis posticus tendon; and it must be borne in mind that the ridge of the cuboid sometimes projects rather far backwards beneath the os calcis on the outer side.

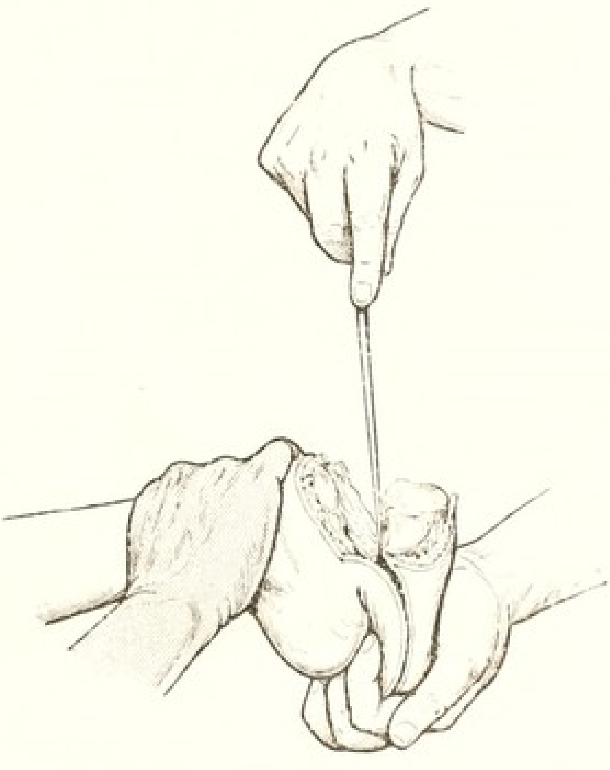


Fig. 450.

When the bones have been cleared for about an inch in the manner described, the surgeon passes the blade on the flat between the bones and the flap, re-articulates, and *finishes by transfixion* (see p. 246).

The result may be considered good if the dorsal integument projects a few millimetres in front of the bones, forming a tiny pocket where it joins the plantar flap at each border of the foot.

Greater care must be taken than in Lisfranc's disarticulation to shave the bones very closely, so as to preserve all the plantar fibrous tissue and the muscle pad. The flap which will be turned over the remaining bones is thus a thick one, and, especially if the dorsal tendons are sutured to it, will resist the action of the calf muscles, which tend to rotate the os calcis into a position of equinus. In the living, if sufficient tissue for an adequate plantar flap has been preserved, the operator should not hesitate to make the disarticulation in front of the scaphoid.

SUBASTRAGALOID DISARTICULATION.

Anatomy.—Two articulations, approached from the dorsal and external aspect of the foot, must be opened :—

A. The Astragalo-scaphoid Articulation.—This has already been considered (see p. 247).

B. The Astragalo-calcaneal Articulation.—In this articulation there are three points that call for consideration :—

1. *The Surface on which the Astragalus rests.*—This is formed by two structures : (*a*) The upper surface of the os calcis ; (*b*) The calcaneo-scaphoid ligament. This ligament reaches forwards and

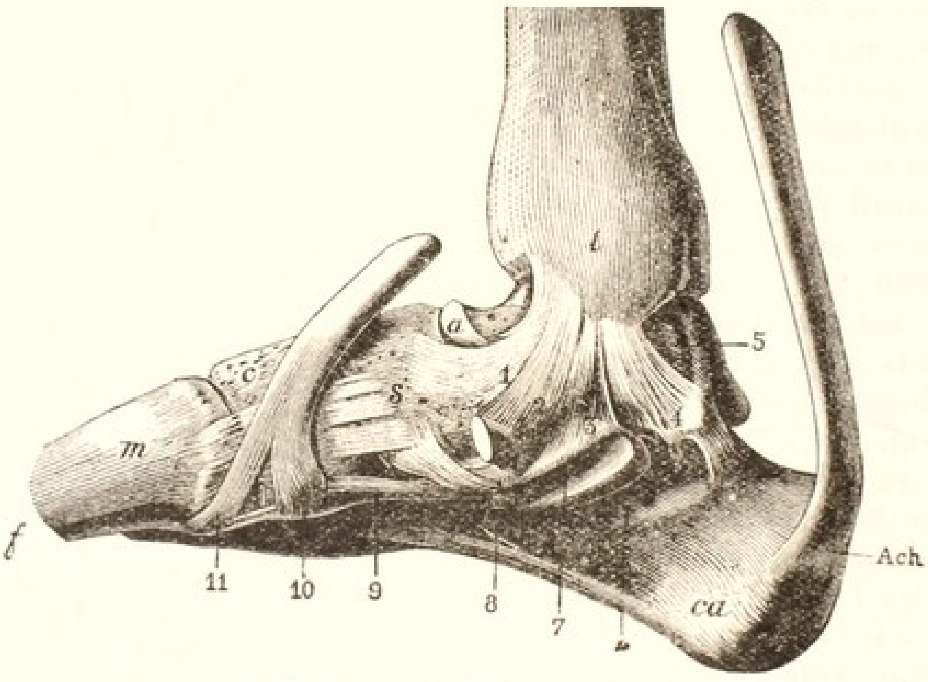


Fig. 451.—The inner surface of the right ankle-joint.
a, Head of astragalus ; *s*, scaphoid ; 8, tendon of tibialis posticus ; 10 and 11, tibialis anticus tendon.

inwards from the sustentaculum tali to the corresponding half circumference and tuberosity of the scaphoid. It is reinforced by the tibialis posticus tendon, which frequently contains a sesamoid bone.

The upper surface of the os calcis shows two articular surfaces : (i) *Posteriorly*, an extensive, slightly convex surface, commencing at the level of the posterior surface of the tibia, one and a quarter inches in front of the point of the heel, and running obliquely forwards, *downwards*, and inwards. (ii) *Anteriorly*, a small, slightly concave surface, nearly horizontal, but a little higher on the inner side and behind. This lies over the upper surface of the sustentaculum tali.

These two surfaces converge on the inner side, where they are separated by a narrow groove only ; on the outer side the groove becomes wider and deeper.

The astragalus may be likened in shape to a snail which has hollowed its ventral surface in order to thrust out its head. Under the tail and body of the snail, posteriorly, is a large facette which rests on the posterior facette of the os calcis; beneath the head is another facette divided into two parts, one for the os calcis, the other for the calcaneo-scaphoid ligament. The hollow ventral surface, wide on the outer side, narrow on the inner, lies over the calcaneal groove, forming together with it the *sinus tarsi*, a funnel-shaped passage with the wide opening in front and on the outer side.

The astragalus sits crosswise on the os calcis; the long axis of the body is nearly antero-posterior, but the head turns obliquely down-

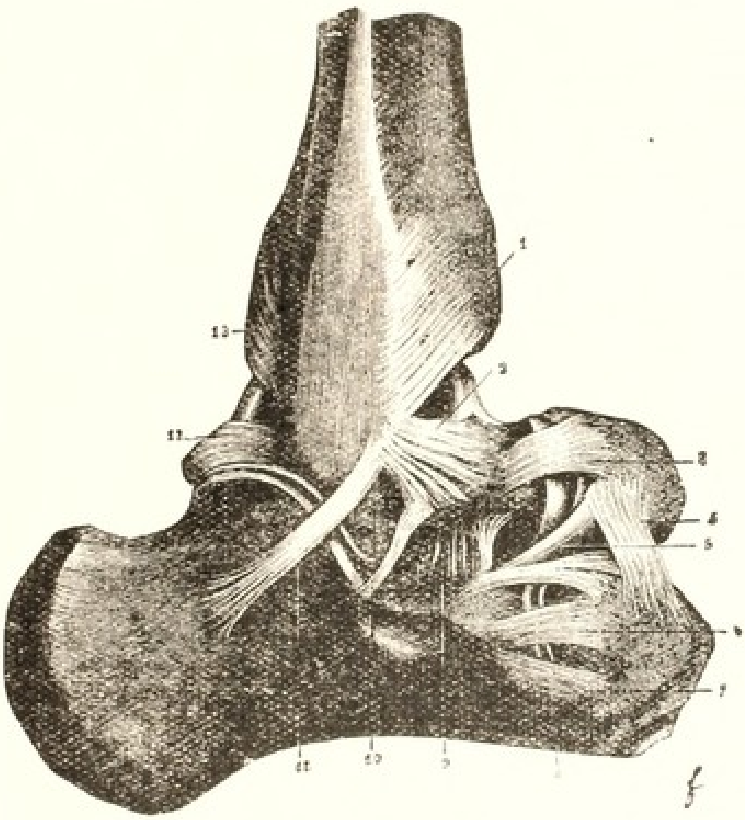


Fig. 452.—The outer surface of the right ankle-joint.
5, Scaphoid branch of the Y-shaped ligament; the cuboid branch can also be seen; 3 and 6, dorsal ligaments, easy to divide.

wards and inwards, while the anterior extremity of the os calcis turns outwards and upwards.

The anterior articulation is continuous with the astragalo-scaphoid joint.

The movements between the astragalus and os calcis are very slight, and the bones are held very firmly together.

2. *The Ligaments which hold the Bones in Position.*

a. The superficial tibio-tarsal ligaments, which pass over the astragalus. These are: (i) On the outer side, the middle fasciculus of the external lateral ligament passing from the fibula to the os calcis; (ii) On the inner side, fibres of the internal lateral ligament passing fanwise from the tibia to the os calcis, the calcaneo-scaphoid ligament, and the scaphoid. This powerful ligament is continuous beneath the sustentaculum tali with the tendon sheath of flexor longus hallucis, and beneath the calcaneo-scaphoid ligament with the sheath of the tibialis posticus tendon.

b. The subastragaloid interosseous ligament. This consists of a double row of laminæ converging inwards, arising from the hollow above described along the edge of the articular surfaces. The anterior row is much stronger than the posterior. The ligamentous fibres run obliquely forwards, inwards, and a little upwards, but are nearly horizontal in the normal position of the foot. If the anterior extremity of the os calcis is dragged forwards, downwards, and inwards, by placing the foot in a position of equino-varus, the fibres become nearly vertical, and give a little play to the articulations, thus allowing the os calcis to slip a little forwards. It is in this position that the line of the posterior calcaneo-astragaloid articulation gapes on the outer side of the foot, about the level of the external malleolus, allowing the blade to enter.

3. *The Calcaneal Canal.*—This canal, on the inner surface of the os calcis, contains the tendons, vessels, and nerves which pass from the posterior aspect of the leg to the sole of the foot. These structures (flexor tendons, tendon of tibialis posticus, and the posterior tibial vessels and nerve) are held down by the internal annular ligament passing from the tail of the astragalus and from the sustentaculum tali to the inner border of the plantar fascia and the postero-internal tubercle of the os calcis; an osteo-fibrous canal is thus formed between the ligament and the smooth hollow internal surface of the os calcis. Behind the tail of the astragalus, and under the sustentaculum tali, the tendon of flexor longus hallucis lies immediately in contact with the bone.

Behind the calcaneal canal, the bulky tendo Achillis is inserted into the os calcis.

Examination.—The foot should be palpated as described on page 216, and the following points noted:—

1. The position of the malleoli.

2. The insertion of the tendo Achillis, easily felt if stretched by dorsiflexion of the foot.

3. The tuberosity of the scaphoid internally, and the tuberosity of the 5th metatarsal externally.

4. The inner surface of the internal cuneiform; the scapho-cuneiform joint, which is on the same transverse line as the tuberosity of the 5th metatarsal; and the first cuneo-metatarsal articulation.

5. The extensor tendon of the great toe, easily made visible by plantar flexion of the toe.

Line of Incision.—On the outer surface of the foot, one good finger-breadth below the tip of the external malleolus, the line runs horizontally forwards from the border of the tendo Achillis to a point above, but on the same transverse level as, the tuberosity of the 5th metatarsal (*Fig.* 453). The line then curves, like the lower edge of a gaiter, across the dorsum of the foot as far as the prominence of the extensor longus hallucis tendon, still at the level of the tuberosity of the 5th metatarsal, and therefore at the level of the scapho-cuneiform joint also (*Fig.* 454). From the tendon the line runs forward, crossing the inner surface of the internal cuneiform diagonally, so that the plantar surface is reached beneath the first cuneo-metatarsal joint (the mid-point of the inner border of the foot). The sole is then

Fig. 453.

Fig. 454.

Fig. 455.

crossed somewhat obliquely outwards and backwards, reaching the outer border of the foot at the tuberosity of the 5th metatarsal, and from this point the line runs backwards along the outer border of the sole until, curving upwards at the outer border of the tendo Achillis, it rejoins at right angles the commencement of the incision (*Fig.* 455).

In the following figures (455*a* and *b*), taken from Farabeuf, the plantar flap and the method of suturing it are shown.

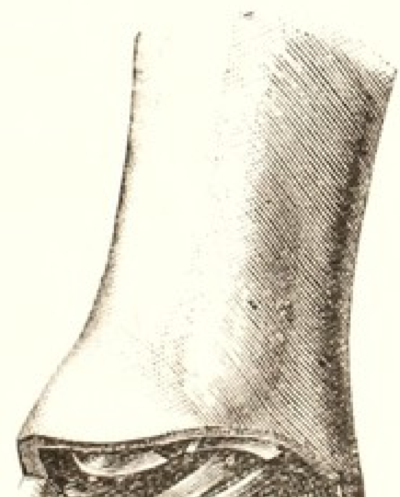


Fig. 455*a*.—Subastragaloid disarticulation (outer surface of the left foot), the flap hanging free.

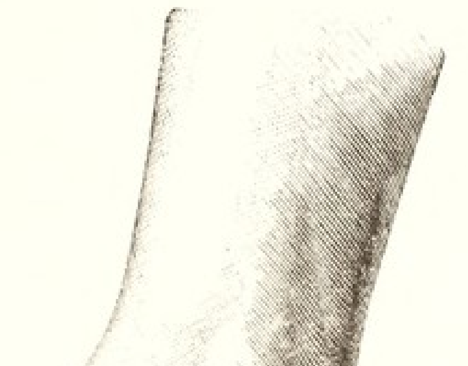


Fig. 455*b*.—The same, after suturing the flap.

Principal Steps.

1. Division of the skin, and incision of the soft parts of the sole as far as the bone.

2. Disarticulation. The articulation should be entered from the outer side.

3. Liberating the plantar flap by detaching the structures of the calcaneal canal, and dividing the tendo Achillis.

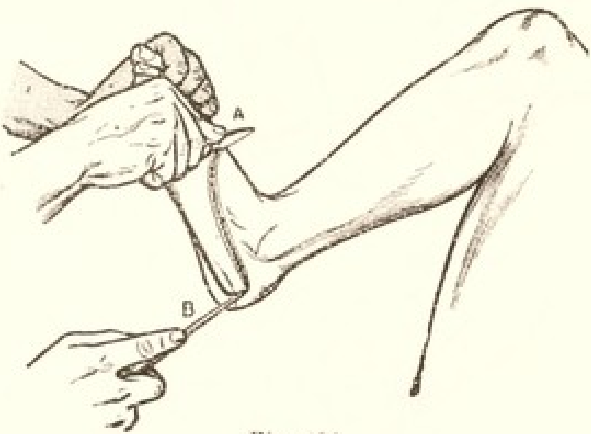


Fig. 456.

A broad short knife, about $2\frac{1}{2}$ inches long (Syme's knife), is used.

It is necessary to describe the operation separately on the left and on the right sides.

LEFT SIDE (the easy side).

Division of the Skin.—The assistant stands to the inner side of the limb, and grasps its postero-external surface in his left hand to stretch the skin and rotate inwards the half-flexed knee. In this way the dorso-external surface of the foot is presented almost horizontally to the operator.

On this side the *skin is divided in two steps.*

First Step.—The surgeon stands outside the leg, grasps the dorsal surface of the front of the foot in his left hand, and applies the heel of his knife, point directed slightly downwards, against the prominence of the extensor longus hallucis tendon. Cutting with the full edge, he now passes from left to right over the dorso-external surface of the foot, exposed gradually more and more by twisting the foot to the left while the assistant increases the adduction of the thigh. This part of the incision is ended by curving, with little sawing movements of the point, along the outer border of the tendo Achillis as far as the plantar surface of the heel (*Fig.* 456, A, B).

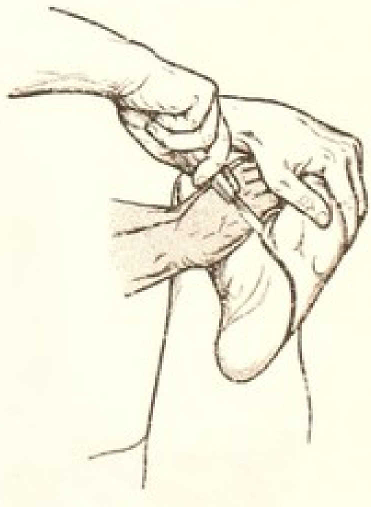


Fig. 457.

Second Step.—The surgeon next passes to the inner side of the limb, while the assistant abducts it with the knee semi-flexed. With his pronated left hand the operator now grasps the outer border of the fore-part of the foot, thumb beneath the toes, and twists it to the right by pressing it downwards, then starts the incision with the point of the knife over the prominence of the extensor longus hallucis tendon at the commencement of the first incision, the right hand under the left (*Fig.* 457). The tissues are divided, somewhat obliquely, to the bone, the knife passing to the sole and across it along the line described, the operator bringing his left hand gradually more towards him until the sole faces him, leg horizontal, the knee and hip flexed at a right-angle (*Fig.* 458): the incision is terminated by drawing the knife downwards along the outer border of the foot as far as the heel, where it curves to rejoin the posterior extremity of the first incision (*Fig.* 459).

The tissues of the sole and on the outer surface of the foot must be divided to the bone, with sawing movements of the point of the knife, and contact with the bone must never be lost. It is best to divide the dorsal tendons also in the first stroke; but the division can easily be completed when the skin is being freed before disarticulation.

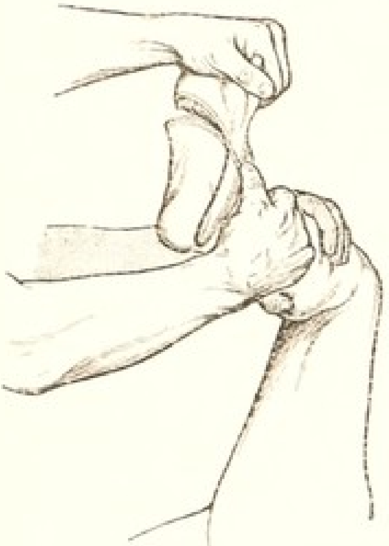


Fig. 458.

Fig. 459.

Disarticulation.

Position of the Limb.—The assistant flexes the knee to a right-angle, and with his left hand maintains the thigh in a position of adduction and internal rotation, so carrying outwards the leg and foot. The internal surface of the supramalleolar region rests at the edge of the table, and on the outer surface he presses with his right hand, at the same time stretching the skin on the dorso-external aspect of the feet with the ulnar border of the hand (*Fig.* 460).

The operator now grasps the plantar surface of the front of the foot in his left hand, thumb over the 5th metatarsal, and holds it in the equino-varus position. The head of the astragalus is thus made to project, and against it the knife enters the astragalo-scaphoid joint perpendicular to the outer border of the foot. The head of the astragalus is next rounded until the blade lies horizontally; then pressing the foot downwards with his left hand, the operator cuts horizontally from left to right, dividing the interosseous ligament with little sawing movements, and thrusting the point into the narrow part of the sinus tarsi as the heel of the blade passes backwards, until the posterior calcaneo-astragaloid articulation has been opened (*Fig.* 460). Under the pressure of the left hand this joint now gapes, and the upper surface of the os calcis rotates towards the operator,

17

allowing the upper and internal surfaces to be shaved closely without the point leaving the bone (*Fig.* 461). This is the best moment to commence to divide the tendo Achillis and enucleate the os calcis, using light sawing movements of the point engaged behind the posterior extremity of the bone. By strongly twisting the foot inwards with the ankle flexed, and so causing the retro-astragaloid portion of the os calcis to project upwards, it is possible nearly to complete the decortication without further difficulty (*Fig.* 462).

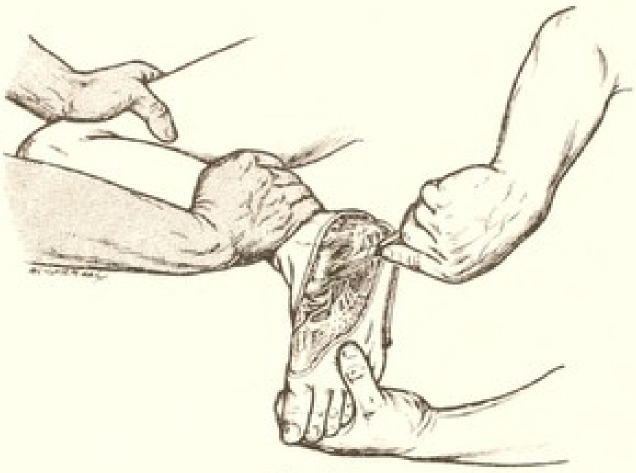


Fig. 460.

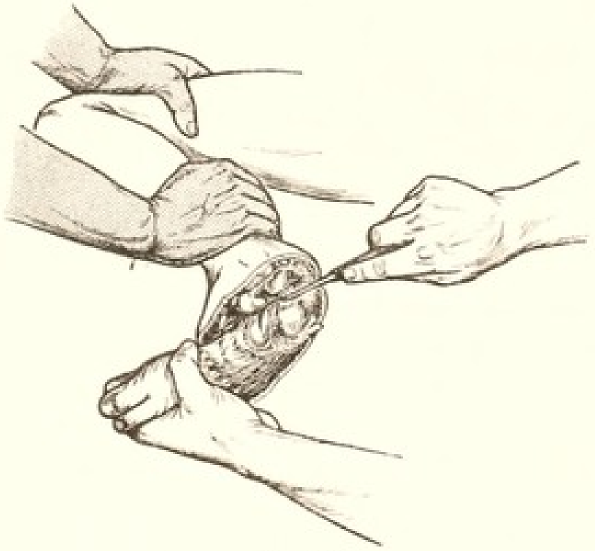


Fig. 461.

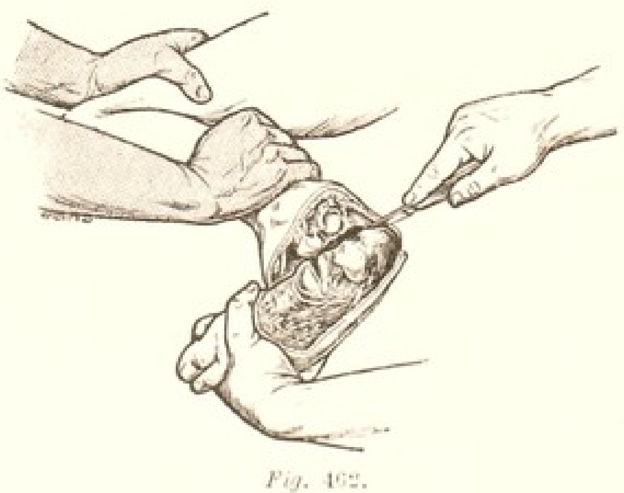


Fig. 462.

Freeing the Flap.—The foot being thus well freed towards the heel, the surgeon hooks his thumb over the inner border at the level of the internal cuneiform, and rotates it until the sole faces upwards. He then follows the calcaneal canal from the extreme left to the extreme right, dividing the tibialis posticus tendon against the scaphoid, then the calcaneo-scaphoid fibres of the internal lateral ligament of the ankle-joint, then the sheath of flexor longus hallucis tendon beneath the sustentaculum tali, which is rotated still further towards him. The remaining soft parts of the sole adhere less closely to the bone. They are divided in several strokes, while the foot is twisted more and more, until the sole looks vertically upwards when the skin incision on the outer border of the foot is reached. It must be remembered that the calcaneal canal runs obliquely downwards and forwards, and its curve must be followed lightly, the edge of the knife inclined towards the bone, blade nearly horizontal. Each stroke must begin at the extreme left, at the edge of the plantar incision, and terminate at the extreme right, after passing round the posterior extremity of the os calcis (*Fig.* 463).

Fig. 463.

RIGHT SIDE

(the difficult side).

Division of the Skin.—This is carried out *in a single step*. The assistant, standing on the outer side, grasps the lower part of the leg in his supinated right hand, stretching the dorso-external skin with his thumb, passed transversely above the external malleolus; while with the pronated left hand he grasps the patient's knee, thenar eminence over the external condyle of the femur, thumb descending over the head of the fibula. The knee is flexed and rotated inwards by adduction of the thigh, so that the leg is presented almost horizontally to the surgeon, the outer surface uppermost.

Fig. 464.

Fig. 465.

The surgeon stands at the extremity of the limb, a little to the outer side, and grasping the toes in his strongly pronated left hand, thumb below, twists the fore-part of the foot downwards and to the right until he can see the apex of the heel and the outer part of the sole. Then with the right wrist flexed, the handle of the knife above, edge towards the external malleolus, he pierces the skin as near as possible to the sole, close to the outer border of the tendo Achillis, and ascends alongside this tendon, with jerking movements of the wrist, as far as one finger-breadth below the level of the tip of the external malleolus, where he turns forwards (*Fig.* 464).

He now begins to untwist the foot, carrying the toes upwards and to the left, while the blade, inclined at an angle of 45°, is drawn across the dorsal surface (*Fig.* 465). The assistant at the same time lessens the adduction of the thigh, so that when the blade reaches the tendon of extensor longus hallucis the foot is once more straight (*Fig.* 466).

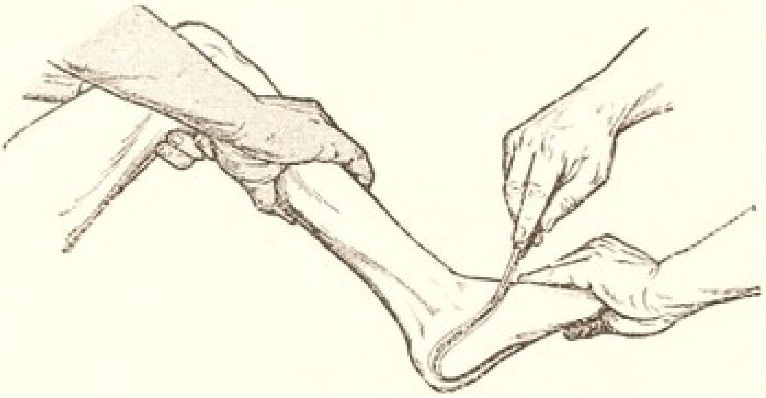


Fig. 466.

The operator then turns a little on the point of his knife, and beginning to rotate the foot to the left, crosses diagonally the inner surface of the internal cuneiform, and then crosses the sole as it stands vertically before him; at the same time he turns gradually on his left foot, until, placed on the outer side of the limb, he is in a suitable position to complete the incision by drawing the knife straight downwards along the outer border of the sole as the foot is inclined gently inwards (*Fig.* 468). The posterior extremity of the incision must be curved upwards to rejoin accurately the point whence it started at the outer border of the tendo Achillis.

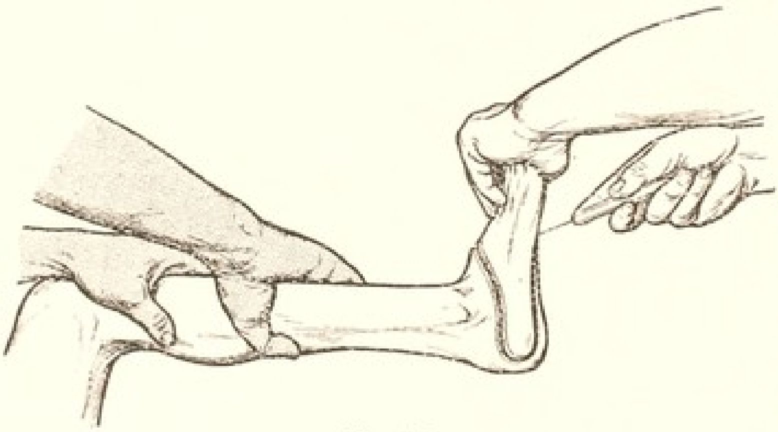


Fig. 467.

Fig. 468.

This incision should divide the soft parts down to the bone. It is especially important *to divide completely the tissues of the sole*, which is crossed with sawing movements of the point without losing contact with the bone; the same process is continued along the outer border of the foot. It is best to divide the sole somewhat obliquely, and if necessary the incision may be repeated, until it is certain that the tissues have been completely divided, both beneath, behind, and on the outer side of the heel.

The operator may now proceed at once to disarticulate, or he may dissect the flap before disarticulation. The first of these procedures is the one here described.

Disarticulation.—The limb may be placed against the edge of the table, as on the left side; but it is equally convenient if the assistant presents it nearly horizontal, the knee semiflexed and rotated inwards, while he retracts the dorso-external skin with the ulnar border of his right hand (*Fig.* 469). Returning to the extremity of the limb, the operator applies the base of his left palm over the dorsum of the foot, his fingers curved beneath the sole, and presses the foot into the varus position with slight equinus; then, holding the knife in his strongly flexed and pronated right hand, and beginning in the posterior calcaneo-astragaloid articulation at the left border of the sub-astragaloid ligament, to the left of the calcaneo-astragaloid depression, he passes the blade horizontally from left to right, edge towards him, in little semicircular movements around the point, which is pressed deeper and deeper into the narrow antero-internal portion of the sinus tarsi, dividing the ligament as it goes. The joint opens increasingly until the knife reaches well beneath the head of the astragalus in the anterior calcaneo-astragaloid joint; the head of the astragalus can then readily be separated from the scaphoid by passing the blade round it (*Fig.* 470). The foot can now be rotated inwards as much as desired, by pressure of the operator's thumb hooked over its inner border where the tissues of the sole are attached to the bones, from which they must next be freed (*Fig.* 471).

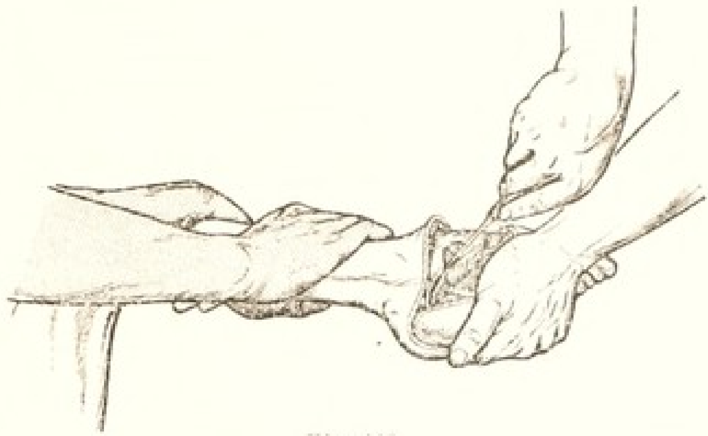


Fig. 469.

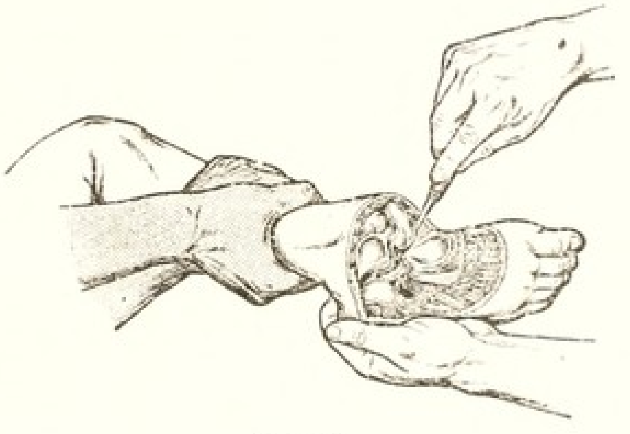


Fig. 470.

Fig. 471.

Freeing the Flap.—The calcaneal canal may be cleared safely and without difficulty from the heel towards the toes, if care is taken first to clear the posterior surface of the os calcis, and then to divide the tendo Achillis at the extreme left of the wound with the point of the knife flat against the bone. The operator can now depress the heel, and holding the foot transversely before him (*Fig.* 471), he follows the concavity of the os calcis with his blade, the edge turned slightly towards the bone, and carefully divides the sheath of the flexor longus hallucis tendon beneath the sustentaculum tali, as shown in the figure. Successive strokes of the knife are next made from the extreme left to the extreme right of the wound, the handle held lightly, turning in the surgeon's hand as the point follows the curve of the bone.

Fig. 472.

This method is more convenient than that shown in *Fig.* 472, in which the operator faces the heel and frees the flap from the toes towards the heel.

To avoid these difficult manipulations, Farabeuf advises that *the*

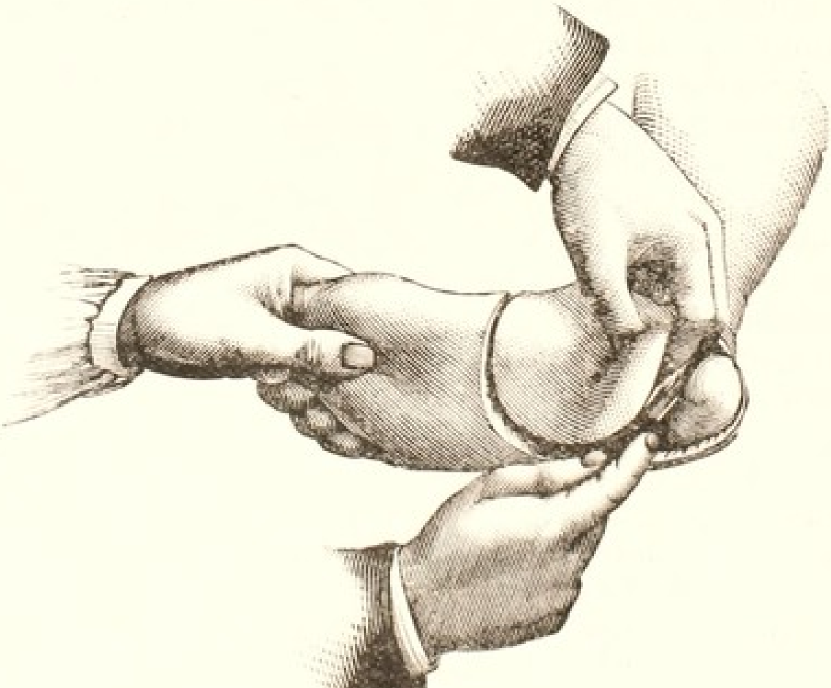


Fig. 473.

flap be raised before disarticulation, as represented in *Fig.* 473, which is borrowed from his book. In this method, as soon as the sole has been completely incised, the surgeon picks up the posterior border of the flap, and shaves the os calcis with his knife from behind forwards. The posterior portion of the flap is raised first, and after the tendo Achillis has been divided, the concavity of the os calcis can be followed without difficulty. When the flap has been completely raised from the plantar and internal surfaces of the bones, disarticulation is performed from the outer aspect of the joint as above described.

Fig. 474.

Resection of the Posterior Tibial Nerve. — In the living this step is essential. The nerve is sought for at the base of the flap, between the tendons of flexor longus hallucis and flexor longus digitorum, with a stroke or two of the director ; it is then divided, and the distal portion removed (*Fig.* 474).

TIBIOTARSAL DISARTICULATION

(Syme's Amputation).

Anatomy.—The tibia and fibula, solidly united together, form a socket beneath which plays the astragalus.

The socket is formed above by the horizontal inferior surface of the tibia, of which the posterior border reaches rather lower than the anterior, and on either side by the malleoli passing downwards at right angles to the inferior surface of the tibia. The internal malleolus is formed by the tibia, the external by the fibula. The fibular malleolus reaches rather lower, and its axis lies a little behind that of the tibial malleolus.

The astragalus bears a nearly vertical articular facette on either side, at a blunted right-angle to, but continuous with, the upper articular surface.

The *anterior ligaments* are unimportant ; the capsule is merely reinforced by a few fibres beneath the extensor tendons and the tendon of tibialis anticus.

The *lateral ligaments* arise on each side from the corresponding malleolus in *two layers* : a deep layer (astragaloid), stopping at the astragalus, and a superficial (trans-astragaloid) layer, which passes over this bone to the os calcis.

The *trans-astragaloid or superficial layer* is formed on the outer side by the middle fasciculus of the external lateral ligament, a rounded, cord-like structure which runs obliquely downwards and backwards (nearly horizontally) ; on the inner side by the fan-shaped internal lateral ligament, which passes downwards to the os calcis, the calcaneo-scaphoid ligament, the sheath of tibialis posticus, and the scaphoid.

The *astragaloid or deep layer* is formed on either side by two kinds of fibres: slender anterior strands running to the neck of the astragalus; powerful posterior fibres passing to the tail of the astragalus and to the groove for the flexor longus hallucis tendon. Disarticulation cannot be completed without dividing these posterior fibres.

The *tendons* on the lateral and posterior aspects of the joint are:

1. The peroneal tendons lying behind the external malleolus, and curving forwards beneath it to the outer surface of the os calcis.

2. The tibialis posticus and flexor longus digitorum tendons behind the internal malleolus.

3. The flexor longus hallucis tendon passing nearly behind the astragalus, and curving forwards beneath the sustentaculum tali.

4. The tendo Achillis, a very bulky tendon, passing to the posterior surface of the os calcis. It is not attached, however, to the upper quarter of this surface, being separated therefrom by a bursa. On either side a flattened area separates the tendon from the malleoli.

Examination.—The tip and anterior border of each malleolus must be palpated. The line of the ankle-joint passes upwards along

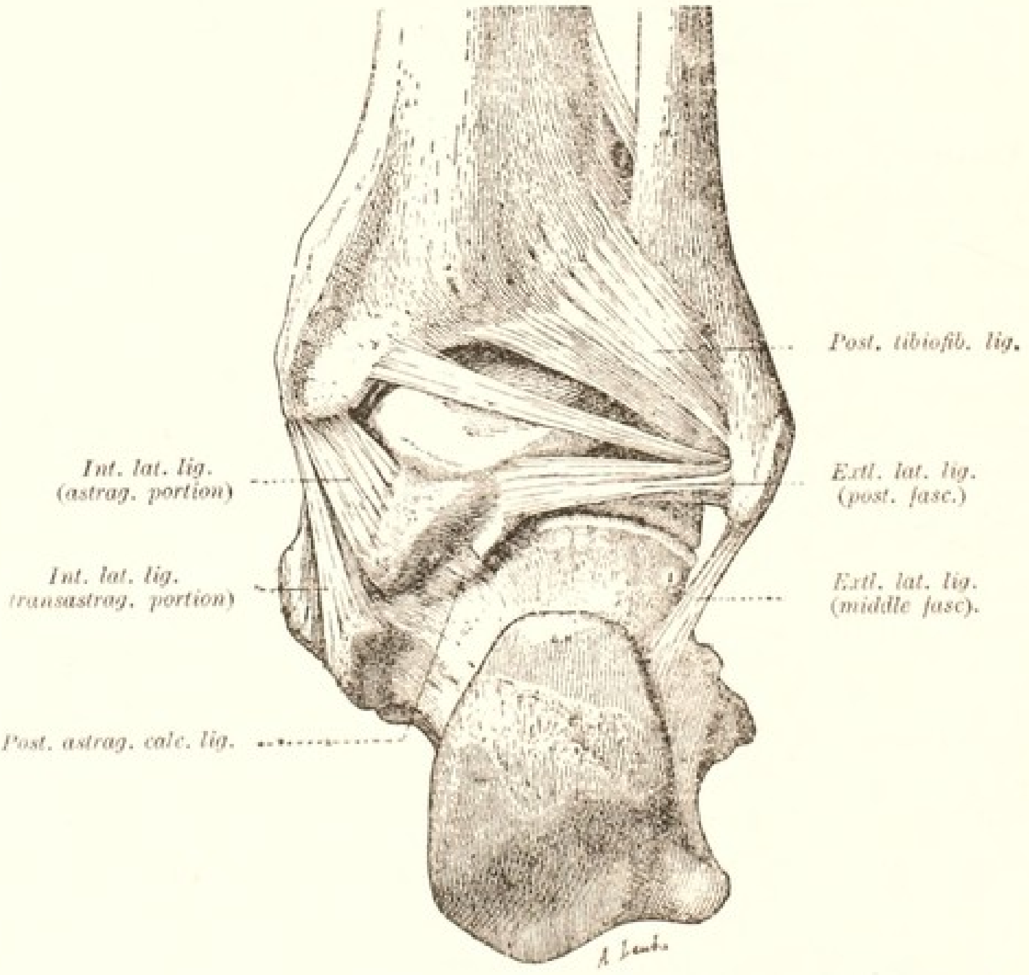


Fig. 175.—The ankle-joint and the inferior tibiofibular articulation, seen from behind.

these two borders, and transversely between them beneath the anterior border of the inferior surface of the tibia; it can readily be felt by alternately flexing and extending the joint. In dorsiflexion the astragaloid pulley becomes hidden beneath the tibia; in plantar flexion it projects anteriorly.

The external malleolus is slightly behind the internal, and reaches about a finger-breadth below it.

Line of Incision.—A number of different incisions have been suggested. A flap may be employed similar to that used in a subastragaloid disarticulation, but a finger-breadth shorter. The easiest procedure, however, as well as the best, is Syme's amputation with a heel flap.

The incision commences one finger-breadth below the tip of the internal malleolus, passes thence vertically *beneath the sole*, and ends just beneath the tip of the external malleolus. On the dorsum of the foot the heads of this U are united by the shortest route, and the incision therefore passes about a finger-breadth in front of the line of the joint.

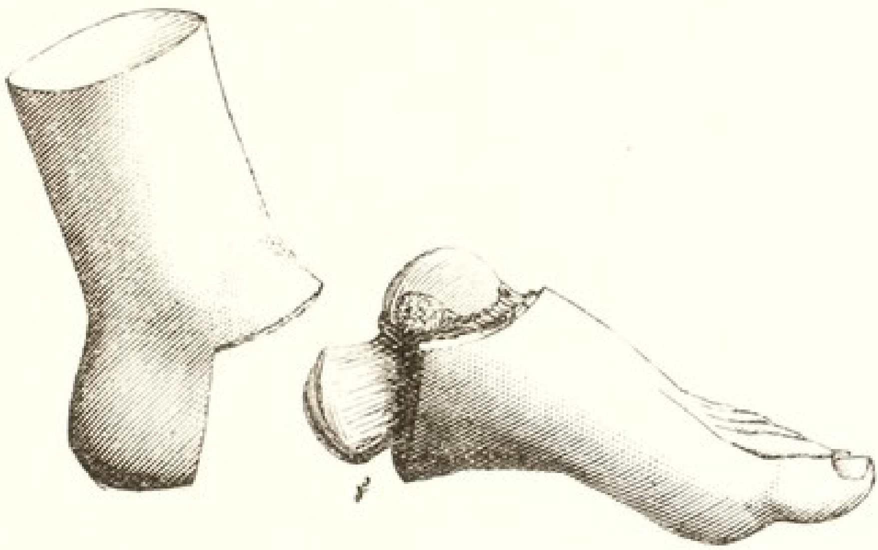


Fig. 176.—Syme's amputation, showing the outline of the heel flap and the lines of the sub-plantar and 'gaiter' incisions.

The operation only gives a good result if well-padded plantar skin is brought beneath the divided bones, and if the cicatrix is definitely superior. If the condition of the skin does not allow of this, it is better to perform a supramalleolar amputation (p. 133).

Principal Steps.—

1. Division of the lateral and plantar skin.
2. Division of the dorsal skin, and opening the joint.
3. Disarticulation, by section of the lateral ligaments.
4. Division of the tendo Achillis, and decortication of the os calcis.
5. Sawing the bones.

Syme's knife is used, as for the subastragaloid disarticulation.

Division of the Lateral and Plantar Skin.—The assistant, standing on the outer side, grips the base of the thigh between his elbow and trunk, the knee nearly at a right-angle; then, holding the posterolateral surfaces of the limb in his hands, thumbs above, he presents the leg in a horizontal position.

The surgeon, placed at the extremity of the limb, seizes the toes and heads of the metatarsal bones in his left hand, thumb beneath the sole, and rotates the foot rightwards, in order to see to the left. He then passes his right hand under the raised left elbow, and pierces the tissues at the left extremity of the **U**, knife perpendicular to the sole, which stands vertically before him. Cutting from left to right, and at the same time rotating the foot little by little to the left, he passes to the right extremity of the **U**, cutting with sawing movements, and dividing the tissues from end to end of the wound *down to the bone*, contact with which should not be lost during the incision (*Figs.* 477, 478).

Fig. 477.

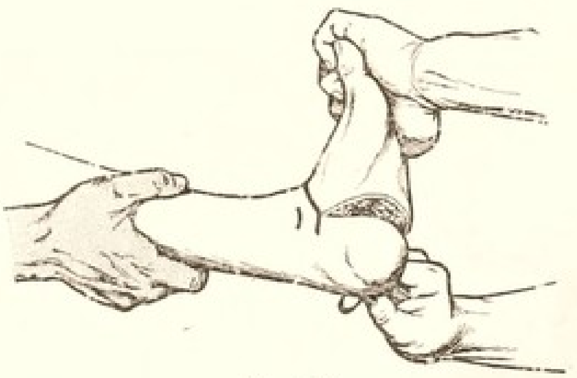


Fig. 478.

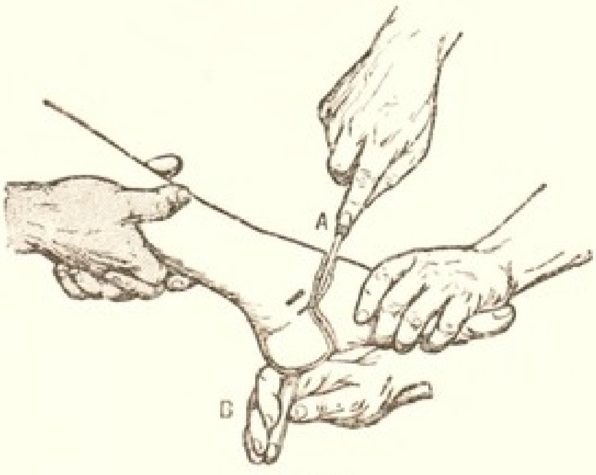


Fig. 479.

The toes are next entrusted to the assistant, who holds them vertically with his outer hand, while the operator liberates about an inch of the flap over the lateral and plantar surfaces, hooking it back with the left thumb, and passing the knife two or three times from left to right, blade flat to the heel, between the left, plantar, and right surfaces of the bone and the deep surface of the flap. Over these three surfaces everything must be divided, including the lateral tendons, until the posterior tubercles of the os calcis are freed.

Dorsal Incision. — The assistant lowers the leg to an angle of about 45° with the horizontal, and the surgeon grasps the dorsum of the foot in his left hand and places it in the equinus position. The dorsal skin is then divided with the full blade (*Fig.* 479, A), ending with the point, handle below, and held like a violin bow (*Fig.* 479, B). Skin and tendons must be completely divided. With the foot at a right-angle to the leg, the incision should cross the neck of the astragalus.

Disarticulation.—At the level of the skin, retracted by the ulnar border of the assistant's outer hand, the surgeon now enters the dorsal line of the joint, transversely, just below the border of the tibia, the foot in equinus; the astragaloid pulley then comes into view, flanked on either side by the surfaces of the malleoli.

Fig. 480.

The malleoli are united to the tarsus by two ligamentous layers: one superficial, the trans-astragaloid, which is attached below to the os calcis; one deep, which is inserted into the astragalus below and behind the corresponding articular facette. The posterior portion of the deep plane is inserted into the tail of the astragalus and the groove for the tendon of flexor longus hallucis. This ligament is a powerful one, especially on the outer side.

Fig. 481.

The equinus position allows some play in these joints, because the astragalus is broader in front than behind, and in this position, therefore, the joint can be made to gape on one side by carrying the foot to the opposite side.

Fig. 482.

The opening is broadest between the base of the malleolus and the border of the upper surface of the astragalus, as can readily be understood, so that the easiest way is to proceed as represented for *the right side of the joint* in *Figs.* 482, 483.

Fig. 483.

With the foot in equinus and twisted to the left, about an inch of the blade is introduced between the astragalus and malleolus, edge downwards (*Fig.* 482); the tissues are then divided, first over the side of the astragalus, then over the side of the os calcis. Under pressure of the surgeon's hand, the astragalus becomes dislocated and rotates still further forwards; the posterior fibres attached to the astragalus can then be divided in a second stroke by thrusting the knife still deeper (*Fig.* 483).

On the left side of the joint exactly the same steps may be taken, with the foot in equinus and rotated to the right; but a practised operator employs the following more rapid and neater method :—

Cutting away from him, he passes along the anterior border of the malleolus from apex to base, dividing the anterior ligaments from without, first over the os calcis, then over the astragalus (*Fig.* 480). The articulation opens under the pressure of the left hand, and the point can be thrust still further backwards to divide the posterior astragaloid ligament (*Fig.* 481).

Operating in this manner, disarticulation can be completed without change of position; the joint is entered on the left by reversing, the dorsum of the astragalus is followed transversely, and the knife is then brought out on the right, in the order of *Figs.* 480–482.

Decortication of the Os Calcis.—When the two malleolar joints have been opened, the foot rotates freely; pushing his left hand forwards, the operator makes the posterior extremity of the os calcis project towards him, together with the tendo Achillis and the skin over it. Then by successive strokes of the point, made with little sawing movements—not too deep, in order to avoid buttonholing the skin—the os calcis is enucleated, the blade held flat to the bone, following first the left surface, then the upper surface (or the posterior surface when the upper has been cleared), and finally the right surface. Each stroke of the knife should be a semicircular one, shaving the bone closely, passing from the extreme left to the extreme right of the incision, always at the same depth, while the left hand twists the foot from right to left in order to present the different surfaces in succession to the blade (*Fig.* 484).

Fig. 484.

To decorticate correctly, the operator should pull on the foot as well as depress it; and he must also remember that although the skin is thick and protected by the tendo Achillis posteriorly, it is thin at the sides. It is at the sides especially that an inexperienced operator is likely to buttonhole the skin, and for this reason it is best to free it from before backwards early in the operation, after dividing the plantar skin, and to divide the tendons at the side against the lateral surfaces of the os calcis at the same time. If this precaution has not been taken, the skin at the sides is thrown into folds, and the base of one of the folds may be perforated during the manipulations for enucleation above described. If the operator is not sure of the precision of his movements, the lateral borders of the flap should be retracted.

Freeing the Bones up to the Point where they are to be Sawn.—This is done, as in raising a cuff, in two semicircular strokes, one in front, the other behind, the blade flat between the soft parts and the bone, and passing round the bone from left to right (*Fig.* 485).

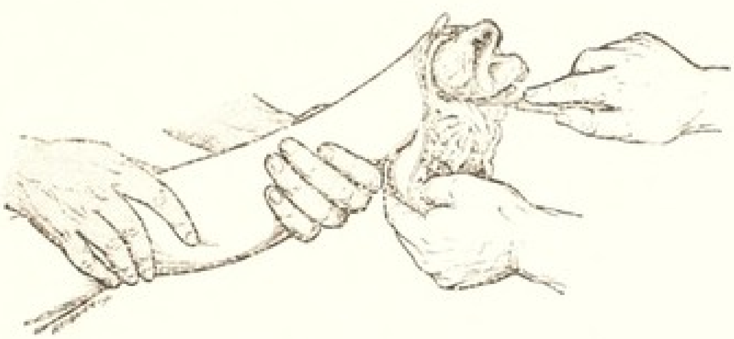


Fig. 485.

The retromalleolar tendon-sheaths are then divided longitudinally, so that the tendons may be preserved in the flap. The operator next leaves the extremity of the limb, and standing so that the foot lies to his left, he divides the periosteum circularly.

Sawing the Bones.—The internal malleolus is seized in its long axis by lion forceps: it is a more solid structure than the external malleolus. (If Farabeuf's lion forceps are preferred, the smaller grip

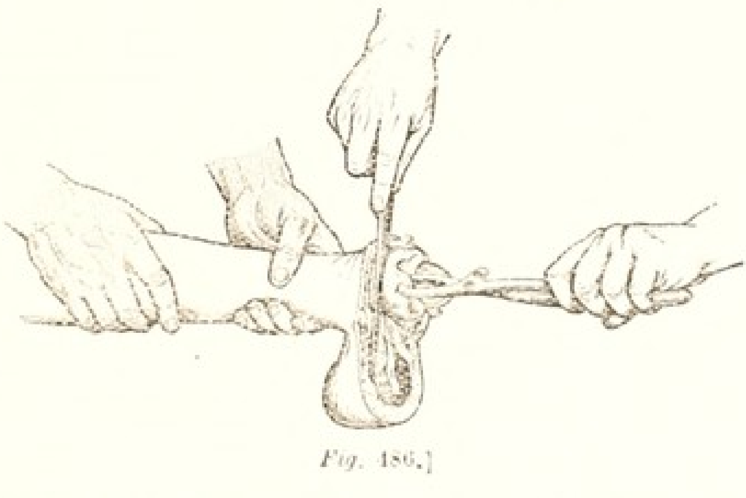


Fig. 486.]

should be used.) The bones are then sawn, with the hand above; the tibia is first attacked, then the fibula, and finally the tibia again (*Fig.* 486).

The saw is applied at the level of the lower surface of the tibia, just above the base of the malleoli, so that it passes beneath the little depression in the articular surface of this bone close to its junction with the fibula. On the outer part of the tibia, therefore, a little cartilaginous disc is left, and in the part removed there is a little hole corresponding thereto. There is no practical drawback in sawing the bones two to three millimetres higher.

Fig. 487.

The heel flap fits the sawn ends of the bone very well as shown in *Fig.* 487. It will readily be seen that the cicatrix, situated above and in front, is protected from all pressure when the stump is used in walking. The tendo Achillis reinforces the flap, to which it will be adherent below if the os calcis has been shaved closely enough during enucleation. It is maintained in position by suturing it to the anterior tendons.

Chapter XVII.

DISARTICULATIONS OF THE KNEE AND HIP.

DISARTICULATION OF THE KNEE.

Anatomy.—There are two articulations at the knee: (1) Between the femur and patella; (2) Between the femur and tibia.

1. *Joint between Femur and Patella.*—Into the base and borders of the patella the fibres of the quadriceps tendon are inserted, and the apex of the bone is attached by the bulky patellar ligament to the tubercle of the tibia. In extension of the knee the patella lies over the thigh, above the line of the femoro-tibial joint; in semiflexion, the position in which the joint is entered, it lies tangentially to the femoral condyles, and its middle part alone is incont act with bone.

2. *Joint between Femur and Tibia.*—This is placed horizontally and transversely between the femoral condyles (separated by a large cleft posteriorly) and the upper surface of the tibia, to which are attached the semilunar cartilages. There are in reality two tibial articular surfaces and two interarticular cartilages, separated by the projecting bifid tibial spine.

Ligaments.—1. The external lateral ligament, a thick, cylindrical cord running obliquely downwards and backwards from the tubercle of the external condyle of the femur to the head of the fibula, holding against the femur the popliteus tendon, and related externally to the deep surface of the biceps tendon, which, from the operator's point of view, must be considered with it.

2. The internal lateral ligament, a long flattened band running obliquely downwards and forwards from the tubercle of the internal condyle of the femur to the inner surface of the tibia, beneath the insertions of the semitendinosus, gracilis, and sartorius.

These two ligaments are free for some distance between the tubercle of the condyle and the line of the joint, and it is in that part of their course, against the bone, that they must be divided; for below the femur they are adherent deeply to the corresponding semilunar cartilages, which should be removed with the tibia.

3. The anterior crucial ligament, which passes from in front of the tibial spine very obliquely backwards and upwards to the internal surface of the external condyle. In flexion of the knee it rests between the two points of the tibial spine, and in this position, using the tibia as a block, it is easily divided transversely.

4. The posterior crucial ligament, passing from the external surface of the internal condyle of the femur to the posterior border of the upper surface of the tibia, far behind the spine, where it is

inserted into a fairly large depression lying between the articular surfaces. It may easily be divided transversely, therefore, if it is approached from before backwards, against the posterior border of the bone, the blade nearly parallel to the posterior surface of the tibia (see *Fig.* 504).

5. The posterior ligament (with which are connected the semimembranous tendon and the sheaths and tendons of the gastrocnemius)

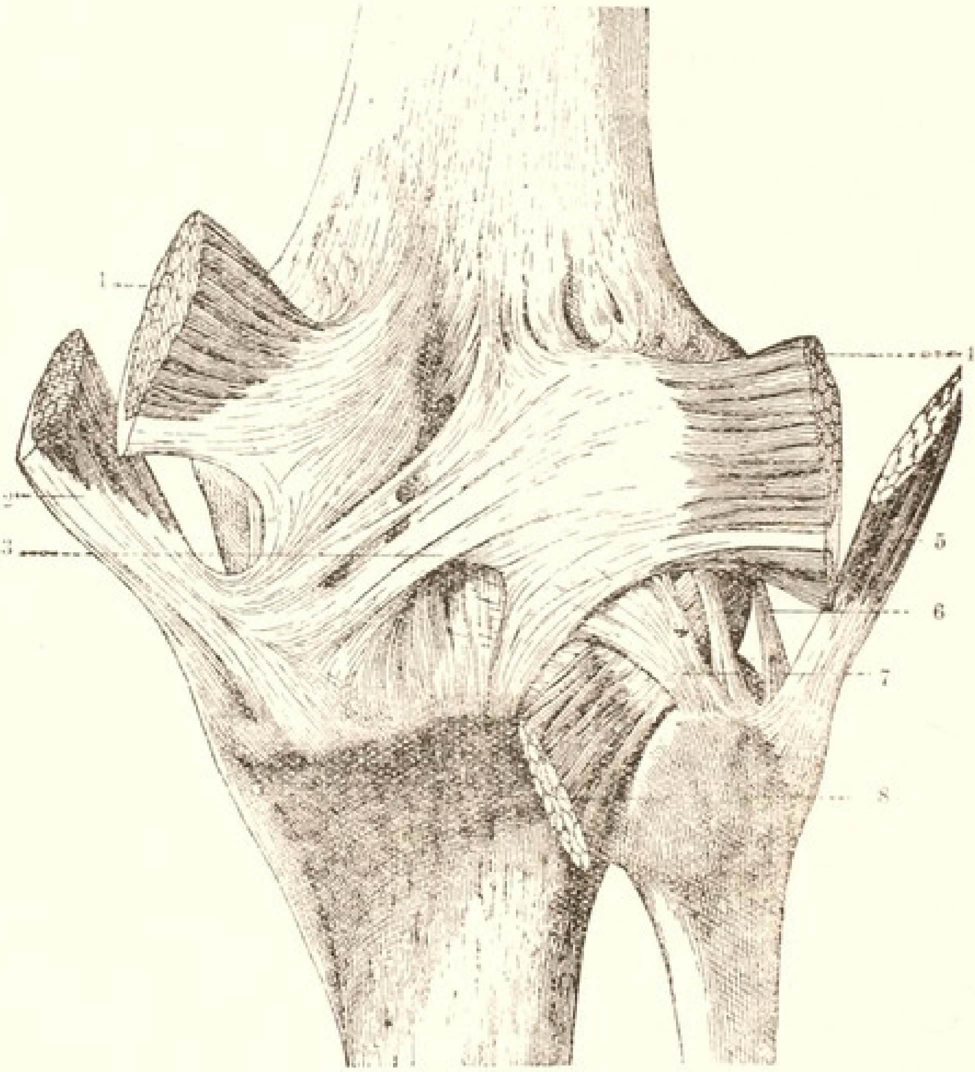


Fig. 488.—The knee-joint viewed from behind.

(1) Inner head of gastrocnemius; (2) Semimembranosus; (3) Extension of the semimembranosus tendon; (4) Outer head of gastrocnemius; (5) Biceps; (6) External lateral ligament; (7) Arcuate popliteal ligament; (8) Popliteus muscle.

surrounds the condyles posteriorly, and forms a resistant plane of fibrous tissue reaching from the femur to the posterior border of the upper surface of the tibia behind the posterior crucial ligament.

Popliteal Vessels and Internal Popliteal Nerve.—These lie in the intercondylar notch close to the posterior ligament.

Examination.—The edges of the patella are easy to feel and to mark. The broad line of the joint between the condyles of the femur and the upper surface of the tibia, its breadth corresponding to the thickness of the semilunar cartilages, may also readily be palpated by making little movements of flexion and extension.

Line of Incision.—The cicatrix must lie posteriorly. This result may be attained by an *elliptical incision*, a very graceful one to make, the upper extremity being situated posteriorly, half a diameter of the limb below the line of the joint, and the lower extremity over the tibial crest, a full diameter below the joint line. But if the calf is thin and the knee large, or if the skin is not

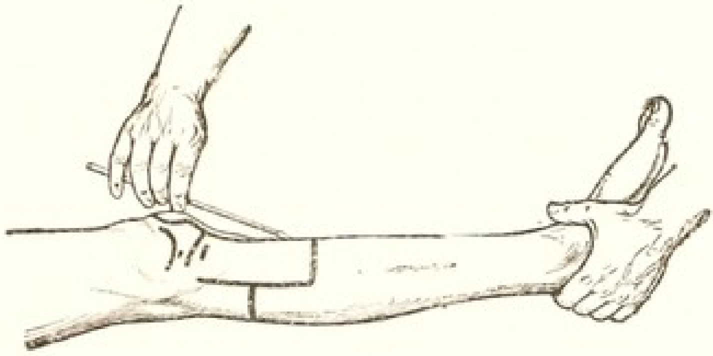


Fig. 489.

sufficiently supple, it will be found difficult to reflect the anterior skin. I should therefore advise an *anterior flap* in preference to an ellipse.

The antero-posterior diameter of the limb having been estimated, the anterior flap, which should be equal in length to this diameter, is marked out by two symmetrical lateral lines at the level of the head of the fibula—a little behind the median coronal plane of the limb, therefore—their upper ends one finger-breadth below the articulation.

The two branches of the U are united transversely behind, so as to leave a *posterior flap* equal to half the diameter of the limb.

Principal Steps of the Operation.

1. Division of the skin, first in front, then behind.
2. Raising the anterior flap as far as the upper border of the patella.
3. Opening the joint transversely, beneath the apex of the patella.
4. Division of the lateral ligaments.
5. Division of the crucial ligaments.
6. Detachment of the posterior ligament close to the tibia, and completion of the operation by transfixion.

A knife with a blade 6 inches long is used.

One assistant, placed on the outer side of the thigh, is sufficient; but it is more convenient to have two.

Division of the Skin.—Standing at the extremity of the limb, the operator seizes the foot in his left hand, the knee in extension, and twists it to the right in order to see the left head of the U, where the point of the knife is applied, the blade at an angle of 45° (*Fig.* 490), and drawn downwards along the corresponding branch of the U. After turning on the point (*Fig.* 491) in a rounded right-angle, the surgeon crosses the limb anteriorly (*Fig.* 492) while it is held in the normal position; then turning again (*Fig.* 493), he changes his

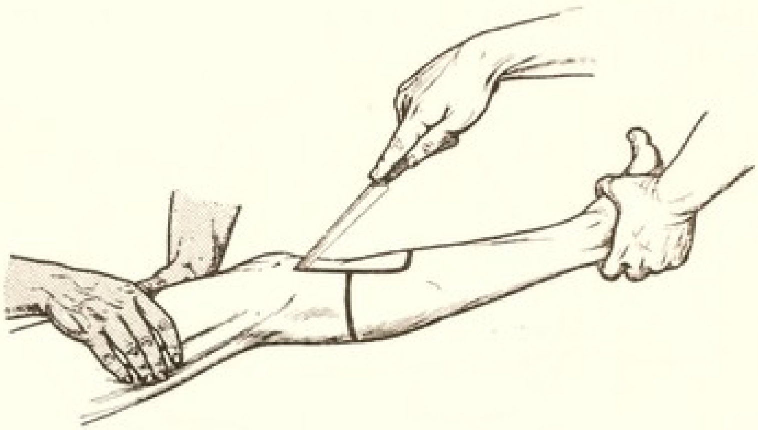


Fig. 490.

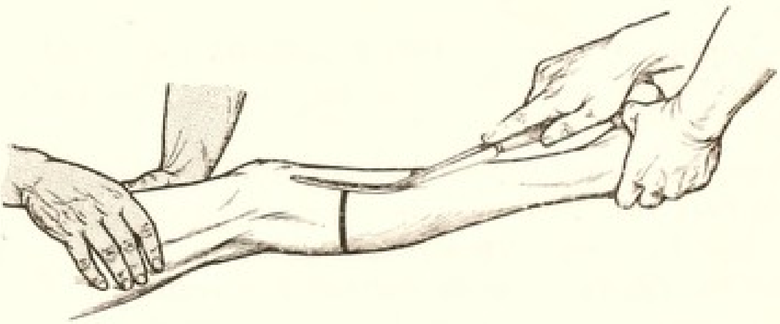


Fig. 491.

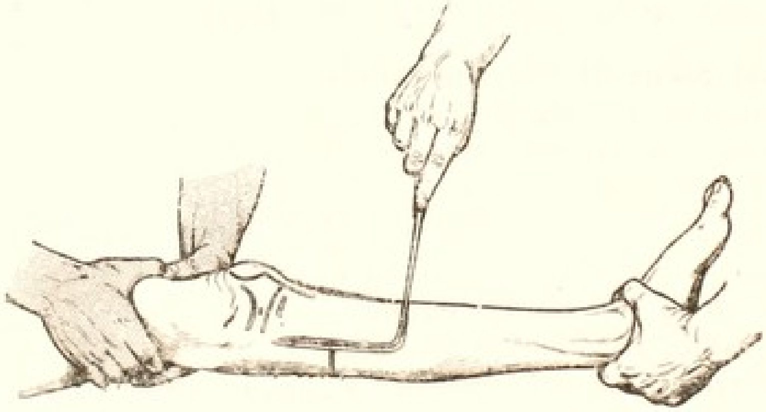


Fig. 492.

position in order to face the right surface, and twisting the limb to the left (*Fig.* 494), he passes upwards along the right branch of the U.

The skin is liberated by repeating the incision. The operator—now standing inside the right limb, but outside the left—next divides the skin transversely on the posterior aspect of the limb from heel (point above) to point (handle above) of the knife. The movement is the same as in dividing the skin posteriorly after cutting an anterior flap from the thigh. The surgeon can hold the foot himself in his left hand, but it is more convenient to entrust it to an assistant.

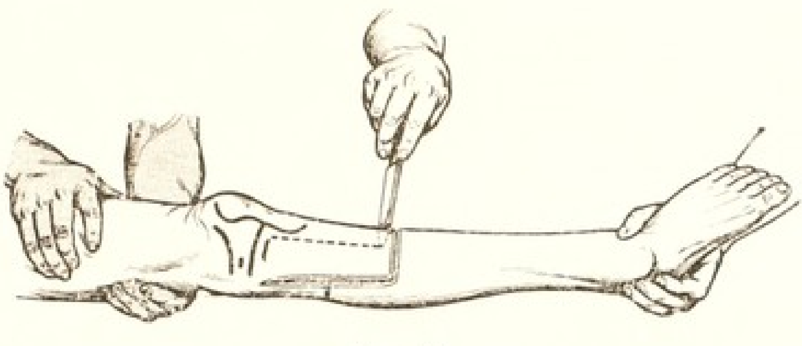


Fig. 493.

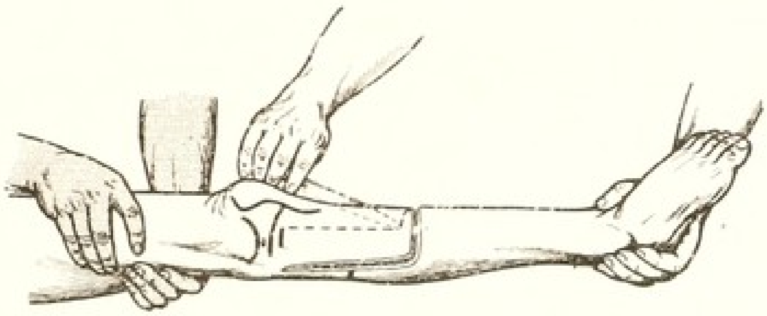


Fig. 494.

The skin must again be most carefully freed, especially at the angles.

Dissection of the Flap.—The operator entrusts the foot to his assistant, who holds the limb in extension; then, taking the edge of the flap in his own left fingers, he raises it in a half cuff for two or three finger-breadths, with the blade flat to the bone (*Fig.* 495).

Fig. 495.

The assistant now takes the flap in his two hands, spreads it out, and pulls it upwards (*Fig.* 496), while the operator holds the ankle in his left hand in the normal position, and with violin-bow movements of the knife, from left to right and from right to left, divides the white connective-tissue strands which appear between the osteoaponeurotic surface and the flap. The edge of the knife is turned a little obliquely towards the tibia, and the limb is flexed little by little until it reaches an acute angle. The process is continued until the anterior surface of the patella has been bared (*Fig.* 497), this being confirmed by little taps with the back of the blade.

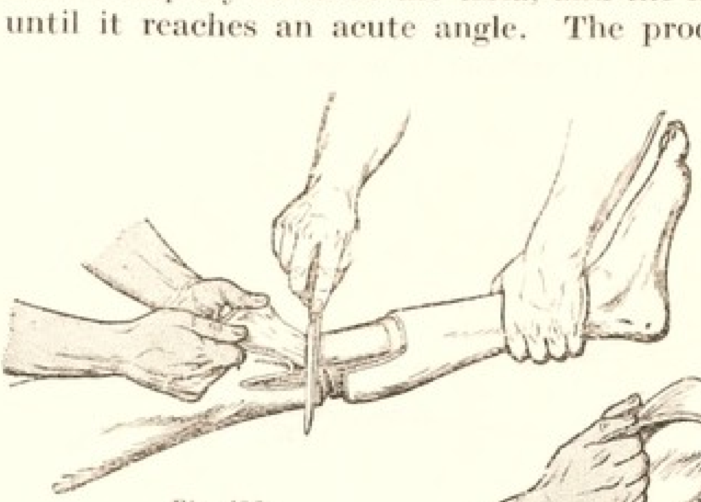


Fig. 496.

Fig. 497.

Opening the Joint.—The edge of the knife is now applied transversely over the patellar tendon, facing obliquely upwards (*Fig.* 498), and the tendon is divided until the blade is arrested by the femoral condyles (*Fig.* 499). As the assistant continues to retract the flap the patella passes away from the surgeon; and within the joint, which opens before him as the knee is flexed *to its maximum*, the ligamentum mucosum is seen. This the surgeon divides, either by a stroke of the point, or by passing the blade transversely behind it and bringing it out edge upwards and towards him.

Fig. 498.

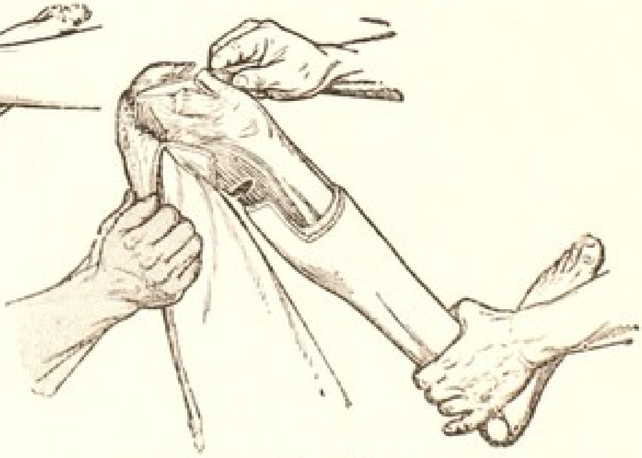


Fig. 499.

The anterior portions of the condyles are now extensively exposed, and the structures next to be divided are the lateral and the crucial ligaments.

Division of the Lateral Ligaments.—With the knee flexed nearly to a right-angle, the surgeon begins with the ligament to his left, bending the knee to the right by twisting the leg in that direction with his left hand. In my opinion the best course is first to divide the anterior portion of the ligament with a stroke of the knife-point over the femoral condyle and above the semilunar cartilage; this is not an essential step, but it facilitates the subsequent procedure. Then, using the bone as a support, and keeping a little above the cartilaginous border, push the blade as far backwards as possible, and divide the remainder of the ligament from the heel to the point (*Fig.* 500). There is no danger if the skin has been sufficiently freed. When the ligament on the left has been completely divided, the leg is twisted to the left, so bending the knee in this direction, and the blade is passed round the femur at the level of the cartilage, ending with the handle below, and dividing the ligament to the operator's right *over the condyle, as far back as possible*, from the heel to the point of the blade (*Figs.* 501, 502).

Fig. 500.

Fig. 501.

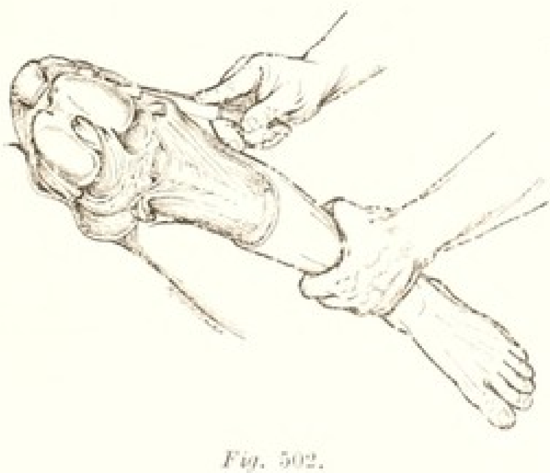


Fig. 502.

On both sides, while the ligament is being divided, the knee is first held moderately flexed, and the flexion is gradually increased until, when the posterior fibres are being divided, the joint is in acute flexion. While flexion is increased, the leg is also inclined to the right when the left ligament is divided, and to the left when the right ligament is divided.

It is most important that the skin should be freed very carefully everywhere on the posterior aspect of the joint, and that the assistant should retract it above the condyles; otherwise it will be injured.

Fig. 503.

Division of the Crucial Ligaments.—The operator, who was standing a little to the right of the limb, now resumes a position directly opposite to it, and removing his left hand from the ankle, grasps the leg posteriorly at the level of the upper extremity of the tibia, the thigh being presented at an angle of 45°, while the leg hangs vertically. With the left hand he pulls the tibia straight towards him, and the anterior crucial ligament comes into view, running nearly horizontally from before backwards over the upper surface of the tibia and in the cleft of the bifid spine. At this point it is divided transversely, the edge of the knife perpendicular to the tibia, which serves as a block (*Fig.* 503). The traction being continued, the tibia can now be dislocated completely forwards, and the posterior crucial ligament appears, running nearly vertically upwards from the posterior margin of the tibia to the internal condyle. It is divided with the point, from left to right, close to the tibial border (*Fig.* 504).

Fig. 504.

Transfixion. — The tibia now comes still further forwards, and the blade is passed behind it, flat against it, the edge facing downwards and forwards. The leg is then rearticulated, the knee placed in extension, and the knife is brought out with sawing movements at the level of the skin posteriorly (*Fig.* 505).

Fig. 505.

For an artificial apparatus which necessitates direct support, disarticulation of the knee often gives an unsatisfactory result ; the thin skin is compressed beneath the projecting condyles more than it will suffer. The result given by a *transcondylar amputation* is perhaps better. The operation is carried out much as has been described, but the lateral incisions reach up to a point level with and just behind the tubercles of the femoral condyles. The condyles are sawn, after disarticulation, and when the patella has been removed, a good fibrotendinous pad remains.

DISARTICULATION AT THE HIP.

This will only be described briefly, to indicate the principles involved ; it is not an ' examination ' operation, and a student would hardly be expected to know more than the anatomy of the joint and how best to enter it.

The *prize method*, in which a candidate is able to show that he can handle a knife neatly and safely, is disarticulation *with an anterior flap*.

On the living, the racket operation is to be preferred, with ligature of the vessels before disarticulation, whether an external or an anterior racket be chosen. The chief danger is from hæmorrhage, either from the smaller vessels or from the femoral artery itself. A very practical method is first to perform a circular subtrochanteric amputation, and make sure the vessels are adequately secured, then to clear the bony stump and open the joint from the outer side.

It is this procedure that will here be described, especially because, in the dissecting-room, a disarticulation at the hip is never performed except on subjects on which the thigh has already been amputated at a higher or lower level.

Fig. 506.

The manipulations described will be for the left side. One assistant, standing on the outer side at the level of the buttocks, is sufficient.

The thigh having been amputated, then, the operator grasps the anterior surface of the stump in his left hand, and slightly flexes and adducts it. He then pierces the skin with the point of the knife down to the neck of the bone, mid-way between the upper border of the great trochanter and the iliac crest (*Fig.* 506), and draws the knife along the anterior border of the great trochanter and down the femur as far as the cut surface of the thigh. The point of the knife should never leave the bone from one end of the incision to the other.

The assistant now seizes the lips of the wound, one in each hand, and separates them, while the operator takes the divided end of the femur in the large grip of Farabeuf's lion forceps. The denuded outer surface of the bone can now be seen, and the rest of it is readily cleared by drawing two or three strokes of the knife along it anteriorly from

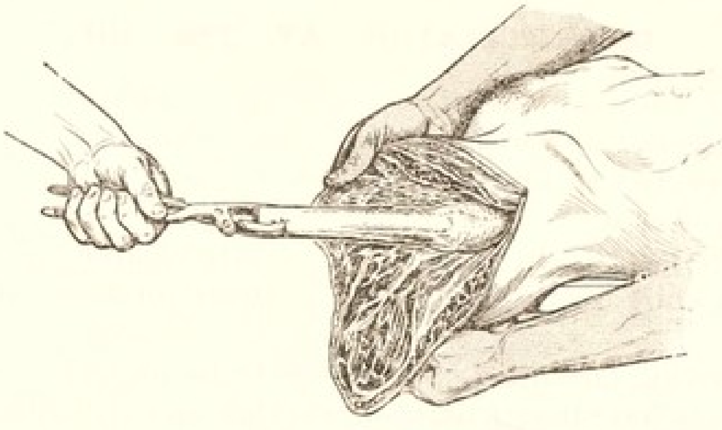


Fig. 507.

end to end, and a similar number posteriorly, keeping in each case close to the bone (*Fig.* 507).

The anterior surface of the great trochanter, and the capsule covering the head and neck of the bone, can now be seen ; posteriorly those parts are still adherent to the muscles of the buttock. Two steps are now necessary.

1. **Incision of the Capsule.**—This is done at the middle of the neck, with a stroke of the point parallel to the axis of the neck—obliquely downwards and outwards, therefore. Extending the femur and rotating it outwards, the operator pierces the tissues as close to the ilium as possible, so as to divide first the glenoid cartilage and then the capsule, stopping only when the blade comes into contact with the great trochanter.

2. **Division of the Two Lips of the Capsule.**—The two lips of the slit which has just been made are held tense by extension of the limb, and must first be relaxed by flexion. They then separate, and leave an interval on either side between them and the neck of the femur. The two halves of the capsule must be divided along their insertion into the intertrochanteric lines. The following description applies to the left side :—

The thigh being flexed and slightly abducted, the point of the knife is insinuated on the flat between the anterior surface of the neck and the outer lip of the capsule, edge towards the great trochanter, and perpendicular to the axis of the neck (*Fig.* 508). When the upper border of the great trochanter has been passed, the handle is raised, and the blade is engaged, still on the flat, behind the posterior surface of the neck. The surgeon then makes a double movement ; with the left hand he extends the femur and places it in adduction and internal rotation, so stretching the outer lip of the divided capsule, and tending to wedge the blade between it and the upper border of the bone, while with the right hand he lowers the handle of the knife towards

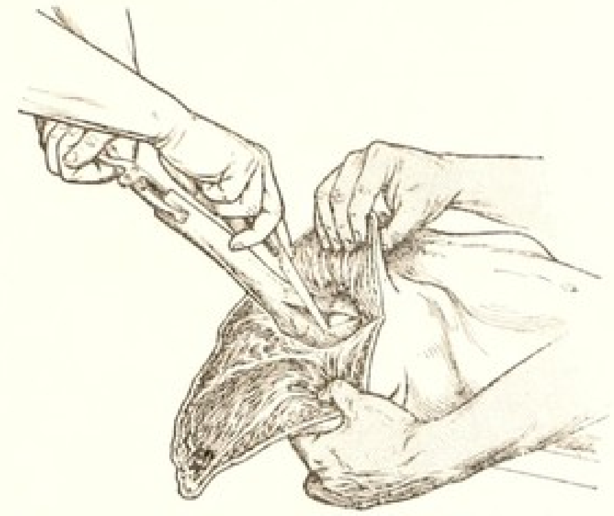


Fig. 508.—Point engaged between the neck of the femur and the outer lip of the capsule. If the leg is twisted to the left and extended, while the right hand is dropped, the capsule will be divided.

him, aiming for the posterior border of the great trochanter. The upper part of the posterior insertion of the capsule, and the transverse portion of the ligament of Bigelow, are thus divided close to the bone. This manipulation resembles that in which the tendons are divided behind the malleoli in a supramalleolar amputation (see p. 138).

The manœuvre for division of the inner lip of the capsule is similar, but the inverse of that just described. The handle of the

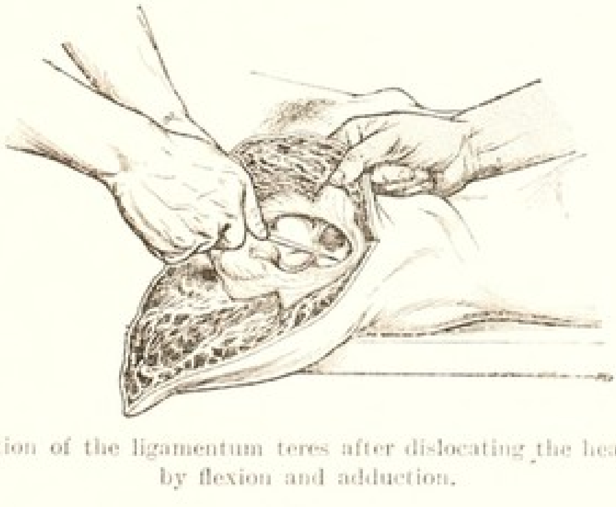


Fig. 509.—Section of the ligamentum teres after dislocating the head of the femur by flexion and adduction.

knife is lowered in order to pass the point on the flat beneath the neck ; the femur is then placed in extension, abduction, and external rotation, tending to imprison the blade, with its edge towards the operator, between the capsule, the neck, and the lesser trochanter, at which level the capsule and vertical portion of Bigelow's ligament are divided.

On the right side, the process commences on the inner and finishes on the outer side.

Fig. 510.—Division of the remaining posterior portion of the capsule.

If now the first incision into the capsule has divided the glenoid cartilage as well as the capsule, the head of the femur becomes dislocated forwards by the external rotation. The ligamentum teres is divided with a stroke of the point on to the head of the femur, which serves as a block (*Fig.* 509); and nothing remains but to bring the knife out by shaving transversely the posterior aspect of the neck of the bone and the great trochanter (*Fig.* 510).

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