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FRACTURED FEMURS

PEARSON AND DRUMMOND

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FRACTURED FEMURS

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Period since wound in months.

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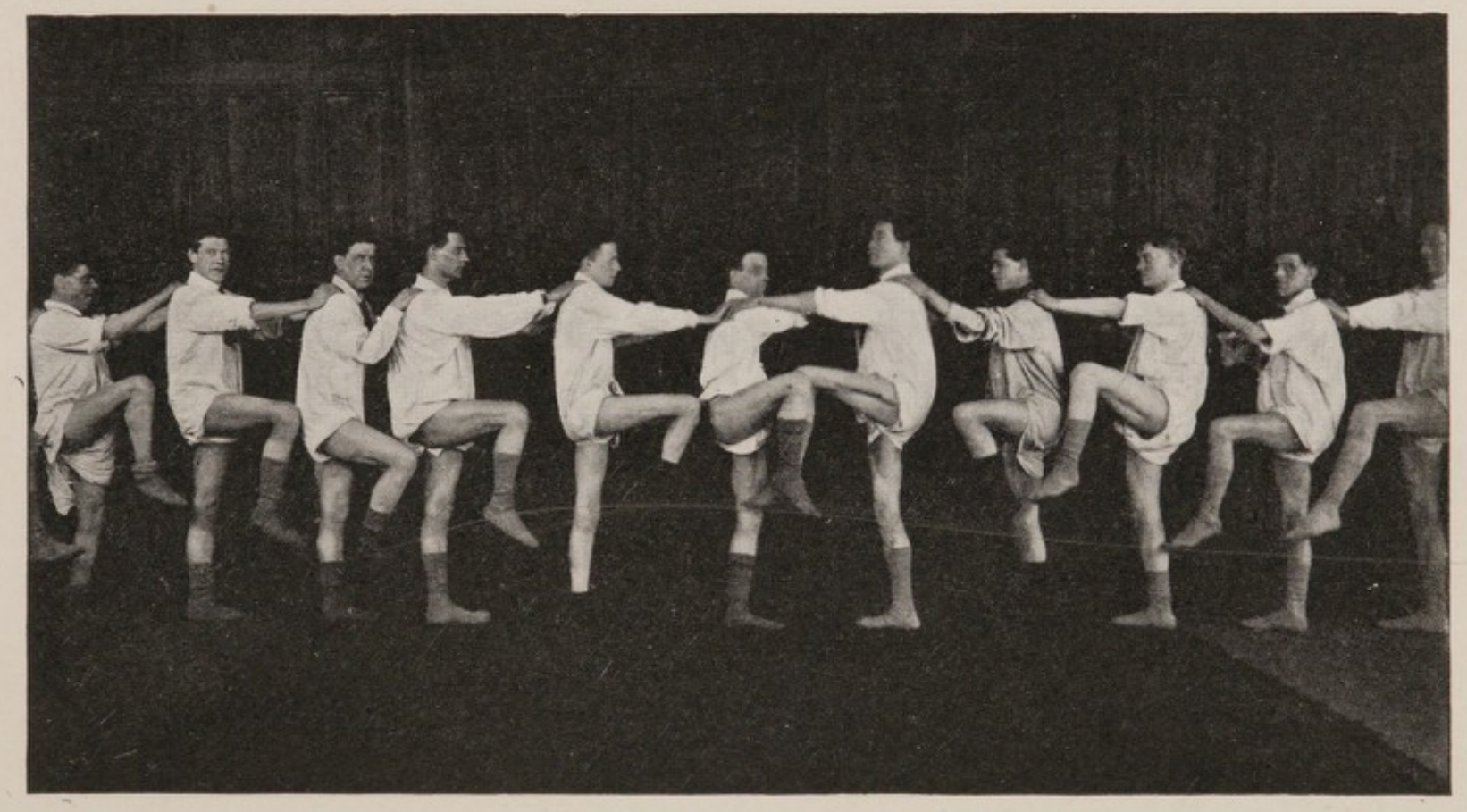

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Alteration in length of injured limb in centimetres.

GROUP OF WAR FRACTURES OF THE FEMUR, AVERAGING 6½ MONTHS SINCE WOUND, SHOWING FLEXIBILITY AND MUSCULAR CONDITION OF INJURED LEGS. IN MOST OF THESE CASES KNEE MOVEMENTS WERE BEGUN AFTER THE FIRST MONTH.

FRACTURED FEMURS

THEIR TREATMENT BY CALLIPER EXTENSION

BY

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TO THOSE THAT NURSED THEM

FOREWORD

By Colonel Sir H. M. W. GRAY, K.B.E., C.B., C.M.G., *Assistant Inspector of Special Military Surgery, late Consulting Surgeon, 3rd Army, B.E.F., France*

Those who have had the privilege of seeing the excellent work done by the authors and their colleagues, especially at Edmonton Special Surgical Hospital, will welcome the publication of this book. I believe all will agree that the treatment of fractured femurs, as carried out by them, left little to be desired. The work of the teams, the meticulous attention to all details, the frequent checking of the position of fragments by scientific and reliable methods, the apparent ease, accuracy, and painlessness with which all the manipulations were carried out, and, finally, the personal supervision and encouragement given by Lieut.-Colonel Pearson, combined to produce such comfort and well-being of the patients during the more acute stages of their illness, and also such excellent final results, that visitors were stimulated with the desire to go and do likewise.

The description of the methods employed should make it possible, even for surgeons of ordinary ability, to obtain equally good results, provided they will give the necessary attention to detail.

My experience, both in France and in Home hospitals, compels me to say that the teaching of the principles of treatment of fractures in general and of their practical application must be vastly improved if ordinary justice is to be done to fracture cases in future. The results of treatment of such cases by those who have become experts in dealing with serious war injuries show that, by careful attention, the frequent deformities and consequent incapacity which used to follow comparatively simple fractures of civil life are preventable, and should be looked upon usually as being due to incompetence or inattention on the part of the responsible surgeon.

The statements and teaching, with regard to treatment of fractures, of such men as Lieut.-Colonel Pearson, who have had exceptional and intensive training and experience, should receive the utmost consideration by surgeons all over the world.

H. M. W. GRAY.

June, 1919.

PREFACE

THE greater part of the practical details of the method here described was worked out in France at a period of great stress, when time and appliances were equally scarce. There were occasions when, all beds being full, patients on stretchers occupied the floor space around, and even under, the beds. Thanks to the hearty co-operation of Capt. Renwick, A.O.D., appliances were quickly improvised and made in very large quantities, while others were purchased locally with funds liberally supplied to us by the Natal Red Cross and other South African friends, whom we wish to take this opportunity of thanking.

For much encouragement and surgical help we are indebted to Major-General Sir Anthony Bowlby in France and to Major-General Sir Robert Jones in England.

Most of all do we owe thanks to Colonel Sir H. M. W. Gray, who took such a large part in the organisation of special femur hospitals in Britain and in standardising their methods, who was an ever-available source of prompt help when prompt help was needed, and whose sceptical mind was a constant tonic. For these and for the great trouble he has taken in criticising the proofs of this little book we can never be sufficiently grateful.

Nor would good results have been possible without the sustained interest and enthusiasm of the nursing sisters.

We wish to thank also Miss A. Livens, Miss V. Chapman, and Mr. Sewell for their help in providing the illustrations.

M. G. P.,
J. D.

June, 1919.

CONTENTS

PAGE

Foreword vii
Preface viii
List of Illustrations xi
Introduction 1

CHAPTER I
Evolution of Femur Treatment in War 5

CHAPTER II
Surgical Anatomy of Fractures of the Femur 12

CHAPTER III
Early Operative Treatment of Compound Fractured Femurs . 17

CHAPTER IV
The Mechanics of Femur Treatment 25

CHAPTER V
Calliper Traction and Mobilisation of Joints 39

CHAPTER VI
Treatment of Special Varieties of Fractures 52

CHAPTER VII
Nursing and General Management 63

CHAPTER VIII
Intermediate and Late Treatment of Fractured Femurs . . 70

CHAPTER IX
Results 78

Conclusion 89
Addendum 89
Index 91

LIST OF ILLUSTRATIONS

Group of war fractures of the femur . . . . . *Frontispiece*

FIG. PAGE

1. Fractured femur slung for transport (Gray) 10
2. Upper-third fracture, showing *abduction* of upper fragment—the usual type 13
3. Upper-third fracture with *adduction* of upper fragment—the exceptional type. 14
4. Lower-third fracture, lower fragment tilted backward into popliteal space 16
5. Severe comminution 19
6. Filling in of partial gap 20
7. Four-inch gap, occupied, after sequestrectomy, by fine débris only . 21
8. Much comminution of large septic wound near knee 22
9*a*. Backwardly tilted lower fragment 23
9*b*. Same case after suspension of lower fragment by wire loop . . . 23
10. Various methods of using Thomas and Hodgen splints . . . 26
11. Adaptation of Thomas splint to permit of knee-flexion . . . 28
12. The ordinary cause of pressure sores. 30
13. Thomas's splint with knee-flexion piece added 31
14. Non-penetrating callipers applied 32
15. Suspension of the foot by a bandage glued on to the sole . . . 33
16. Improvised form of fracture bed 34
17. Fracture bed 35
18. A canvas sling with straps at one end and "quick-release" at the other 36
19. Non-penetrating callipers applied to the shaft above the condyles . 40
20. Besley's callipers inserted *into* the condyles 41
21. Unnecessary penetration of points of calliper before modification . 42
22. Non-penetrating callipers after being sixteen weeks *in situ*, close to a large and very septic fracture 43
23. Callipers after being sixteen weeks *in situ* for fracture of upper third. 44
24. Lower-third fracture photographed three days after coming out of splints, to show (*a*) extension; (*b*) flexion 45
25. Patella fractured transversely in an effort to flex a rigid knee . . 47
26. Callipers applied above the malleoli as for fractured tibia or for some exceptional cases of fractured femur 49
27*a*. Very septic fracture of lower third as admitted more than six months after being wounded 50

PAGE

27*b*. Same case two months later 50
28. Method of treating upper-third fracture by abduction and flexion of one leg only, the other being left free 53
29. Goniometer for measuring degree of abduction of leg 54
30. Capt D. Crile's abduction splint 55
31. Screw pressure pads, applied as for correction of outward bowing . 56
32*a*. Upper-third fracture before abduction of limb 57
32*b*. The same case after abduction of the limb 57
32*c*. Same case after application of two screw pressure pads to approximate the surfaces. 58
33. (*a*) An outwardly bowing fracture with imperfect union; (*b*) the same case after application of pressure pad 59
34. Diagram to show how suspension of the ring prevents external rotation of the upper fragment 60
35. Chart indicating alteration in length. 66
36. Arch, suspension cord and hook, screw pressure pad, and femur measure 67
37. Cap-shaped sequestrum over the end of the upper fragment . . 71
38. "Anti-aircraft" position, enabling the patient to move his own knee through an increased angle 74
39. Thomas walking calliper and boots 75
40*a*. Extreme angular deformity resulting from many changes of hospital and too early discarding of splints 80
40*b*. Antero-posterior X-ray of same case. 81
40*c*. Lateral X-ray of same case. 81
41. Lower-third fracture; four months wounded at time of photograph . 83
42. Lower-third fracture; seven months wounded 83
43. Middle-third fracture; 8½ months wounded 84
44. Lower-third fracture; 5½ months wounded 84
45. Large shell wound of buttock; 5½ months wounded 85
46. Middle-third fracture; five months wounded 85
47. Lower-third fracture; wounded six weeks before admission; photos taken five months after being wounded. 86
48. Middle-third fracture; seven months wounded when photographed . 86
49. (*a*) As admitted with tie-on extension and Thomas splint; (*b*) after application of callipers and 10 lb. extension; (*c*) as evacuated to England eight weeks after wound 87
50. Gunshot wound of femur, upper half 88

INTRODUCTION

THE following pages are meant to give practical help to the surgeon who has charge of fractured femur cases either in military or in civil practice. They describe in detail one of the methods evolved during the war as a direct result of the policy of assigning special hospitals and special surgeons for the treatment of such injuries. The concentration of 300 to 500 cases of fracture of one particular bone in the human body into one hospital affords an experience unique in surgery, and one never likely to recur. It will be strange indeed if the lessons of that experience do not help the general surgeon. The new methods evolved for war fractures are applicable to civil fractures, whether simple or compound.

The lessons in treatment which have been learned from fractures of the femur are applicable largely to fractures of other bones. On the other hand, some old principles, hitherto only exceptionally applied in fractures of the femur, although widely used in fractures of other bones, have been brought strongly into prominence. The most important of these is that urged so long ago by Lucas-Championnière, viz., the early mobilisation of joints adjacent to the fractured bone. This principle has been so widely accepted and acted upon in the case of some fractures, *e.g.*, Colles' fracture at the wrist, that at first sight it is difficult to understand why it has been and is still so much neglected in other cases, and especially in fracture of the femur. The explanation probably lies in the difficulty of controlling position and correcting malposition when the injury concerns a single large bone like the humerus or femur. To move the knee-joint without disturbing a neighbouring recent fracture of the femur requires some strategy.

Whatever the explanation, the fact remains that throughout the war the general practice has been to immobilise the knee-joint in a case of fracture of the femur, and to a less extent the elbow and shoulder in fracture of the humerus. The functional results have too frequently been disastrous. We venture to point out that nowadays it is not

enough to turn out patients with apparently anatomically perfect limbs while the functional result is unsatisfactory. The striking improvement in anatomical results as a direct effect of concentrated war experience provides a legitimate source of pride to the surgeon, but is a poor satisfaction to the patient if the function of the limb is seriously interfered with. We believe it to be a fact, and a very regrettable one, that many patients with fractured femur are being discharged from the Army with knees permanently so limited in their range of movement that the patient is badly crippled and prevented from following many ordinary employments.

In other words, while the obstacles to saving life and limb have been largely overcome, and the anatomical results have been perfected both as regards length and form of the limb, the functional results have been and are still very bad in too many cases, and must be considered so as long as the more or less stiff knee remains the rule instead of the exception. All of us know of many cases recovering with perfect use of the knee, but few of us see the much larger numbers scattered throughout the country with knees permanently stiffened by long immobilisation. The knee is most frequently affected because the femur is supposed to demand a longer period of total immobilisation of the limb. The elbow, the shoulder, and the ankle suffer to a less extent only because early movement is easier and consolidation of the adjacent fracture is more rapid.

On all sides one sees valiant efforts being made to restore complete functional utility to these stiff knees and atrophied limbs by means of exercises, manipulation, massage, electricity, baths of endless variety, and so forth, but too frequently with disappointing results.

Prevention is better than cure. The system described in this book allows the use of movement of the knee from the very beginning of treatment and its maintenance throughout, without detriment to the fractured femur or to the wound of the soft parts—indeed, with distinct advantage to both. The waste of months on possibly futile effort after consolidation of the fracture and healing of the flesh wounds has occurred is thereby avoided. Further, it permits of active movements of the muscles, electrical stimulation and massage unimpeded by bandages, so that when the patient leaves his bed he has freely movable joints and active muscles.

The principles are old, the mechanical difficulties in carrying them out are real, but with care, patience, and ingenuity they can be overcome. The results speak for themselves.

A large part of the military problem consisted in organising the work on a huge scale and almost on factory lines, so that not merely isolated

brilliant results, but a general uniform average of good results could be obtained in very large numbers and with a minimum staff. This necessitated the use of every possible labour-saving and time-saving device.

The effect was that, while at the beginning of the war such cases were regarded as being most trying and unsatisfactory to deal with, they came to be treated in large numbers without being a great tax on the nursing staff, and the end results of even badly comminuted septic smashes were in many respects better than those of simple fractures before the war.

The organisation of femur wards does not at present interest the civilian surgeon, and we have not discussed it fully, but it is to be hoped that before long civil hospitals will adopt the policy of concentrating their fractures into a few wards and under the care of few surgeons instead of scattering them indiscriminately among many. The average compound fracture case does not afford much scope for operative brilliance, but there is no class of case which so well repays careful and patient work and attention to detail, or that has suffered so much from the want of these in the past. Only concentration and specialisation will secure them, because only concentration and specialisation will procure the necessary appliances and enthusiasm.

We have not gone deeply into questions of physiology and of pathology concerning bone-growth and bone-regeneration, nor into details of operations such as plating and grafting.

The details of the care of a particular case closely concern the general surgeon. It is our object to help him in that. We make no attempt to describe other methods that have been evolved during the war, nor do we claim that the method used by us is perfect. We are, in fact, very conscious of the directions in which it needs improvement. But it has been the routine method used in a very large number of cases and has stood the test, both as regards functional results and ease of working, in the vast majority.

FRACTURED FEMURS

CHAPTER I

EVOLUTION OF FEMUR TREATMENT IN WAR

In pre-war days the question of the treatment of fractured femurs was always one of some difficulty, and we were accustomed to regard a recovery after some months without marked disability as a thing to be proud of. Yet in the mind of the conscientious surgeon there was always a lurking regret.

Results were not uniformly good. Disability was all too frequent—so much so that in Treves's "Surgical Anatomy," 1915 edition, we find it recorded that "recovery without shortening of the affected limb was the exception," and this, mark you, in dealing with patients under the best possible conditions, *i.e.* in more or less isolated cases to which full individual attention could be devoted, and in cases of simple fracture uncomplicated by wounds, and, above all, uncomplicated by sepsis. Yet "recovery without shortening was the exception."

The methods taught and applied were more or less standardised before the war descended on us with all its attendant difficulties and hardships.

Some were accustomed to regard the long Liston splint with perineal band, etc., as something heaven-sent. Some regarded the Hodgen splint with considerable awe and frequently used it wrongly. Some considered the double-inclined plane for treatment of lower third fractures as the ideal. Yet because cases recovered with an inch or more of shortening, because they often got union in a deformed position, and because they so often had stiff joints, it was felt that there was a good deal more to be said on the question of the treatment of fractures of the femur. Some showed a desire to improve by having recourse to plating, and evolved a technique requiring considerable skill in its application. The results were good—in simple fractures.

Apart from open operation on the fracture, extension through adhesive plaster attached to the skin had gradually become the routine method,

and yet we find evidence of a search for something better, for something to produce direct traction on the bone, in the evolution and use of the Steinman Pin, transfixing the femur.

This pin had one disadvantage, among others, common to it and to the practice of plating. It was restricted in its use, and as a rule was the perquisite of the highly skilled surgeon only. For the majority of general practitioners the long Liston splint, with all its attendant worries and dissatisfactions, was the usual implement.

With the advent of the war we were, so to speak, "snowed under." Worked out from the statistical point of view, the incidence of fractured femur was one in sixty of all battle wounds. In the last nine months of the war there were 5,000 new femur cases in the British Army in France. Think of the problems! Casualties mounting into thousands and tens of thousands daily, the whole question of transport under most trying and difficult circumstances, and the appalling sepsis which played such havoc! And yet these problems had to be faced concurrently in many parts of the world.

Most of us were faced for the first time with all the horrors of septic wounds with attendant gas gangrene, tetanus, etc.; and to meet the situation we had only our pre-war knowledge with all its deficiencies. We found that many cases arrived at the casualty clearing stations in a moribund state so that no surgical skill could save them, and that many of those operated on according to our pre-war methods died of gas infection early or of prolonged sepsis or secondary hæmorrhage during the subsequent treatment. The number of surgeons was limited and could only deal adequately with a tithe of the work, and the problem so worked on the minds of the operators that the pendulum swung in the direction of early amputation for all cases with a view to saving lives. Fortunately, this policy was never adopted in its entirety.

It was realised that any improvement must include the whole system of transport and treatment. It had to begin where the patient was picked up and end at the gymnasium in England.

A man with a smashed arm can walk in and get treatment; a man with a broken tibia can hobble in between two comrades, but the man with a femur fractured by shell or other missile is helpless indeed; he can neither help himself nor can he, without special splints, bear to let others help him. For a leg is a heavy thing, one-fifth of the body-weight, and deprived of its own motive power is a most difficult thing to manipulate. So it comes about that these cases stay out longer after a battle than the rest; they lie out in shell holes until stretcher parties can get to them, and many of them die out there from immediate hæmorrhage, from shock or from exposure and exhaustion.

The Germans saw the difficulty of dealing with these cases, and recognised the fact that as soldiers they were for the most part useless for war, even if they were got into hospital. We had in 1917 three Germans with fractured femurs in our casualty clearing stations who all told the same tale—shot in "No Man's Land," visited by their own stretcher parties, examined, stripped of their accoutrements, and left, to be subsequently brought in by our bearers.

After every advance, for days after all ordinary cases were got in, the casualty clearing stations received a steady stream of femur cases, cases that had been lying out exposed to the weather; and because of the long delay before they got their first operation, they were more prone to gas gangrene and secondary hæmorrhage than the rest. What the real total mortality was will never be known, for statistics begin at the field ambulances or casualty clearing stations. Those dying out in the field were buried there, no one knows how many, and one can only guess that they were a large proportion. Some maintained themselves there for a long time. One man with a fractured femur lay in a shell hole for seven weeks; for the first five weeks another man with a less serious injury was with him and crept out at night, foraging for both, collecting iron rations from the dead, until one night he failed to return For two more weeks no help could get to the femur man, and then he crept into our lines with wounds healed and fracture united; $2\frac{3}{4}$ inches of shortening, slight anterior bowing, considerable eversion of the foot.

What of those who were lucky enough to reach a hospital alive and wounded comparatively recently?

Statistics collected over part of the army Area in 1916 led Colonel Gray to estimate the total mortality at nearly 80 per cent., a large portion of it being at the casualty clearing stations or on the way there. Obviously the long Liston splint was deficient as a means of fixation during transport, and just as obviously the applied principles of surgery in vogue at the casualty clearing station and base hospital at that time were too often ineffective even in saving life.

Before 1918 the mortality was reduced enormously, and it is worth while going into the history of the innovations which brought about this improvement in some detail, for it gives valuable clues as to the probable future lines of evolution. It began at the Front at the time of the Battle of Arras, in April, 1917, when, largely owing to the efforts of Colonel Gray, the Thomas splint came into general use as the routine method of fixation for transport in the Army in place of the long Liston splint, which had been the ordinary method until then. Before that offensive a good supply of Thomas splints was distributed to the field ambulances and even further forward than that, and orderlies were trained to put

them on. The result was that cases, instead of arriving at the casualty clearing station almost moribund from shock and exhaustion, came in well enough to stand immediate operation, and the death-rate actually in the casualty clearing stations of one army fell from nearly 50 per cent. in 1916 to 15·6 per cent. in 1917. This is interesting as showing the effect of one detail in treatment, but just typical of the whole of fracture work : results depend upon attention to detail right through.

A second detail affecting the condition of the patient was in use in a tentative sort of way before this, but was intensified about this time by stringent instructions. It had to do with the warming and reviving of the patient at dressing stations and during the subsequent period of transport back to the casualty clearing station. The use of the improvised hot-air bath, of stimulants and morphia, and the utilisation of the hot exhaust in the ambulance were exactly defined and carried out on an ever-enlarging scale.

The third great improvement took place in the casualty clearing stations early in 1917, when earlier and more extensive operation was adopted, facilitated by the introduction of operating teams, rushed up to any part of the line that happened to be most actively engaged. This system increased the number of surgeons available at the desired front, and so made it possible to operate upon even as many as 50 per cent. of the wounded brought into a casualty clearing station. Coincident with this, more thorough excision of dead and damaged tissues was introduced and an immediate result was a further decrease of deaths from gas infection and sepsis, and from secondary hæmorrhage caused by sepsis.

The fourth great improvement took place at the base hospitals in France. In January, 1918, Sir Robert Jones published a paper in the *British Medical Journal* advocating specialisation, alluding to fractured femurs as " the surgical tragedy of the war," and argued that while we were saving lives and limbs in France, England was being flooded with cripples, with useless limbs, stiff limbs, short limbs, and deformities generally ; and that the remedy for it was more specialisation, more team work. One such special hospital existed already at Boulogne, where Major Sinclair and others had devoted their skill and attention to fractures.

Curiously enough, a week or two before this article appeared, the system had already been introduced in the British Army in France. One hospital in each large area was set aside to receive all fractured femurs coming to that area, a special staff of medical officers, nurses, and orderlies being told off for that work. Each of these hospitals was given a free hand to develop its own line of treatment. Appliances had to be improvised, struggled for, bought or " acquired." In our own

femur wards at the First South African General Hospital much of the special gear was got by highly irregular means. But the net result of specialisation was good from everybody's point of view. The death rate in femur wards of this hospital fell to about 3 per cent. and the amputation rate also to 3 per cent., excluding those that died or were amputated within twenty-four hours of admission. Secondary hæmorrhage was practically abolished where a year before it had been an ever-present nightmare. Nursing was made so much easier that wards which had previously been looked upon as heavily loaded if they had eight or ten femurs, now ran easily with thirty.

During and subsequent to the March and April retreats (1918) the base hospitals in France were threatened with destruction by the intensive bombing of back areas which the Germans carried out.

The patients, with sadly strained *moral* as the result of their injuries, began to show signs of the repeated strain of wakeful nights and threatened destruction in its most frightful form. The crisis culminated with the tragedy of Etaples, and the authorities determined on the early removal of these cases to England.

The necessity for the extension of specialisation there was at once perceived, and to that end several teams (including the authors'), which had been carrying on the work in France, were transferred to England to institute their methods in selected hospitals in different parts of the country. That was only nibbling at the problem. The several teams from France with the institutions already doing the work in this country could not cope with the thousands of cases coming across the Channel and from abroad.

Hence arose the next stage. Certain hospitals throughout the kingdom were told to prepare for a fixed quota of fractured femurs, and each was advised to send an officer for instructional purposes to one of the already accredited centres where treatment on systematic lines was fully established.

The cases proceeding to England were coming at an early stage in their disability. In order to appreciate fully what this means and to judge fairly of the difficulties our medical officers on the other side have had to overcome, it is worth while tracing the course of an individual case from Front Line to Base.

If the patient is lucky enough to escape the immediate dangers of death by hæmorrhage or shock, and is not lost sight of and left out in a shell hole, he may be attended to and a Thomas Splint applied on the spot. In rush times this is more likely to be done at an advanced dressing-station of the field ambulance where the teams of orderlies are so practised that they can complete it in something like four minutes per case,

including putting on the extension. The trousers are cut open and a dressing applied, the splint put on and support in the form of bandage slings, with or without a back splint, applied. The method of extension is very ingenious; without removing the boot, a wire clip, Tapson's Sole Clip, is applied to the sides of the sole of the boot and a bandage from this to the end of the Thomas Splint gives fairly efficient extension, with no fear of injury to the foot. The splint and limb are then hung from suspension bars resting on the sides of the stretcher on which the patient is lying (Fig. 1). He is given a dose of anti-tetanic serum, a hypodermic of morphia and a hot drink. While being dressed and during the wait for the ambulance he is kept warm in certain ingenious ways, the origin of the heat being a Primus or other stove.

He is removed as soon as possible to the casualty clearing station. Generally the road is bumpy. The shock attendant on transport is necessarily considerable; the better the splinting the less the shock, not

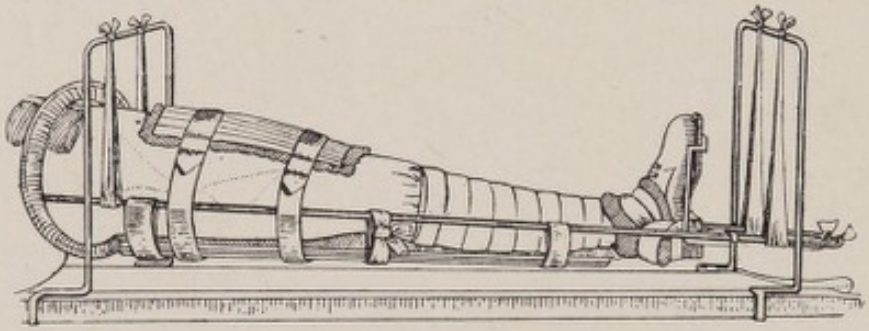


FIG. 1.—Fractured femur slung for transport (Gray).

merely at this stage but throughout the whole illness—in the train, the ward, the operating theatre and whether the patient is under an anæsthetic or not. Even late manipulations involving disturbance of the fracture cause a considerable amount of shock. For this reason, every endeavour must be made to avoid alterations of position during transit; if the stretcher is reasonably clean it is not even necessary to remove him from it for operation, and the same stretcher can go with him to the base or even across to England if he is fit to stand the journey.

On arrival at hospital, he is lifted into bed by a method involving no disturbance. This method will be described later and should be practised.

Among the many lessons then that peace surgery has learnt from war will undoubtedly be the value of adequate temporary splinting before the patient with a bad compound fracture is removed to hospital, the importance of having as little disturbance of the fracture as possible at *all* stages of treatment, the great value of thorough and scientific

shock treatment—warmth, morphia, blood transfusion, etc., and, above all, the necessity for early operation with thorough excision of dead and lacerated tissues, followed by primary suture, or primary suture deferred. Every endeavour must be made to get such a patient to a hospital at the earliest possible moment; it is almost as important that this thorough operation should be carried out promptly in civil compound injuries as in battle casualties. Every fracture case with a lacerated wound should be operated upon as soon as the patient's condition permits. If left for twenty-four hours he may or may not develop gas gangrene, but his wound will almost certainly become septic, adding risk and many weeks of illness to an already serious case; whereas immediate operation with adequate excision of lacerated tissues will in a large proportion of cases make primary suture possible, converting a compound into the much more easily managed and less dangerous simple fracture.

CHAPTER II

SURGICAL ANATOMY OF FRACTURES OF THE FEMUR

WHILE it is possible to classify fractures of the femur according to their position into one of three groups, these groups themselves are subject to sub-division. The groups are :—

1. Upper Third.
2. Middle Third.
3. Lower Third.

Fractures of the Upper Third.—In this group we have certain well-defined subdivisions.

(*a*) Intra-capsular fracture of the neck.
(*b*) Extra-capsular fracture of the neck.
(*c*) Fracture above the small trochanter.
(*d*) Fracture below the small trochanter.

(*a*) *Intra-capsular fractures* of the neck may be simple or compound, incomplete, complete or impacted. In cases of compound fracture of the neck the great trouble in treatment is usually due to comminution of fragments and to sepsis. Drainage is difficult and to make this efficient it is frequently necessary to remove fragments of bone and often the head of the bone, which has a poor blood supply and is prone to necrosis ; and to make posterior drainage through the buttock. Moderate traction is made to immobilise the joint with the limb in the abducted position. When sepsis has subsided, the free end of the neck should be brought into contact with the acetabulum and endeavour made to obtain ankylosis.

Impacted fractures not complicated by sepsis are usually best left in the impacted position. A plaster spica will fix the joint, maintain impaction until firm union is obtained and allow the patient to get about on crutches at an early date. A walking calliper is very efficient for this purpose also.

(*b*) Fractures of the "*extra-capsular*" variety are usually not truly so. The capsule extends to the anterior inter-trochanteric line, and the fracture in front is often within the capsule, though, behind, it is without.

If these fractures are impacted, as often happens, it is frequently

wise not to reduce the impaction, but to treat the fracture on the same lines as the impacted intra-capsular fracture.

The non-impacted fracture of this region is subject to certain deforming forces, which produce a typical picture.

The shaft and great trochanter are drawn up by the action of the long muscles of the thigh, the hamstrings, rectus, adductors, etc. At the same time, the gluteus maximus tends to draw this lower fragment backwards and to rotate it out, assisted in this last process by the obturators, gemelli, pyriformis, etc. Excessive external rotation is checked by the anterior portions of the gluteus medius and minimus, by the tensor fasciæ femoris and by the ilio-femoral ligament.

Owing to the drawing up of the shaft, the neck assumes a more transverse position, the angle of junction of the neck and shaft is reduced and a condition of coxa vara is produced.

The treatment consists in applying traction to the femur and putting the leg in abduction in order to correct the coxa vara.

To make traction more effective, the knee is flexed, relaxing the hamstrings. Outward rotation is controlled by the flexion of the knee and slinging the foot in the vertical position.

(*c*) *Fractures above the Small Trochanter.*—The deforming forces here are the same as those operating in extra-capsular fractures, but, owing to the situation of the fracture, produce different results.

The upper fragment is abducted with a tendency to outward rotation by the action of the glutei.

The lower fragment is drawn upwards by the hamstrings, rectus, etc., and inwards by the adductor group. The ilio-psoas may draw it slightly forward as well as upward.

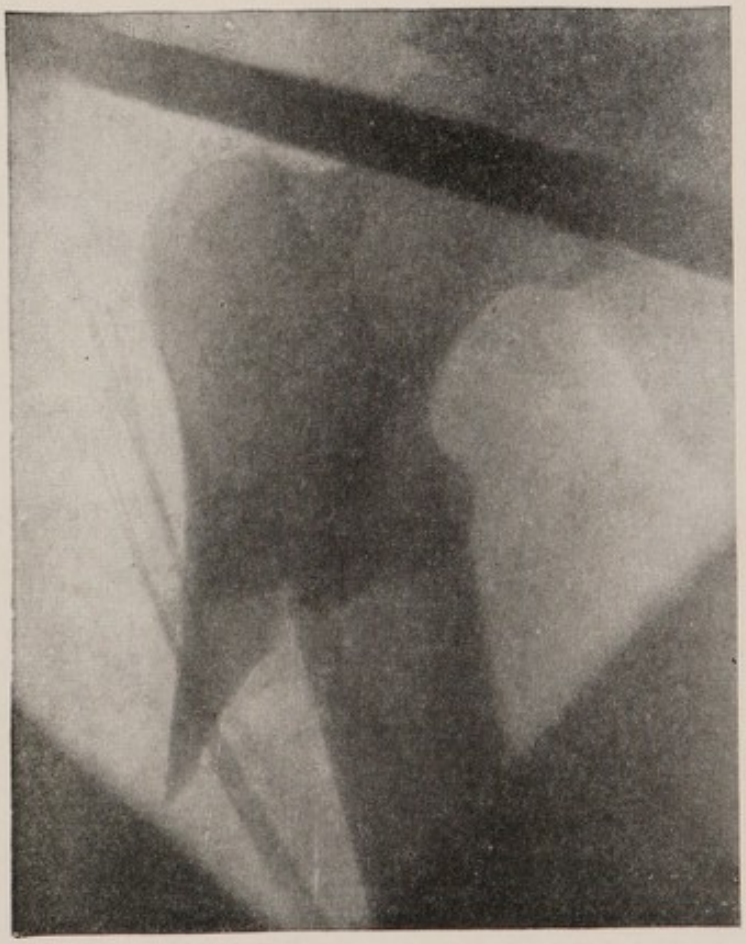


FIG. 2.—Upper-third fracture, showing abduction of upper fragment,—the usual type.

The limb below the fracture therefore must be put in the abducted position, to bring it in line with the upper fragment, and slightly flexed at the hip, to relax the ilio-psoas. This flexion at the hip tightens the hamstrings, and to counteract this, the knee can be flexed, provided that traction is being applied above the knee and not below it.

Extension in the line of the abducted femur in this position will control the fracture.

(*d*) *Fractures below the Small Trochanter.*—The resulting deformity is typical, though there is one exception which will be described later.

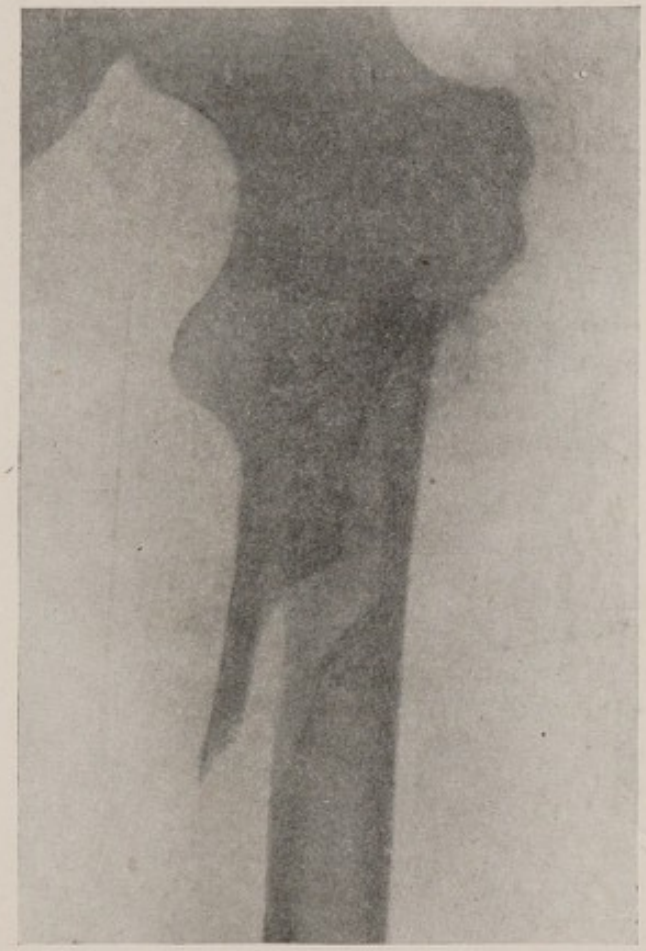


FIG. 3.—Upper-third fracture with *adduction* of upper fragment,—the exceptional type.

The same forces are at work as in the case of the fracture above the small trochanter, with the important exception that the ilio-psoas is now operating on the upper instead of on the lower fragment.

Therefore the upper fragment, in addition to being abducted and slightly rotated outwards, is more or less acutely tilted forwards (Fig. 2).

The lower fragment is drawn upwards by the hamstrings and inwards by the adductor group.

The limb must be abducted and flexed to bring the lower fragment into line with the upper. Traction in the new line of the limb will correct shortening.

There is a deviation from the normal type of fracture below the small trochanter. It is seen when the line of fracture runs obliquely downwards and inwards, the upper fragment then being subject to the influence of the adductor brevis. The deformity is pathognomonic. One finds the upper fragment tilted forward and adducted instead of abducted. Treatment is the same as for the commoner variety, with the substitution of cross-legged adduction for abduction (Fig. 3).

Fractures of the Middle Third.—Fractures in this situation do not follow any fixed laws as regards deformity. They show considerable

variety, ranging from the simple oblique to the comminuted. There is a tendency for the lower fragment to be drawn inwards by the adductor group of muscles.

Ultimate malposition seems to have some dependence on the position assumed at the time of injury. That is to say, if the patient, when he receives the injury, is in the erect position, then the limb buckles and the jagged ends of the fragments may be driven into the surrounding muscles at an angle, and if not replaced in line early will remain in malposition. Therefore at the initial operation every endeavour should be made to restore the line of the bone as far as possible.

Gravity, acting later on, produces what is by far the commonest and one of the most serious deformities resulting from fracture of the femur, particularly in these middle-third cases, viz., a backward sagging of the thigh. A broken thigh is a very helpless and heavy mass and if, during treatment in bed, the greatest care is not taken to maintain its natural forward arch by adequate posterior support, the unpleasant discovery will be made that the bone is firmly united with a concavity forwards instead of backwards, with a resulting serious impairment of function. Traction in the line of the thigh will correct any tendency to lateral bowing in most cases. It was in these cases particularly that the now abandoned long Liston splint so often caused outward bowing.

Fractures of the Lower Third.—The difficulty of controlling the lower fragment in these cases by extension applied below the knee has long been recognised, and in these perhaps more than in any others the value of callipers applied above the condyles has been demonstrated.

In the classical case, the lower fragment is tilted backwards into the popliteal space by the action of the gastrocnemius (Fig. 4).

This deformity can be very much lessened by flexing the knee.

Through the action of the adductor magnus in its attempt to fix the fracture, a pull is exerted on the upper edge of the internal condyle and the upper end of the lower fragment is often found tilted obliquely outwards.

The same muscle tends to rotate the lower fragment outwards. This deformity is increased by the weight of the foot, which falls outwards if unsupported. Lastly, the pull of the long muscles makes the fragments overlap and produces shortening.

Lower-third fractures are difficult to treat because of their proximity to the knee-joint. Early movements of this joint tend to disturb the fracture unduly unless very carefully carried out. It is very important, therefore, that they should be begun early, before the knee has begun to stiffen from immobilisation. Mobility is then easily maintained, whereas

if it is once lost attempts to regain it will cause more disturbance of the fracture than is desirable.

When sepsis obtains a footing in the cancellous tissue, it is difficult to eradicate. The shell of hard bone surrounding the cancellous tissue of the condyles is so thin as to be almost negligible. The greater part of the lower end of the bone may become transformed into an abscess cavity, with egg-shell walls. The power of repair is low and there are special difficulties attendant on an attempt to fill up such cavities. Further, the popliteal surface of the bone is very brittle and ill-supplied with blood. A fracture there is often much comminuted and

FIG. 4.—Lower-third fracture, lower fragment tilted backward into popliteal space: 2 inches shortening.

the fragments have little vitality. Yet with all these disadvantages it is possible to get excellent limbs with a good range of movement in the knee-joint, provided that mobilisation has been maintained from the first day.

Failure to correct the backward displacement of the upper end of the lower fragment leaves a very real danger of damage to the popliteal vessels and nerves, as well as a serious disability caused by the tilting forward of the condyles and their articular surfaces, thus throwing an undue strain upon the posterior ligaments of the knee when the patient begins to walk.

CHAPTER III

EARLY OPERATIVE TREATMENT OF COMPOUND FRACTURED FEMURS

Success or failure in dealing with the injury depends so much upon the efficiency of the primary operation that no trouble can be considered too great in the perfecting of its details. It is to be remembered, however, that the patient is certain to be suffering from shock to some extent, and if this is severe it must be combated before he will be in a condition to stand a drastic operation which may involve extensive excision of destroyed tissues. The shock caused by the injury itself may be aggravated to such a degree by hæmorrhage, exposure to cold and wet, hunger, pain from handling or during transport, etc., that the patient arrives in hospital in almost a moribund condition. Methods of resuscitation, varying according to the patient's condition, must be resorted to—hot-air baths, morphia, stimulants are among the most valuable. Saline infusions are of very temporary value, gum solutions more lasting. Where serious hæmorrhage has occurred blood infusion has infinitely the best and most lasting effect, and, provided that hæmorrhage has stopped, it should be given at once.

There is an optimum point to which the patient's resistance can be restored, and this is the moment for operation. Left longer, he retrogresses. He should be taken in the flood tide of his resistance, and the surgeon must recognise it and seize the opportunity. This will rarely be more than three hours after the injury. The retention of lacerated tissues is itself a continuing cause of shock; where a limb is hopelessly shattered it is often remarkable how much the patient's general condition improves after amputation. The development of sepsis, often fulminant, in these serious war wounds demands operation at the earliest possible moment.

Preliminary Examination.—In all cases except those where amputation is obviously the only possible course, a radiogram of the site of injury should be obtained. During great press of work it may not be possible, but most cases are capable of being screened. In these cases the radiologist should furnish the surgeon with notes on the damage

to bone, involvement of joints, etc., and locate with accurate surface markings and directions, any foreign body which may be present.

One cannot insist too strongly on the necessity for careful and accurate preliminary X-ray examination. When the patient is on the table the surgeon should make a rapid examination to ascertain the nature and degree of the injury. He should note the situation of wounds of entrance or exit. He should elicit from the patient some idea of the type of missile that struck him and of his position when struck. He should palpate superficial arteries below the site of injury, with a view to determining the presence or absence of injury to main vessels and should examine for gross tactile and motor changes denoting injury to main nerves in the track of the wound.

Armed with this information, he is in a position to approach the operation with a provisional judgment of what will require doing. The amount of surgical interference required may sometimes be largely determined by the preliminary examination.

For instance, a patient gives a history of being wounded by a machine-gun bullet. His clothes are dry and comparatively clean. The wounds of entrance and exit are mere punctures. There are no superficial indications of injury to a main vessel. Such a patient may possibly be treated as one with a simple fracture. The skin and wounds are disinfected and the limb is carefully splinted, with efficient extension. In the large majority of such cases, attention to the position of the fracture will be all that is called for in the subsequent treatment.

Should the clothing be wet and muddy, there must be at the back of the surgeon's mind the fear of gas gangrene, and he will in many cases excise wounds and subject the incisions to primary or primary delayed suture. His object, again, is to turn the fracture into a simple one.

Excision.—Shell and bomb wounds, as a rule, make more extensive wounds than bullets. There is almost invariably far more damage to the soft parts. The rough, jagged missile travelling at a comparatively low velocity takes in portions of contaminated clothing.

The condition requires a freedom of excision that in the early days of the war would never have been countenanced. The fouling of the site of wound is extensive, and every endeavour should be made to excise all damaged tissues without re-infecting those below. Perfection is rare of attainment, but none the less the freer the treatment the shorter the convalescence.

Whenever possible, the infected and dead tissues should be removed *en bloc*; in any case, it is not sufficient to stop short at removing all muscle which fails to contract on stimulation with forceps; it must be excised until a surface is reached which bleeds on cutting.

Displaced, completely detached fragments of bone are removed. Search is made for foreign body and clothing. Attached bits of bone with fouled medullary cavity are attacked with a sharp spoon, etc., and rendered as free from infection as is possible. Some may have to be removed. Damaged vessels and nerves are attended to. The wound may be wholly or partially sutured according to the confidence of the surgeon in the efficiency of his treatment.

Antiseptics.—Certain people dogmatise about the superiority of one antiseptic over another, but there is a unanimity of opinion nowadays that it is the preliminary operation and the completeness thereof which determine the efficiency of subsequent antiseptics.

One allows that, in the hands of an individual who is constantly using it and who has evolved a very exact technique, an antiseptic will produce often better results than the same antiseptic used in a defective manner by another worker.

Dakin's solution, B.I.P.P., dichloramine T, and flavine all have their advocates, and all produce good results; but no surgeon, because he finds an antiseptic good, should neglect any precautions at the initial operation which could possibly remove or limit infection.

Esquillectomy. — The treatment of the actual fracture at the time of operation involves consideration of the amount of damaged bone which should be removed and of the methods of local fixation which are available. Acting on the assumption that non-union of the femur after fracture was exceedingly rare, the French school adopted the procedure of removing all fragments of bone not in direct continuity with the shaft. These were separated subperiosteally often with the result that a large gap was

FIG. 5.—Bullet wound through upper part of thigh; much comminution; wound excised, leaving fragments of bone; primary suture: no further operations.

In six months from date of wound patient was walking without splints, 1 centimetre shortening, knee flexing through 90°. [Case E 211.]

left. Now, while one has observed in some cases that such a gap may be filled by good weight-bearing callus, there have also been a good many cases of non-union observed following this method of treatment. As a result, the tendency nowadays is to leave all attached fragments in the best position into which they can be got through the operation wound. They undoubtedly serve as a basis for the throwing out of callus ; and if at a later date some of them die and form sequestra, their removal is a comparatively simple matter.

Fig 6.—Filling in of partial gap. Recovery with good union, no shortening.

The treatment of a considerable gap owing to the bone having been shot away is very important. Many arguments based on the source of growth and regeneration of bone have been advanced. The discussion seems to us to be of greater academic than practical interest. However complete the gap may appear to be, it is not possible at an early period to be certain that it does not contain both periosteum and adherent particles of bone. It is our practice, therefore, to maintain the bone at its full length, gap or no gap ; new bone has often formed under the most unpromising circumstances, and if union fails there is always bone-grafting to fall back upon.

When there is a long gap occupied by minutely comminuted fragments, there is every reason to leave these fragments *in situ*. Figs. 5, 6, 7, and 8 show how such unpromising material can give good results.

Amputation may be necessary in cases of extreme crushing and laceration, especially where the main nerves and vessels are implicated, but not merely because the bone is much comminuted : shock depends much more upon the extent of damage of the soft parts than of the bone. And the much comminuted fracture rarely fails to unite. On the contrary, the simple fractures and the comparatively harmless-looking transverse fractures (compound or simple) provide far more than their share of cases of non-union. Where amputation is obviously the only course its early

performance is often the quickest and most efficient means of relieving shock.

Many compound fractures without comminution would seem to lend themselves readily to plating, or grafting. There are certain considerations which preclude the employment of these methods. The operation is a very exact one, requiring ideal surroundings, great precision of technique, and, as a rule, a considerable expenditure of time. As an immediate operation for compound fracture, under civil or war conditions, it has no place. A surgeon rightly hesitates to introduce a foreign body, however aseptic it may be, into a wound which is doing well, looks clean, but may harbour sepsis.

Therefore we think the operations of plating and bone-grafting must be relegated to the treatment of ununited fractures of the femur at a late date—at least six months after all wounds have been healed.

However, a device which should be adopted more generally is that of passing a loop of wire round an oblique fracture which tends readily to become misplaced. This will keep it in excellent position, and it is often possible to bring the ends of the wire out through the open wound, attaching them to an arch over the splint (Fig. 9, *a* and *b*), or to one or other side bar of the splint, so that it acts as a sling supporting the fractured bone in good position.

Fig. 7.—Four-inch gap, occupied, after sequestrectomy, by fine débris only. Recovery with 0·5 centimetre shortening. [Case E 105.]

Secondary Hæmorrhage.—This was the bugbear in the early treatment of fractured femurs, but under recent methods has practically ceased to occur. The causes of this tragedy, which marred the early treatment and in very truth often ended it, are well known, but bear repetition.

(*a*) Primary injury to vessels not dealt with at the initial operation.

(*b*) Sepsis depending on poor initial operation and inadequate drainage.

(*c*) Large drainage tubes left in position in contact with main vessel.

(*d*) Displaced fragments of bone pressing on the vessel.

(*e*) Unnecessary movement of the patient in his bed for dressing and nursing purposes ; a very large proportion of the secondary hæmorrhages occur immediately after using the bed-pan.

(*a*) The first depends on the completeness of the primary examination and operation.

(*b*) Better excision of wounds and efficient posterior drainage are in our opinion the two most important factors in producing the very great reduction of secondary hæmorrhages which occurred in the last two years of the war. We would go so far as to say that, in every case where primary suture or primary suture deferred is obviously impossible, a posterior drainage opening should be established as a routine procedure : where this is done, that much dreaded bogey, the tracking of pus along the thigh and its natural consequence, secondary hæmorrhage, are so rare as to be almost non-existent.

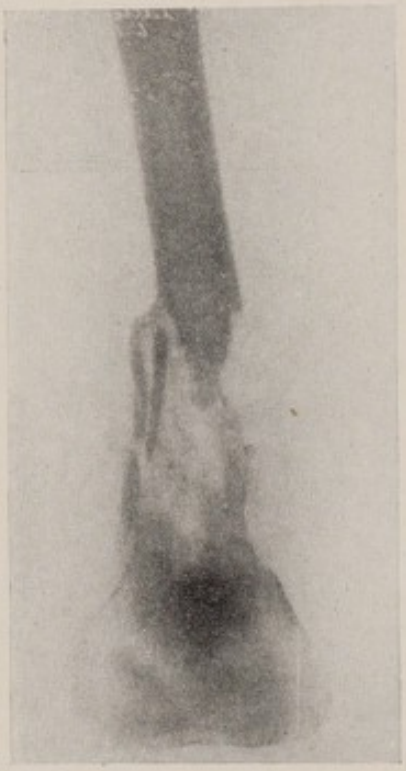


FIG. 8.—Much comminution of large septic wound near knee. Recovery with good union and knee flexing through 30°.

And not only that. A septic wound of the soft parts opening only on the anterior surface of the thigh and " draining " only by overflow, will neither heal itself nor allow the fractured bone to unite. It is one of the commonest causes of delayed union of bone, and that is our excuse for mentioning such an obvious truism. The fact that the patient shows no obvious signs of ill-health, no temperature, no pain, misleads the surgeon into thinking that the presence of pus is doing no harm. The constitutional symptoms are absent because the pus has free exit, but delayed callus formation is there all the same, and the sinus will persist indefinitely if dependent drainage is not afforded.

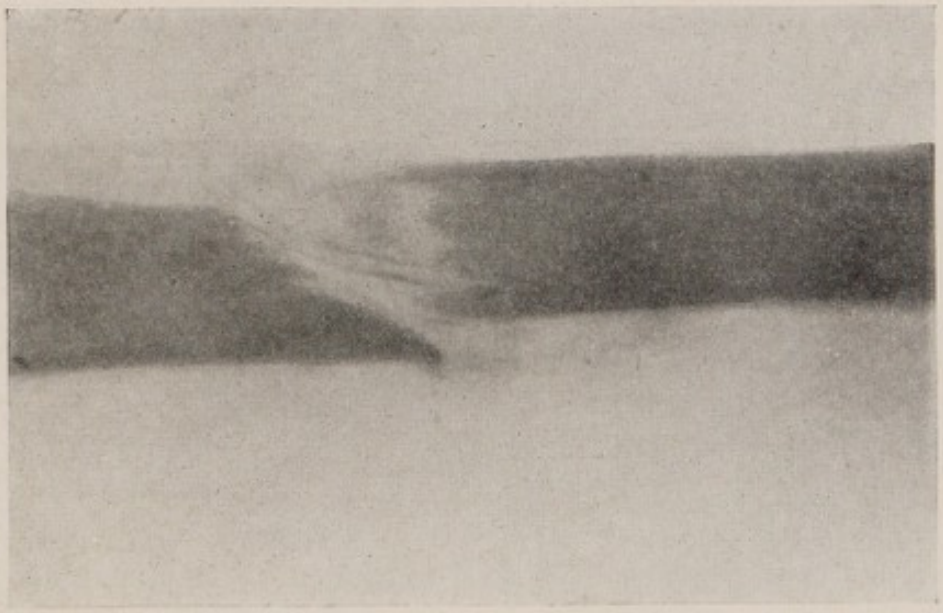
Only where an anterior wound can be so widely laid open from end to end that it becomes a surface wound—and that can rarely be the case with fractures—or where complete suture is possible, is it justifiable to do without posterior drainage.

We have been in the habit of making our drain through the interval

between the hamstring muscles, and so far have had no trouble through scar formation around the sciatic nerve. Such complications do occur,

FIG. 9.

(*a*) Backwardly tilted lower fragment, 5 cm. shortening, great destruction of quadriceps.



(*b*) Same case after suspension of lower fragment by wire loop. Discharged in this position with 1 centimetre *lengthening* and good union.

however; a postero-external opening would avoid this and would give nearly as good drainage.

(*c*) This is bad surgery, and as such is to be thoroughly condemned.

A glove rubber drain acts as efficiently as a tube, and exercises no deleterious pressure on vessels.

(*d*) This can be avoided by moulding the fragments into position at the initial operation and by efficiency of mechanical methods regulating extension and position during subsequent treatment.

(*e*) Appliances, such as the sectional bed, to be described later, are designed to obviate unnecessary movement of the limb or exertion on the part of the attendant. They have a valuable, though indirect, *rôle* in the prevention of secondary hæmorrhage.

If these points are all attended to, the surgeon will not have the constant dread of secondary hæmorrhage before him, and his death-rate and amputation rate will be greatly reduced.

CHAPTER IV

THE MECHANICS OF FEMUR TREATMENT

Splinting.—By common consent, *Thomas's splint* has been adopted in the British service as the routine appliance for the treatment of fractured femurs and for most other fractures of the leg. It has the very great advantage of being equally suitable for transport purposes and for after-treatment right up to the time when union has occurred. It gives very free access to wounds, no matter what their position, excepting those in the immediate vicinity of the ischial tuberosity, but in these cases the splint is easily modified to make it adaptable there also. It is comfortable to the patient and very efficient if properly applied. But its efficiency depends upon counter-extension being maintained by pressure of the ring of the splint against the distal surface of the tuberosity of the ischium. If the ring slips up past the tuberosity, extension and counter-extension are gone. Thomas's splint has the further advantages of being cheap, durable, easily obtainable in many different sizes, and it does not need to be specially made to measure for each patient.

Hodgen's splint was more used before the war than it is now. It is very comfortable and very efficient, but it requires more constant supervision and frequent adjustment and is not suitable for transport purposes. If, therefore, the patient has to travel, be it only to the operating theatre, disturbance of the fracture is unavoidable. Hodgen's splint depends upon the patient's body-weight as a means of counter-extension, *i.e.*, it necessitates the bed being raised at its lower end. This in itself is some disadvantage, though the patient soon gets used to it. Pressure on the tuberosity is not a factor at all, so that for wounds in that region this splint has advantages.

Practically all the splints now in ordinary use for treatment of fractured femurs are of the Thomas or Hodgen type; the "long Liston splint" is rarely used and should be altogether abandoned. There are many different ways of using the Thomas splint; the "extension," for instance, may be by weight and pulley instead of by a "tie-on" over

the end of the splint. Or the bed may be tilted, the lower end of the splint fixed, and in that case the body-weight becomes the counter-extending force, *i.e.*, the splint becomes, in principle, rather of the Hodgen than of the Thomas type. The diagrams (Fig. 10) show some of these variations of method.

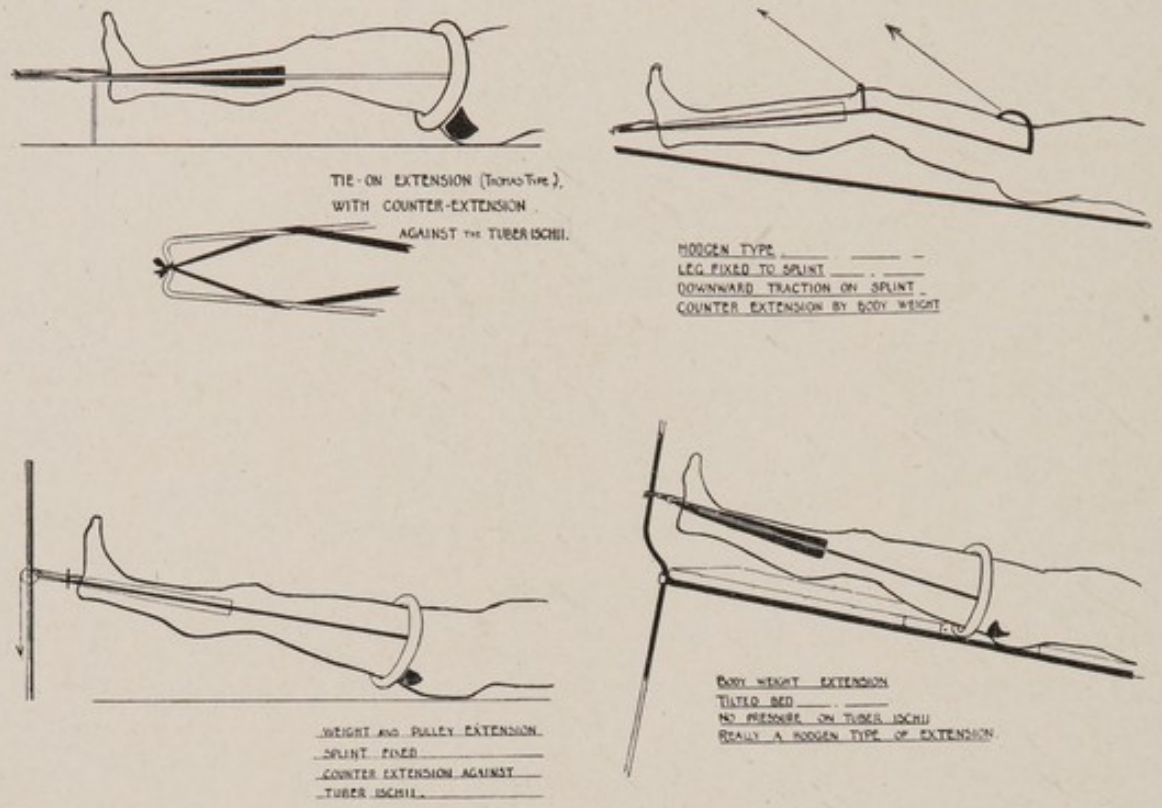


FIG. 10.—Various methods of using Thomas and Hodgen splints.

THE MECHANICAL AFTER-TREATMENT OF A CASE

In dealing with the mechanical side of the treatment of fractured femurs on a large scale as carried out in special femur hospitals, where hundreds of such cases come under one control, it is essential to have uniformity of system and appliances. If this does not exist it becomes impossible to keep up the supply of apparatus, and impossible to train a staff of nurses and orderlies to that point of proficiency which alone makes for rapid and good work—impossible, that is, to carry on as a team. This does not mean that variations are not permissible, that no new method must be tried. Improvements are constantly suggested and should be welcomed; but before being adopted they should be thoroughly considered and discussed. We should then have fewer instances of the trial of new methods which are mechanically or surgically unsound, or of old ones long ago tested and found wanting.

It is unsafe to draw favourable conclusions as to the value of a method from the fact that excellent results have been got in a few cases. Most methods can be made to give good results in the hands of an expert and an enthusiast, and some cases will give good results, however treated. What is wanted is a method, as applicable for huge numbers in a war hospital as for the single case, which can be relied on to give a good result in as short a time as possible, and which introduces no new dangers when used by those whose experience of the method is slight.

In the early days of the war a large part of the mortality was due to sheer pain and exhaustion from prolonged dressing under difficult circumstances and with inadequate methods, the process often occupying three-quarters of an hour or more daily, the patient being rolled on to his side for it and held there by attendants.

In selecting his method, it is well for the surgeon to keep before his mind certain objects to be aimed at and to consider deliberately how far any proposed method meets these essentials. For instance :—

(1) Traction should be made in the line which produces most accurate alignment of the fragments, and should be applied as directly as possible to the bone. Along with it, good support of the fracture in the corrected position should be provided.

(2) Subject always to the above, mobility of the adjacent joints should be procured, for the ankle and knee particularly are very apt to remain stiff long after union of the fracture ; indeed this stiffness may be permanent. For this reason, appliances should permit of controlled movements of the joints, of massage, of electrical treatment, and especially of slight voluntary movements of the muscles.

These desiderata amount to traction and support applied above the knee-joint, with the leg left as bare of encumbrances as possible.

(3) When the fractured ends are put in position a splint should be used which does not require to be changed during after-treatment. It must be suitable alike for transit from one hospital to another, from ward to operating theatre, during operation and during dressings and for nursing purposes. Every change of splints before union involves disturbance and is so far disadvantageous and to be deprecated.

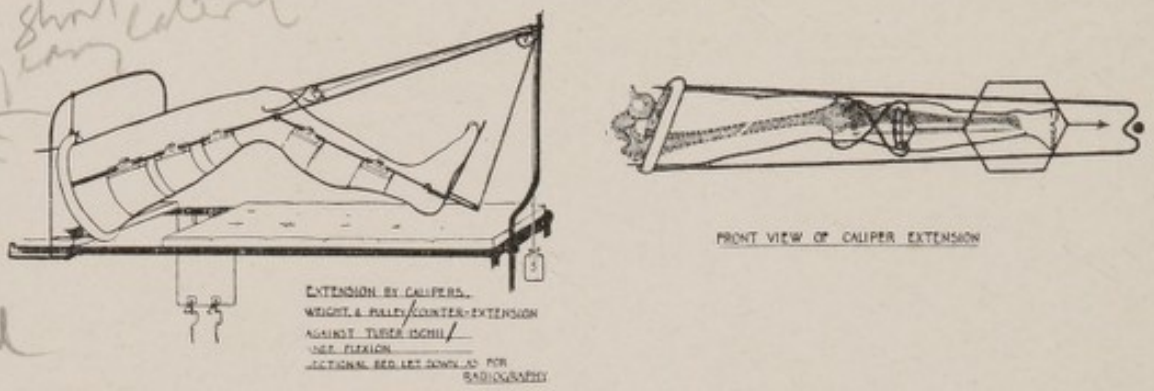
(4) The method used must make dressings easy for patient and surgeon. Labour-saving and time-saving devices must be made use of to the utmost if nurses are to have reasonable chance of coping successfully with a wardful of fractured femurs.

(5) The method should be as painless as possible, capable of giving good results both anatomically and functionally, and be free from new dangers of its own.

(6) Radiography must be freely available and applicable without moving the patient.

(7) From the point of view of health, convenience and of fire-risks in hut hospitals, the bed, appliances and patient should form one "self-contained unit" capable of being carried or wheeled out *en bloc* and not attached in any way to the structure of the building.

The apparatus and appliances here described have been worked out to meet the above essentials. They have been tested in many hundreds of cases as a routine method in the special femur wards of a war hospital in France and later in hospitals in England. On the large scale, the scheme works easily and efficiently and with a comparatively small nursing staff. In the individual case we are satisfied that the functional results are better than we previously obtained by other methods, and



(*a*) (*b*)

FIG. 11.—Adaptation of Thomas splint to permit of knee-flexion. (*a*) from side; (*b*) from front.

that the chances of secondary hæmorrhage, amputation or death are very much lessened.

Put very briefly, the method advocated consists in "weight and pulley" traction in the line of the thigh through a special form of ice-tong callipers which grip but *do not penetrate* the lower end of the femur. The limb remains throughout on the large-ringed Thomas splint which was applied immediately after the injury, but grafted on to which is a hinged knee-flexion splint on which the leg, from the knee downwards, lies free, flexed, supported, yet movable and, in practice, moved every day from the beginning. The patient is nursed on a high bed of sectional type to be described later. The general plan of the method as used before union occurs is shown in Fig. 11.

Suspension of the Ring.—In accordance with the principle enunciated above, that every disturbance of the fracture causes shock and is harmful, it is desirable that fractured femur cases shall travel on one stretcher throughout and not be transferred to cots on hospital ship

or train, and it is essential that the Thomas splint shall be suspended both at its foot end and at the ring, not only in transit but throughout (*see* Fig. 1). It is only lately that the absolute need for suspending the ring of the splint has been insisted upon and generally adopted for transport, and even yet it is far from being universal throughout bed treatment. The need will be obvious if one considers that during transport, and often throughout treatment, the extension of the injured limb depends upon strapping or bandage applied to the leg and tied over the lower end of the splint, counter-extension being obtained by pressure of the ring on the tuberosity of the ischium. If the ring is not maintained in close pressure against the tuberosity, if it slips past the tuberosity, then the whole extension is thrown out of gear and there is nothing to prevent free movement of the fracture.

In practice that is what often occurs, and the patient has in consequence quite unnecessary suffering and arrives at his hospital in a state of shock which may be dangerous and is quite easily avoidable. It might be thought that a small, closely-fitting ring would render its slipping upwards impossible, but this is not the case. Examination of a large number of femur cases arriving at base hospitals in France and in England proved conclusively that in a very large proportion of the cases, whether large-ringed or small-ringed splints had been used, the ring slipped well above the tuberosity and the so-called " extension " was slack and useless. Indeed in a convoy of twenty-one gunshot wounds of the femur arriving from a base in France, all had small-ringed splints on ; in thirteen the ring was proximal to the tuberosity, and in two there were pressure sores over the adductor muscles and elsewhere, proving that the ring had been misplaced for a long time.

During transport, then, the need for suspension of both ends of the splint is beyond dispute. We quite recognise that in some methods during subsequent treatment, *e.g.*, when the bed is tilted and body weight is made use of, that is, where the splint becomes rather a support (*cf.* the Hodgen splint) than a means of extension, the pressure of the ring against the tuberosity is not essential. But in any case where counter extension against the tuberosity is part of the scheme, the suspension of the ring is absolutely necessary and efficacious. Whether that suspension be by means of weight and pulley, or whether by merely hanging up the ring to a bar, is a matter of personal preference ; we prefer the permanently fixed suspension to an overhead bar. But as long as the ring is kept firmly suspended it will keep its position with certainty, with comfort, and with entire absence of pressure sores. It is the ring which has slipped up past the tuberosity that causes pressure sores. They need never occur. We have perhaps laboured this point, but to

us it appears of the greatest importance, and a look round femur wards will demonstrate at once how often the ring is hopelessly out of place for want of such a simple precaution (Fig. 12).

Method of moving Patient.—When the patient arrives at hospital, his transfer from stretcher to bed without pain and without moving his fracture requires some thought and method, especially if there are only two bearers and a nurse to do it; but it is easily done if orderlies have been taught and if the patient has strength enough to help a little. The stretcher is placed on top of the bed, not alongside it. The patient plants the foot of his sound leg firmly on the bed with his knee flexed: with the help of this and a firm grip of both his hands on the derrick overhead he can do much to raise his body clear of the stretcher. The nurse puts one hand under the pelvis and helps to raise it. An orderly lifts up *both* ends of the Thomas splint. The remaining orderly slips the stretcher out from the end. The patient is then lowered on to the bed and some permanent method of suspending the splint applied, and always at both ends. It seems almost unnecessary to say that the leg and splint must never for a moment be allowed to lie unsuspended on the bed itself.

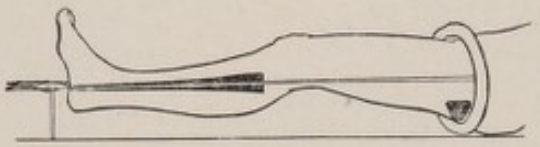


FIG. 12.—The ordinary cause of pressure sores—the ring has slipped up past the tuberosity and is nipped between the bone and the bed.

Should it ever be necessary to take the patient to the operating theatre the same method of transfer to the stretcher should be used, of course in the reverse manner. Wherever possible the operation should be done without removing the splint. The method is applicable for late operations even while traction callipers are *in situ*.

If the patient has already undergone efficient operation in the nature of esquillectomy or excision of damaged tissues that may have been necessitated by his wound—and this, in the case of war wounds, will have been done at the casualty clearing station—there is no urgent need for active treatment when he arrives at the base hospital. All that is essential is to suspend his splint and limb. He should be given a good night's rest and then possibly have his wound, if any, dressed. The limb should in every case be radiographed in bed and measured. We have then all the information necessary to come to a decision as to further treatment, and if the case is at all a reasonably early one, say within three or four weeks of the wound, the routine treatment is that now described.

Application of Knee-flexion Splint and Traction Callipers.—Assuming that the patient is already on a straight or nearly straight Thomas splint, with some sort of adhesive extension applied below the knee and tied to the lower end of the splint, the first

step is to fix this lower end of the splint firmly and immovably to an extension post at the foot of the bed, and high enough to give a considerable slope to the limb. The hinged knee-flexion splint (*see* Fig. 13) and narrow foot-piece are then fixed by means of a thumb-screw to the Thomas splint at the level of the knee so that the weight of the leg below the knee can be transferred to this when desired and at any degree of flexion with the thigh. The skin on either side of the knee is shaved and prepared for operation in the ordinary way, and the pulley, weight, cord, etc., are prepared for extension.

The application of the traction callipers is a matter of a few moments and can be done under local anæsthesia. On the whole we prefer to use nitrous oxide gas, because it enables us, after applying the callipers, to strip off the adhesive strapping or whatever may have been previously used, rapidly and without hurting the patient.

If operative treatment supplementary to the primary operation is necessary, the callipers may be inserted while the patient is in the theatre, but it is more convenient to do it in his own bed.

With the most ordinary care it is impossible to damage the knee-joint in applying the callipers. Fig. 14 (*a*, *b*) shows the limits of synovial attachments and the considerable area of safety available. The landmarks and the points of insertion of the callipers must be defined beforehand. The skin is pulled upwards slightly. Through half-inch skin-incisions the points of the callipers are inserted down to *but not penetrating* the shaft of the bone, gripping it just above its broadest diameter at a level of half an inch above and very little anterior to the adductor tubercle. If put on further forward, the only frequent mistake, they come upon a sloping surface where they tend to slip gradually further forward. The adductor tubercle forms an easy guide to the inner point; the outer guide is less well defined, but it is above the broadest part of the condyles and should be in front of the ridge formed by the junction of the ileo-tibial band with the external intermuscular septum.

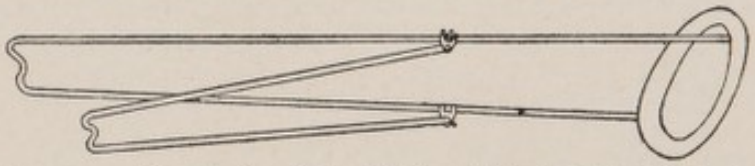
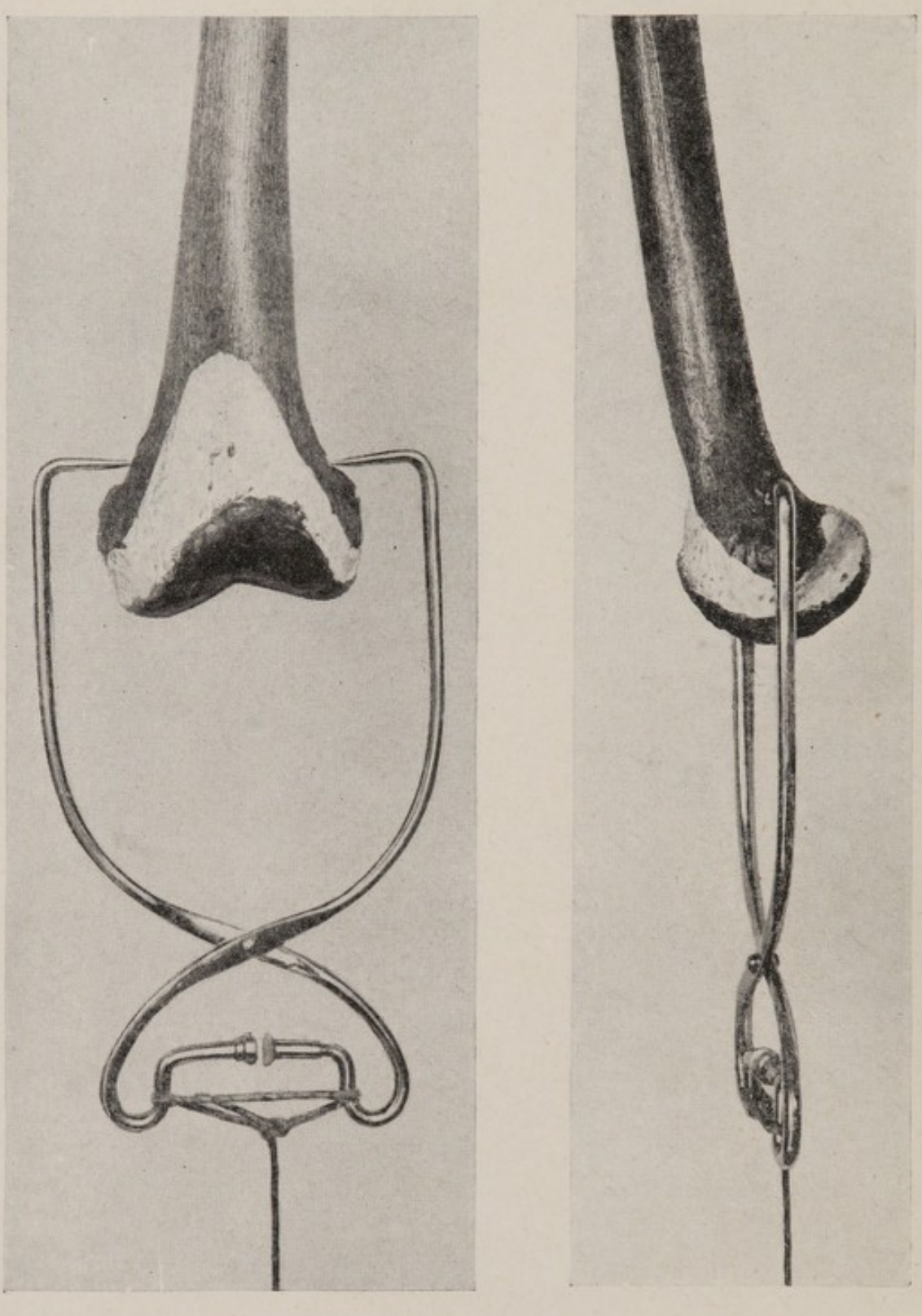


FIG. 13.—Thomas's splint with knee-flexion piece added.

One hand grasping the two blades holds them in position firmly pressed against the bone, while an assistant rapidly ties the two handle-ends together with a piece of stout blind-cord, attaching the other end of the cord to the iron hexagon [shown in Fig. 11 (*b*)] on the other end of which the weight pulls. The weight is a 5 lb. bag of sand, in a recent case, and up to 10 lb. or 15 lb. in an old case. The weight being allowed to act, the grasp of the hand may be relaxed. The callipers



(*a*) (*b*)

FIG. 14.—(*a*) Non-penetrating callipers applied (Pearson's modification of Besley's). Note attachment of cord: the white area on the bone is covered by synovial membrane of the knee-joint. (*b*) Lateral view of same.

[*These non-penetrating callipers are made for us by Messrs. Down Bros. and by Messrs. Allen & Hanbury's, Ltd.*]

will continue to grip firmly as long as the weight is undisturbed. Nurses and others must be made to understand very clearly that lifting the weight-bag for a single moment releases the grip of the callipers and may dislodge them.

While the patient is still under gas the old glue or strapping extension is stripped off, leaving the leg bare from knee to toes. The leg is supported finally on the knee flexion splint, which is lowered to the desired angle and fixed by means of the light chain or cord shown in Fig. 15.

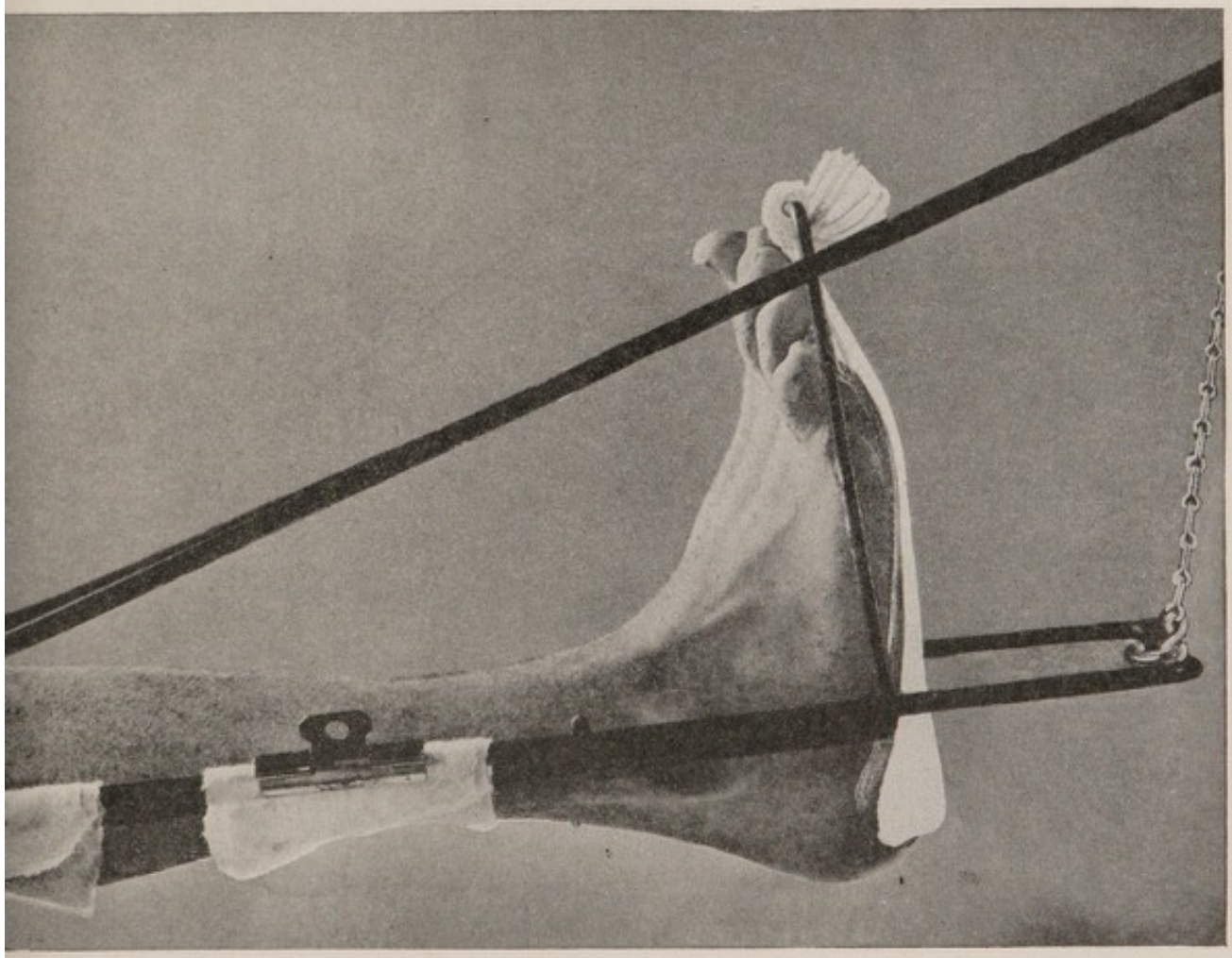


FIG. 15.—Suspension of the foot by a bandage glued on to the sole. Note the bare dorsum of foot and tendo Achillis.

The foot is suspended from the top of the foot piece by means of a bandage previously glued to the sole only. This gives a very satisfactory way of keeping the foot at right angles to the leg and at the same time of avoiding pressure on the tendo Achillis where pressure-sores are common and often serious. It leaves the dorsum of the foot bare, and voluntary movements of the toes and ankle are unimpeded.

Around each calliper point, where it emerges from the skin, is wrapped

a dressing consisting of a strip of gauze soaked in solution of flavine in alcohol (1 in 500). No further dressing is applied.

The whole process is easily carried out in thirty seconds.

Fracture Bed.—To avoid the need for moving the patient for dressings, etc., we worked out in 1916 and 1917 the details of the bed shown in Fig. 16, a form of fracture bed easily improvised where the later standard pattern is not at hand. Many stages of evolution occurred in the First South African General Hospital in France, where every attempt had to be made to utilise available materials and such bedsteads as were obtainable quickly and in large numbers.

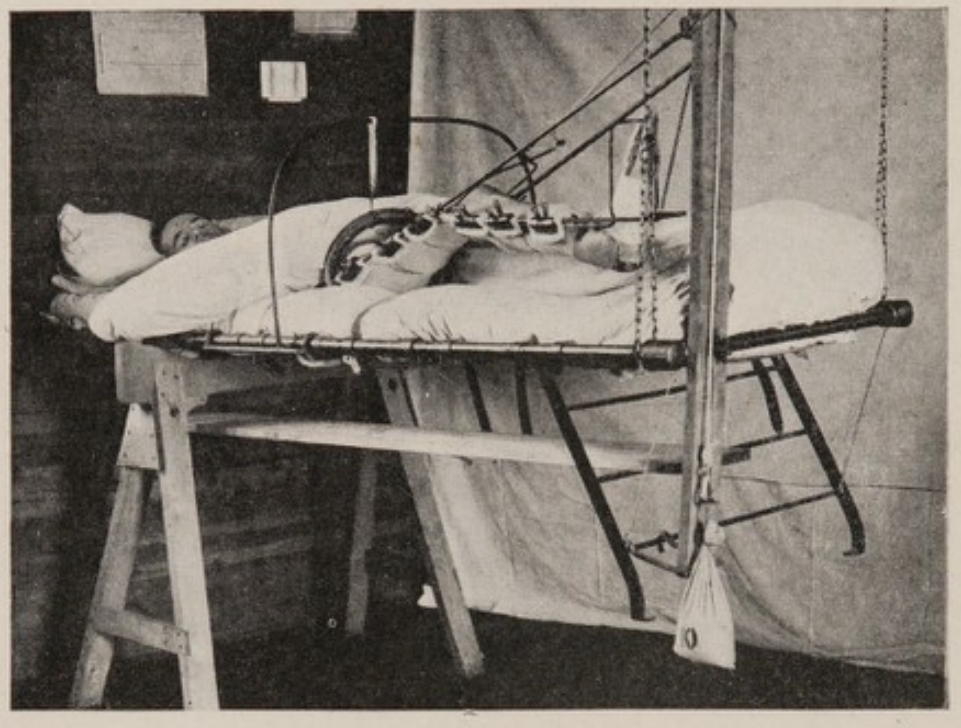


FIG. 16.—Improvised form of fracture bed, made by stripping the spring mattress from an ordinary camp bedstead and replacing by canvas slings and straps. Lower end of bed suspended by chains from the roof to lessen vibration and give increased height.

Owing to the number of early cases sent to England in 1918, the Army Medical authorities adopted as a standard pattern an improved form which contains all the essentials of the South African bed, with the addition of a supply of tubular overhead gear which makes it suitable for almost all forms of fracture suspension and extension. In this new form it is made by Whitfields Bedsteads, Ltd., Birmingham.

The bed is intended primarily for cases of fracture of the femur, but it is also useful for wounds of the arm, shoulder, back or pelvis, where turning the patient is difficult. It is an extension of the "sectional mattress" idea, with this addition—that not only the mattress, but the

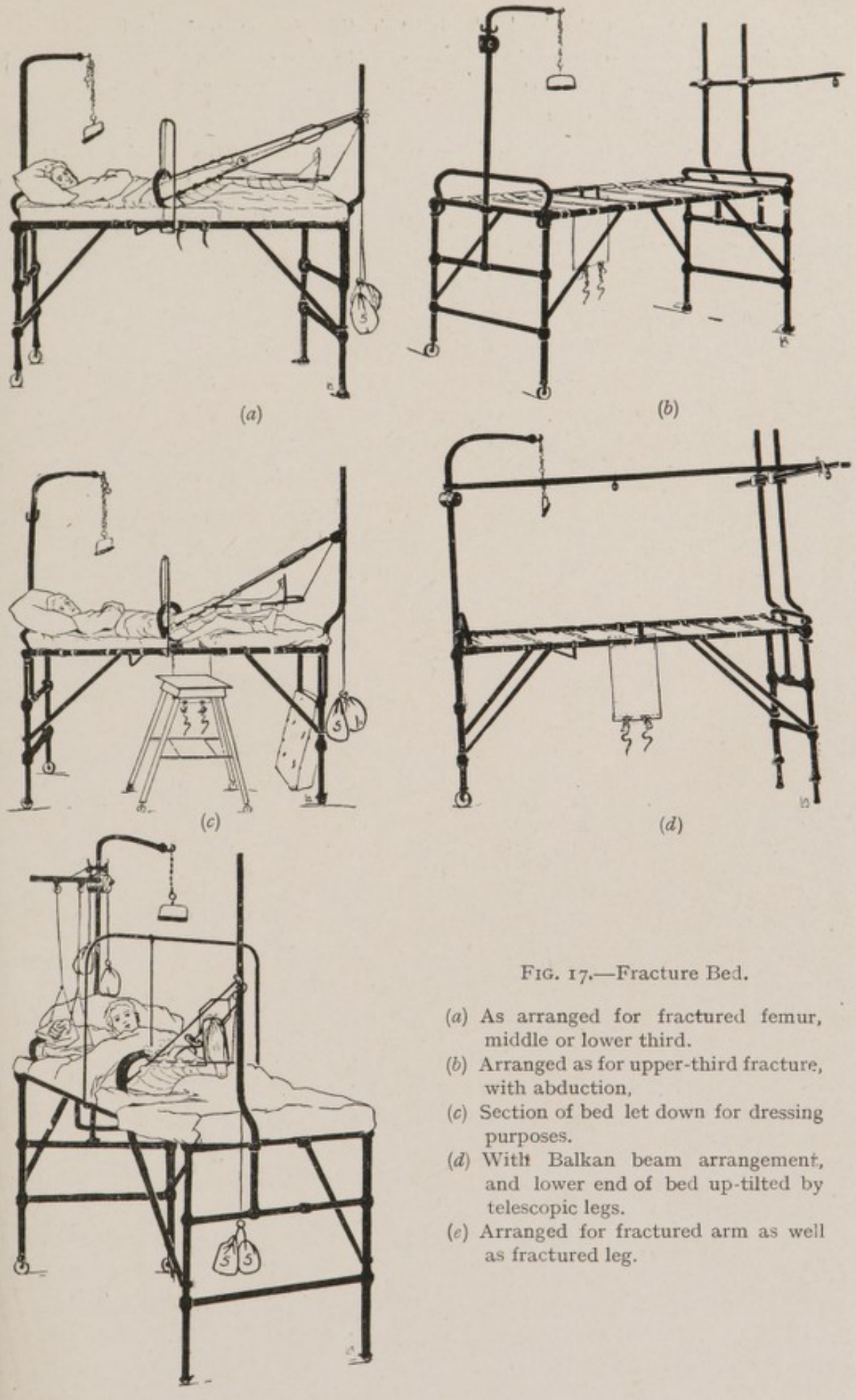


FIG. 17.—Fracture Bed.

(*a*) As arranged for fractured femur, middle or lower third.
(*b*) Arranged as for upper-third fracture, with abduction,
(*c*) Section of bed let down for dressing purposes.
(*d*) With Balkan beam arrangement, and lower end of bed up-tilted by telescopic legs.
(*e*) Arranged for fractured arm as well as fractured leg.

whole of that part of the bed which underlies the wound can be removed altogether, giving unimpeded access either for dressing the wound, radiography, or for ordinary nursing purposes, so that it is unnecessary to move the patient at all.

It consists of a tubular frame bedstead, with the spring mattress replaced by tight canvas slings, 11 in. wide, fastened by straps and buckles to one side-bar of the bedstead, and by metal hooks or a " quick-release " contrivance to the other. [Fig. 18.]

The mattresses lie upon the tight slings in three or more sections. For a femur case, one square " biscuit mattress " is under the patient's head and body, another under the lower part of the legs, and a small piece of mattress, of the same breadth as the canvas slings, lies immedi-

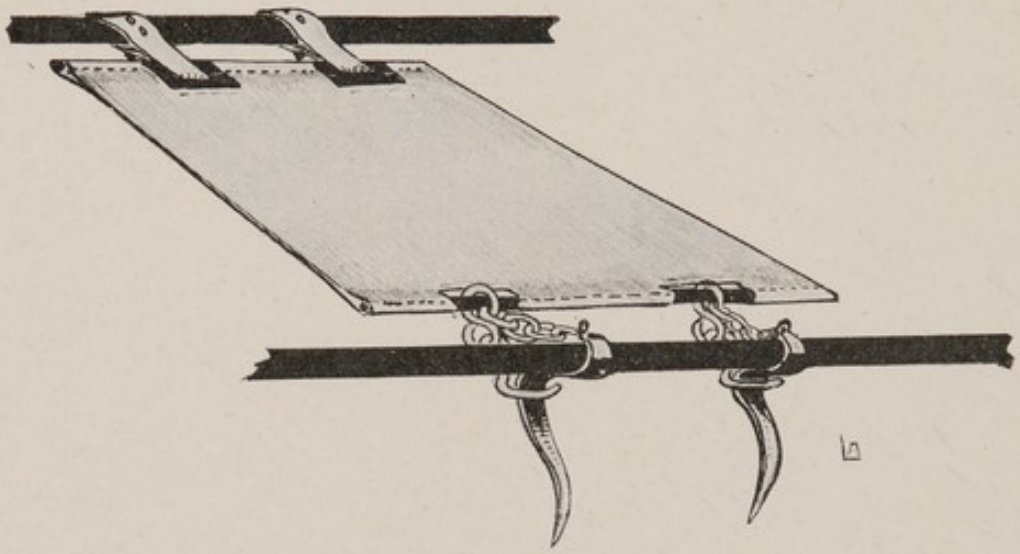


FIG. 18.—A canvas sling with straps at one end and " quick-release " at the other.

ately under the wound and is the one that is removed, with its corresponding canvas, for dressing purposes.

As a matter of convenience for nursing and radiography the bed stands 36 in. high, a good deal higher than ordinary hospital beds. A removable arch of round iron resting on the side bars of the bed or the tubular beam shown in Fig. 17 (*d*) affords means for suspending the Thomas splint, or the pelvis of the patient if it is necessary to expose a large part of the back or buttock at one time. For a femur case, it is never necessary to lower more than one canvas section at a time.

The upper bed legs are furnished with wooden wheels, the lower are telescopic so that the bed can be up-tilted without blocks if body-weight extension is desired. At the head end is the derrick by which the patient can raise himself. It cannot rotate because its lower end is hexagonal.

It can, however, be put into any one of six different positions, can, for instance, project sideways to suspend a damaged arm. At the foot of the bed, near each corner, is a similar hexagonal socket into which a spare derrick can be inserted to suspend a leg ; or a steel tubular extension post with pulley attachments can be inserted. For ordinary fractures of the femur or tibia and fibula, one such extension post is sufficient and the lower end of the Thomas splint is tied against it at any slope that is desired. In the case of upper fourth fractures, where wide abduction of the leg is required, two extension posts are put in and a long tube clamped horizontally across them projecting far beyond the side of the bed ; to this projecting end the splint is fixed. In a similar way a bar may be clamped on to the upright derrick at the head of the bed to suspend or extend an injured arm. The overhead suspension is of light bicycle tubing connected where necessary by clamps of the Maddox type.

The floor space occupied is the same as that of an ordinary bed. The patient is accessible from all directions. Tilting the bed is rarely necessary. There are no attachments to ceiling or floor. In addition, dressing the wounds does not necessitate any moving of the patient ; no sagging occurs at the hip ; no movement at the fracture. There is no lifting, pulling, or rolling. Upper fourth fractures of the femur have always been difficult to nurse. With this bed they are little if any more difficult than others. One nurse can dress a case easily without any assistance.

The efficiency of the method of extension here described depends upon the pressure of the ring of the splint against the tuberosity of the ischium ; that alone prevents the weight from gradually pulling the patient down the bed into the splint. The relative position of the tuberosity and the ring must therefore be frequently scrutinised by the surgeon ; as long as the ring is suspended there should be no trouble : the tuberosity does *not* slip past the ring ; nor does it become sore from pressure. To prevent this certain precautions are taken to cleanse the ring and protect the skin, but the mechanical efficiency of calliper extension is so great that only comparatively light weights are needed, and the pressure against the tuberosity is correspondingly small.

It will be noted that as a rule we do not tilt the bed or depend at all upon body weight as a means of counter-extension : that is to say, the method is nearer the Thomas than the Hodgen principle. Mechanically, body-weight extension *without* weight and pulley is defective, because it is inconstant : the patient can vary the pull as much as he likes or abolish it altogether by moving up or down the bed with the help of his elbows and sound leg, and the amount of the pull is never known. Apart from

that the position is not one of comfort, nor is it easy for nursing and feeding. With weight and pulley extension and a level bed the pull is absolutely constant, cannot be varied by the patient, and is a known quantity.

There are only two occasions on which there is necessity for tilting the bed. If for any reason the skin touching the ring of the " Thomas " should become tender to pressure, tilting the foot of the bed up a few inches will cause the patient to slide slightly towards the head of the bed ; the splint cannot slide with him because its lower end is tied to the extension post, and so the pressure between the buttock and splint is relieved, and in that case the splint becomes a " Hodgen " rather than a " Thomas." But this reason for tilting the bed should rarely exist. Soreness and, still more, blistering or breakage of the skin in this region nearly always betoken wrong placing of the ring or want of attention to skin and ring.

The other occasion is where there is a large buttock wound in the position where the ring should be. In such cases we cut off the lower half of the Thomas ring. With suitable powerful shears this can be done while the splint is still on the patient, and without jarring him. The wound area is then free from pressure and accessible for dressing purposes. In such a case, the counter-extension against the tuberosity is obviously gone, and we then raise the foot of the bed and use body-weight counter-extension, but still with weight and pulley as our extending force.

Consideration of the diagrams above will show that we now have means of moving the leg, knee and ankle without relaxing even for a moment the traction on the femur.

CHAPTER V

CALLIPER TRACTION AND MOBILISATION OF JOINTS

THE advantages and disadvantages of calliper extension require to be discussed. There is no doubt that a large body of professional opinion is thoroughly opposed to any form of extension that necessitates making new wounds. On the face of it, that is a reasonable point of view, and the more so as all of us have seen or heard of not a few cases where necrosis of bone has occurred, resulting in a long-persistent sinus, where sepsis has spread up the thigh, and even where the knee-joint has been infected and a limb lost. This is a very formidable list of objections, and it is no sufficient reply to say that in the hands of expert men such things should not occur. All men are not equally expert. The general results in the hands of the average man have to be considered. Pins penetrating the condyles of the femur and various forms of callipers inserted into the cancellous tissue of the condyles have produced all of the above disasters, not frequently perhaps, but in sufficient numbers to justify the prevalent distrust. It was therefore with some anxiety that we adopted calliper extension.

Major Watkin Williams, D.S.O., had drawn attention to the frequency of stiff knees after long immobilisation for fractures of the femur, and had advocated early movement of the joint to prevent it, just as Lucas-Championnière in France and Mennell in England had long advocated early mobilisation in the treatment of all fractures. Everyone accepted the principle, but the practice had never become general, least of all in connection with fractures of the femur. For many reasons, but especially in order to gain freedom of the leg, mobility of the knee-joint, and to avoid pulling on the knee-joint itself, we were anxious to apply our extension above the knee. Adhesive extension applied to the skin of the thigh was in most cases ruled out by the presence and position of wounds, in addition to other drawbacks. Any form of traction applied through the skin is relatively inefficient and wasteful of power, because much of it is spent on tissues far above the fracture. Adhesive extension is unreliable and inevitably slips

unless renewed at short intervals. It causes blistering, mainly because of the mechanical traction on the epidermis, sometimes because of chemical irritation or sepsis; and this blistering will be slight or severe exactly in proportion to the amount of traction employed.

We were therefore driven to some form of instrumental traction. Now we believe that callipers applied direct to the femur *above* the condyles, in such a way that they grip the bone *without penetrating it*, afford a means of traction which is mechanically almost ideal, and surgically is free from most of the disadvantages hitherto urged against instrumental devices. The risk of necrosis of bone and persistent sinuses disappears. It is quite true that the making of the wounds through the skin and soft parts down to the bone remains a disadvantage and a possible source of trouble. In practice, however, it causes no serious trouble.

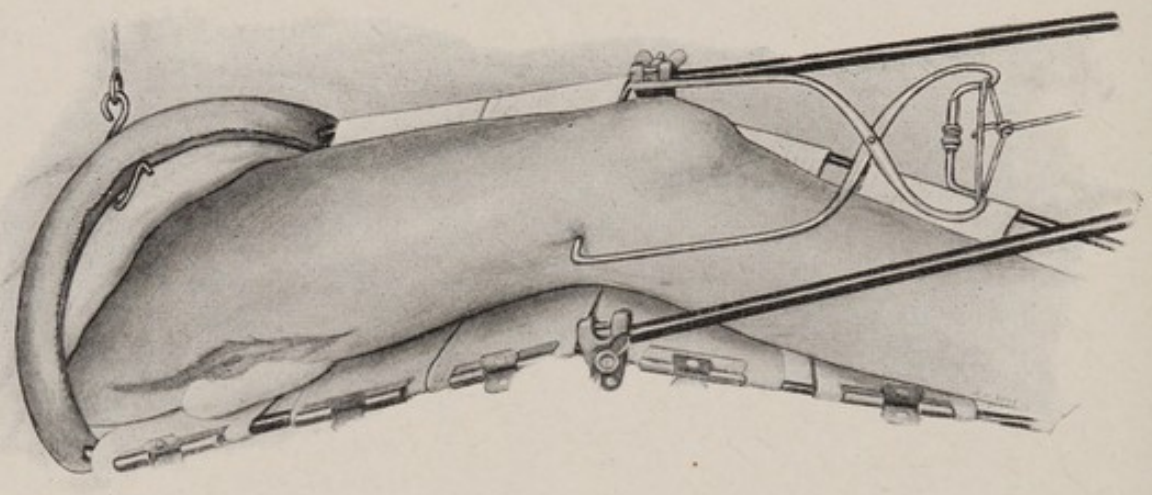


FIG. 19.—Non-penetrating callipers applied to the shaft above the condyles.

Sepsis.—After an experience of some hundreds of cases treated by ourselves and by many other men in hospitals with which we have been connected, we can say that we have so far seen or heard of no case where any serious sepsis has occurred around the calliper points, nor of sepsis spreading up or down the limb from them, nor has there been any case of joint infection. Not uncommonly, a few drops of what appears to be pus appear around the calliper points after they have been in position for some weeks. We have examined this in many cases and found it free from organisms. It is, in fact, in its origin a local leucocytosis due to pressure, and it is easily controlled by local treatment. It does not tend to spread, provided that the skin incision is large enough to allow an outlet, and it does not necessitate removal of the callipers. In most cases it can be got rid of in a few days, but whether this is so or not, a proof of its innocuous nature lies in the fact that, on removal of the

callipers, the wounds through the soft parts invariably are dry and healed within two or three days. In fairness, one must admit that such a discharge might become infected from outside sources; probably it does in some cases; even so, if it has free outlet, it should be harmless, and in practice it is so. We repeat, however, that its harmlessness depends upon a free outlet. For this reason it is unsatisfactory to insert the points of the callipers through a mere skin-puncture. The skin incision should be half or three-quarters of an inch long.

Non-penetrating Callipers.—The form of callipers used by us is a modification of Besley's pattern. In our earlier cases we used Besley's callipers, but without inserting them *into* the bone as practised by him, and found that even so the inward thrust of the points was enough in many cases to penetrate the bone deeply, the more readily because at that time we were applying them at the upper margin of the condyle, where the shell of hard bone is so thin as to be practically absent. To limit this penetration, we adopted the plan of putting in a light steel cross-bar between the handles; and later devised the form of callipers shown in Figs. 14 and 19 as being more convenient and accurate. These have a check-bar between the handles, adjustable by a screw. After applying the callipers to the bone, the screw is adjusted so as to leave just a streak of daylight showing, say $\frac{1}{32}$ inch, through the middle of the check-bar. As long as the calliper points retain their position without penetrating, this streak of daylight

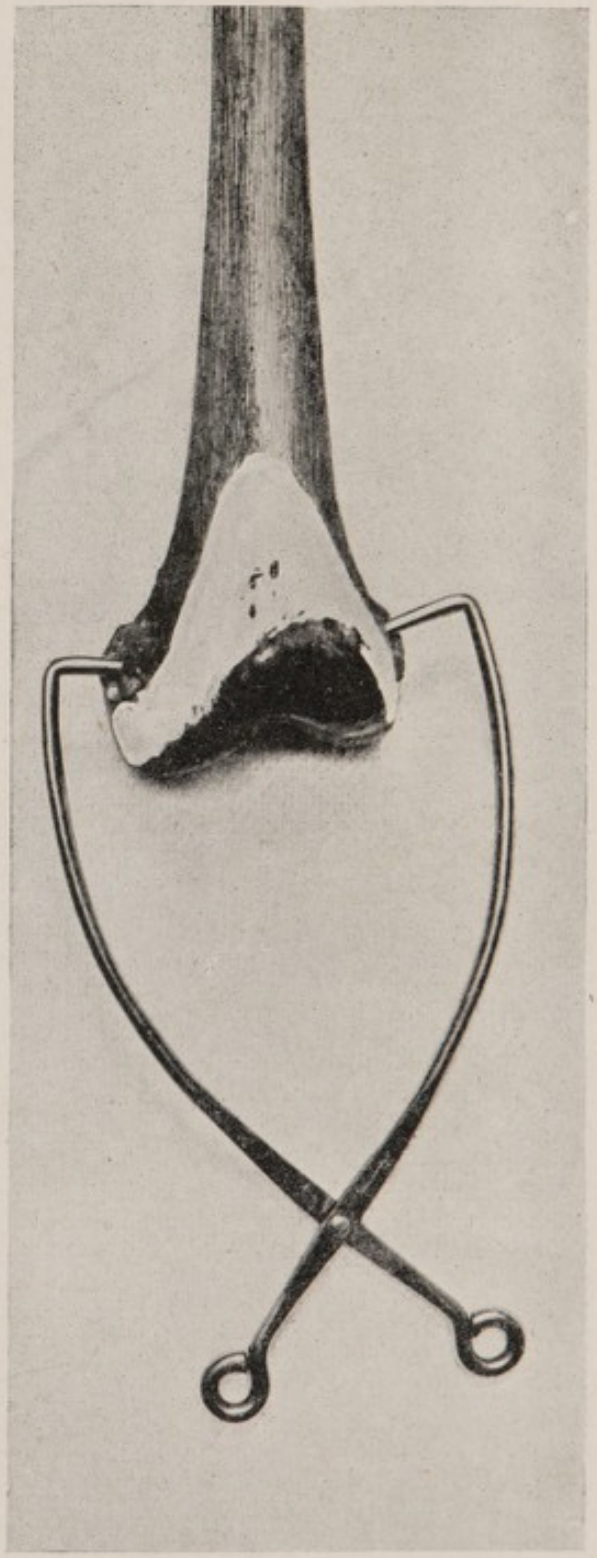


FIG. 20.—Besley's callipers inserted *into* the condyles.

will remain. It does so, commonly, for three or four weeks, showing that the tendency to penetrate is not really great when the points are applied to the harder bone half an inch above the adductor tubercle, which is now our place of election. After that time the gap in the cross-bar often closes and penetration into the hard bone has then presumably occurred, but is limited to a very trivial amount, insufficient to reach the cancellous bone. The check-bar prevents further penetration. [Figs. 22 and 23.]

"Slipping" of Callipers.—The question of slipping of the callipers has been raised. They never do slip suddenly or dangerously; but they do sometimes "creep" very gradually downwards or forwards. This, we believe, is due, in most cases, to gradual rusting and erosion of the points. Erosion does occur. Callipers that have been used always need re-sharpening before being used again. "Creeping" may occur also as a result of too free movement of the patient in bed. In either case the remedy is simple: give gas and re-apply the callipers in their old position or through a new incision higher up. If the points are found eroded a new pair should be used. In the future we hope to have these instruments made of rustless steel; hitherto this has not been practicable. Nickel plating is not sufficient protection.

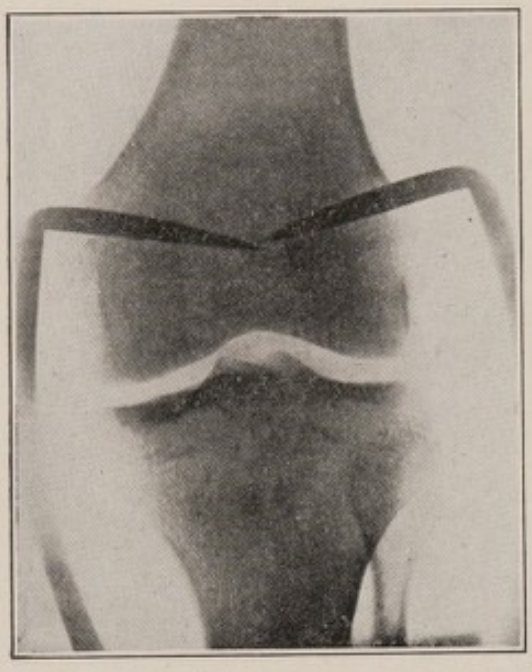


FIG. 21.—Unnecessary penetration of points of calliper before modification. Photo kindly lent by Major Watkin-Williams.

In one case, while one calliper point remained firm, the other pulled down into the cancellous tissue of the wide part of the condyle below it. It caused no trouble, and was only detected long afterwards in a final radiograph of the limb. Non-penetrating callipers as here described depend for their grip upon the true ice-tong principle. The weight, drawing the handles inwards, causes an inward thrust of the points so powerful that it will hold even on the cylindrical part of the shaft, and naturally more firmly still on the wedge where the lower end of the shaft begins to widen out into the condyles.

The advantages of traction above the knee rather than below it are so manifest that every surgeon would prefer it if convinced that it could be done safely and efficiently. Two of the worst results of femur treatment so far have been the wobbly knee-joints where traction of considerable amount has been applied to the leg below the knee, especially

if the muscles have been badly damaged; and stiff-knees where the leg has been kept long in one position; the latter is by far the commonest and most serious disability resulting from fractures of the femur and is not by any means limited to fractures close to the knee-joint. By applying traction above the knee, movement from the first day is obtainable and both of the above results are avoided.

Further, any "adhesive" method which involves covering up a large part of the leg hinders active and passive movements and massage of the muscles and so makes atrophy of muscles inevitable. The contrast between the condition of the muscles in the two methods is very noticeable. With calliper extension we find the leg muscles, and often the thigh muscles, equally good on both legs when extension is abandoned (see Fig. 24, p. 45); with adhesive extension, extreme atrophy is usual.

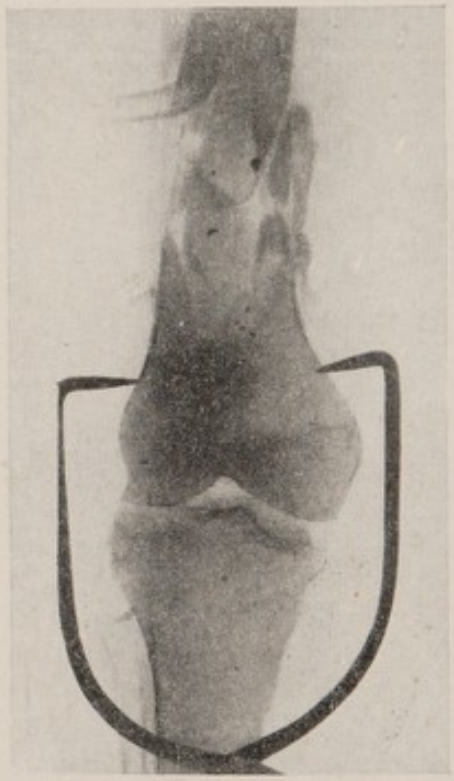


FIG. 22.—Non-penetrating callipers after being sixteen weeks *in situ*, close to a large and very septic fracture. No pain or sepsis at calliper points throughout. [Case E 74.]

Traction applied by means of pins through the tibia appears to us to have most of the disadvantages inherent to adhesive traction below the knee, besides making a fresh wound which perforates cancellous bone. It does not permit of the free movement of the knee which we strive for, and it does not afford traction in the line of the thigh unless the leg is kept extended or nearly so. The same remarks apply to screws in the tibia.

Two long screws put into the tibia, across its medullary cavity and into the hard bone on the further side, afford very secure points for the attachment of traction; they are surprisingly painless, and they usually retain their hold for months without working loose. In a few cases they have caused sufficient absorption of bone to enable them to be picked out of their channel with the finger and thumb, without unscrewing. In six cases we have seen bony sinuses persisting months after the screws had been removed.

If the tibia is to be perforated at all we should prefer one steel pin to two screws. The only advantages we see in either over the adhesive method are the greater certainty, the avoidance of blistering, and the fact that they leave the surface free for massage.

Stiff Joints.—On the face of it, a method which gets the patient

out of his splints with a mobile knee and ankle and well-nourished muscles should get him back to ordinary occupations more quickly than one which, after a similar period in bed, has to be followed by months of exercises to restore joints, muscles, and ligaments to their natural mobility, and even then with entirely disappointing results in a large proportion of cases. Our aim should be, not to *cure* the stiffness and atrophy that so frequently result from these fractures, but to prevent their occurring. Early movement of the joints, combined with massage and active movements of the muscles, whether voluntary or electrically stimulated, gives not only much *quicker* recovery of function, but also on the average *more complete* recovery than is got when the whole limb is completely immobilised from the beginning. Those surgeons whose experience of fractures has been chiefly in the acute, or even in the semi-convalescent, stages will perhaps hardly appreciate this difference. When union, in excellent anatomical position, has occurred, and the patient has arrived at the stage of walking about in a walking calliper splint, he is apt to be handed over to the massage, electrical, and gymnastic department for that unfortunate department to do its best with; and thereafter he disappears from the view of the surgeon who has had charge of his early treatment. If the massage and electrical department were called in at the beginning of treatment instead of at the end, its help would be invaluable instead of hopeless from the outset, as is so often the case. There would then be fewer of the radiographically beautiful, but functionally inadequate, limbs coming up for examination by the Pensions Boards of the nation.

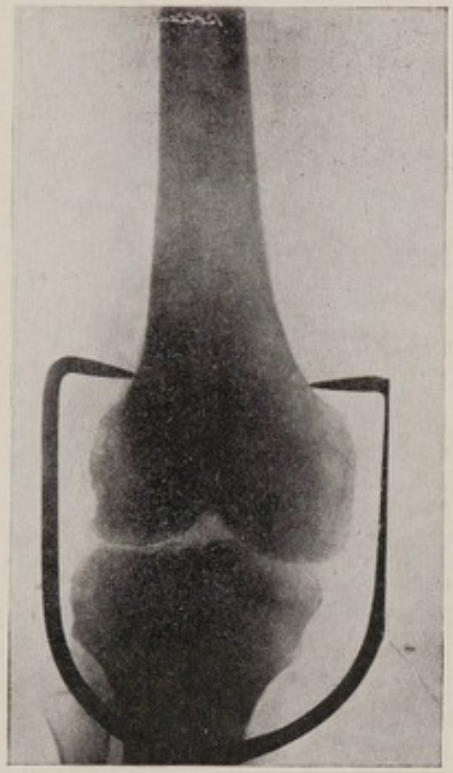
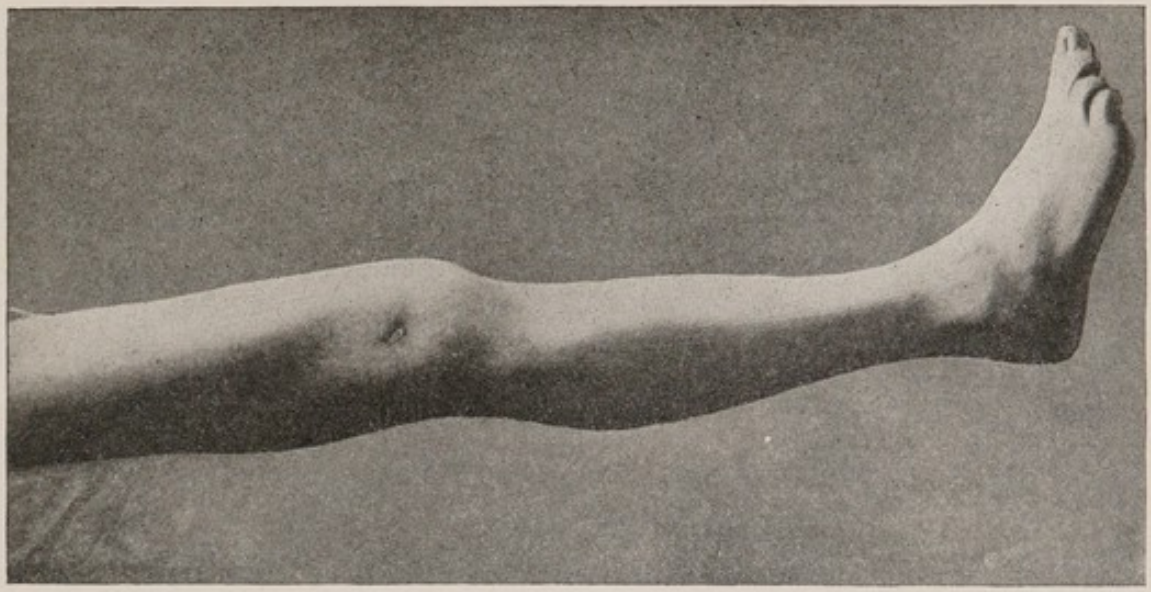


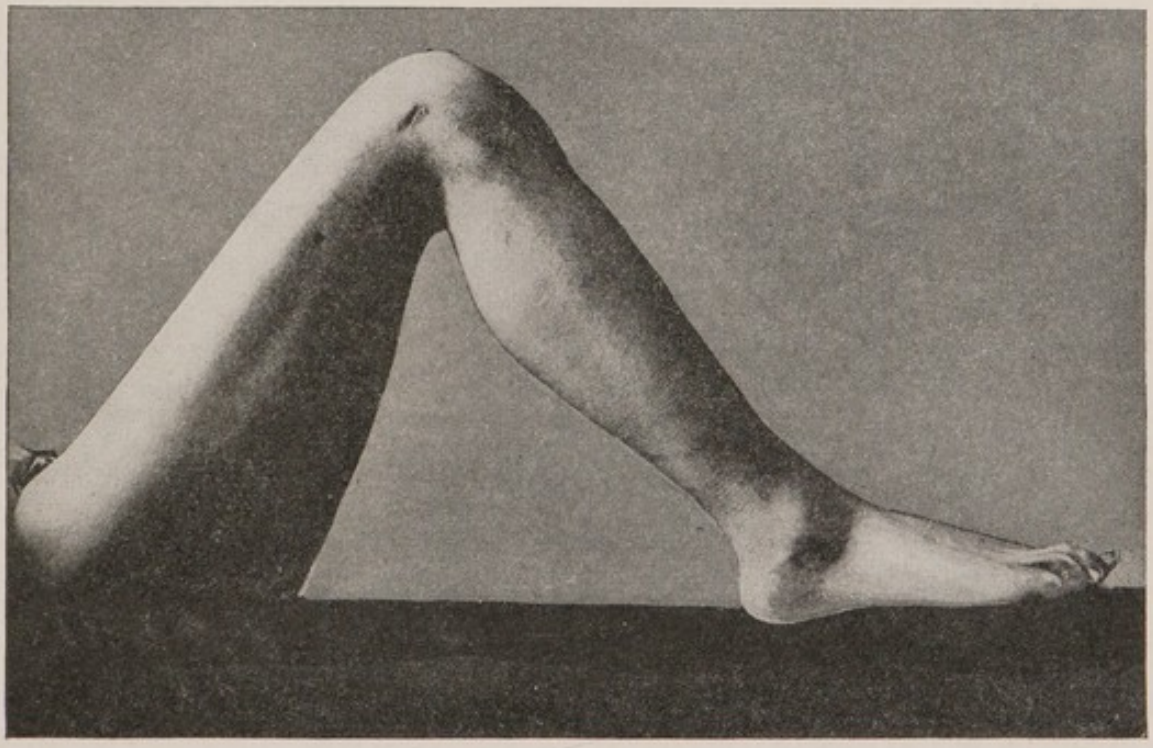
FIG. 23.—Callipers after being sixteen weeks *in situ* for fracture of upper third. No penetration.

Stiffness of the knee-joint may amount to absolute ankylosis where the joint itself has been injured, or where there has been subsequent effusion into the joint, though it is far from universal even when a septic compound fracture reaches the articular surface. Where the fracture is far from the knee, stiffness amounting to almost complete fixation is far too common; a range of movement limited to 5°, 10°, or 15° is frequent. What is the pathological condition upon which this depends?

Adhesions between the patella and the lower end of the femur are one



(*a*)



(*b*)

FIG. 24.—Lower-third fracture photographed three days after coming out of splints, to show (*a*) extension; (*b*) flexion. Note lack of atrophy of limb.

[Case E 226, treated by calliper extension with early movements and massage.]

cause ; much may be done by frequent movement of the patella to prevent their formation. We believe they are rare.

Cicatricial adhesion of the muscles, especially of the quadriceps, is certainly another cause ; that it is not the sole cause is indicated by many facts : the pain felt when forced movement is attempted is felt at the knee, not in the scarred region ; stiffness may be extreme and persistent even when the fracture has been a clean, uncomminuted one at the opposite end of the femur ; and in a case recently under our care, where *both* legs had been fixed in the extended position for three months, the knee of the *sound* leg was absolutely rigid, though it yielded to treatment by massage, etc., in the course of a month. Further, many patients with much comminuted fractures and extensive destruction of the quadriceps have a very full range of movement.

We believe that loss of mobility is due in the great majority of cases to contracture and loss of elasticity in the tendons, ligaments, and other peri-articular structures, to adhesions between the tendons and their sheaths, and to fibrous changes in the muscles themselves induced by long immobilisation and malnutrition. Further, that, in the main, the degree of stiffness will be proportionate to the length of time that elapses before movements are begun ; that the extent and position of the fracture and flesh wound are factors mainly in that they affect duration of treatment ; that early movement does not increase the formation of scar tissue, but that, on the contrary, even in lower-third fractures with extensive destruction of the quadriceps, a fair range of mobility of the knee can be maintained throughout if movement is begun soon after the injury.

We are not advocating violent movement of acutely inflamed and septic muscle injuries. Movement must be slight at first and always slow, and its range must be limited by the sensations of the patient, his expression being watched by the surgeon as he moves the limb. Above all, the movement *must* always be deliberate and gentle, and the patient must be confident that it will be so. If he is fearing some sudden movement his muscles will be on guard, and movement without pain will be impossible. He should not merely hope, but *know* that the daily movement is going to be painless, otherwise his involuntary resistance will mislead the surgeon as to the amount of mobility actually present.

With these precautions, movements of lacerated muscles do not cause spread of sepsis, rise of temperature, or delay in repair. The reverse is the case: they improve the nutrition, relieve lymphatic stasis, and accelerate healing.

The treatment of cases where stiffness has been allowed to supervene is very difficult. Much may be done by a skilful masseuse, and more by the co-operation of the patient himself ; when union is quite firm gymnastic exercises help. The most discouraging cases are the very old ones where

movement at the knee is absent or limited to a few degrees. In these, more forcible manipulation under an anæsthetic is the remedy, the first step being movement of the patella by lateral pressure with the thumbs ; in many cases adhesions can be heard to break down ; the amount of force that is then justifiable in bending the knee is a matter requiring great judgment—either the fracture or the patella may give way. Fig. 25 shows a patella fractured in an attempt to flex a rigid knee. In case of success attending the efforts the movements must be repeated early and often, beginning next day, or even the same day ; otherwise stiffness will recur.

As a final resource in cases of ankylosis of the patella to the femur, open operation to separate the patella and inlaying of a graft of fat and fascia lata under it is available.

And all of these measures should be unnecessary if early treatment has been adequate.

Mobility of the knee and improved nutrition of the muscles are not the

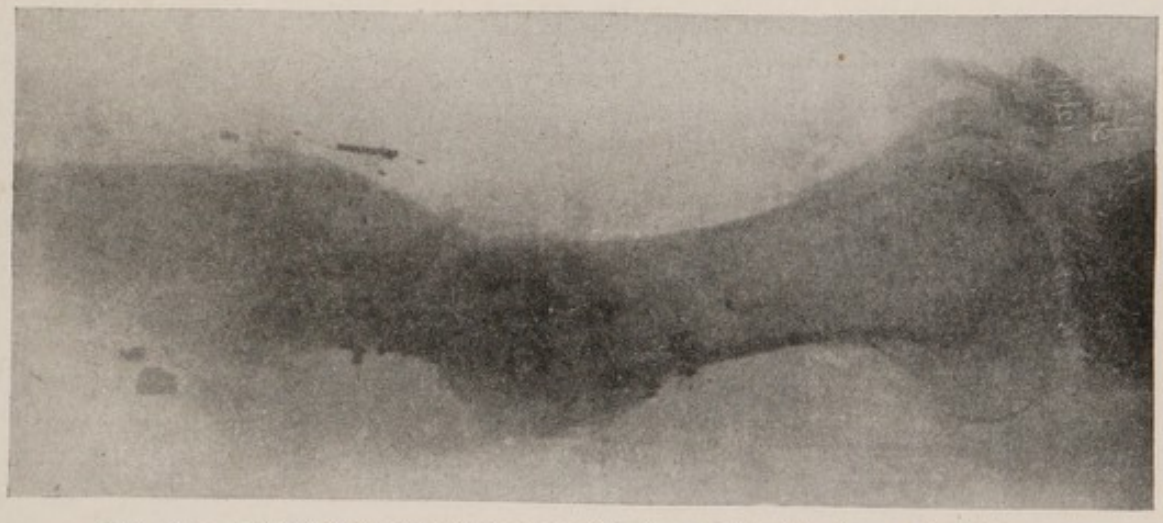


FIG. 25.—Patella fractured transversely in an effort to flex a rigid knee.

only advantages given by calliper extension. We get also very efficient mechanical control of the lower fragment with a very light weight.

We can alter the position of the lower fragment laterally by deviating the direction of the pull of the cord.

The lower fragment can be tilted forward or backward more or less by inserting the calliper points further forward or backward. There is a limit to this, however, as the grip of the callipers is best when on the broadest diameter of the bone. If put on much in front of this, they come on to the sloping surface of the condyles and tend to creep further and further forwards.

Weight Necessary.—In a recent case, say within a week of injury, a 5-lb. weight will give normal length, in most cases within a day. In older injuries, we use up to 15 lb., but rarely more than this. The weights being comparatively light, the pressure on the tuberosity

is correspondingly slight and painless. Yet with these light weights normal length or slight lengthening can be got in nearly all early cases. Simple fractures with little laceration of muscle often require slightly heavier weights.[1]

As to the duration of time for calliper traction, we leave them on until union has begun, until there is little fear of shortening, and wounds are within manageable dimensions—on an average about eight weeks. Frequently we have left them on for seventeen weeks without the slightest discomfort. [Case E 74, Fig. 22.] Some cases, after a few weeks, have had pain, sufficient to cause us to give gas and re-apply the callipers half an inch higher up, with satisfactory results.

After removal of the callipers any form of light extension that will keep the limb in the splint will suffice.

While the form of callipers we use has the great advantage of not penetrating the bone, it carries with it the disadvantage of less security of hold and necessitates some limitation of the patient's freedom in bed. Callipers which are inserted well into the bone and locked there cannot " creep," except by cutting through the bone, however much the patient moves about in the bed. This is not true of the non-penetrating kind. Although their grip is merely on the surface and is ample for all ordinary purposes so long as the weight is not removed, it is *not* sufficient if the patient is going to be rolled on to his side to have a buttock wound dressed, a proceeding which is really never necessary ; for even if a sectional bed is not available, it is always possible by weights, pulleys, and slings to raise the patient sufficiently from an ordinary bed to make wounds accessible from below, though not nearly as easily, as painlessly, or as safely as with the special bed.

AN ALTERNATIVE METHOD OF USING CALLIPERS

The success which attended the principle of applying extension to the fractured femur through the medium of callipers gripping above the condyles was bound to suggest the efficiency of the same device in other directions.

There were always amongst the group of gun-shot wounds associated with fracture of the femur some in which the conditions surrounding the condyles and joint precluded the use of the calliper in the orthodox position.

There was always a subdivision of this class in which the association of septic wounds of the calf, etc., precluded the adoption of glue or

[1] " The amount of weight to be used for traction in fracture of the femur is a difficult problem. Briefly, it should be all the patient will stand. An adult male will stand a weight of 30 or 40, or even 60 pounds. Unfortunately, in some cases, not even these weights will completely correct the defect."—Warbasse's " Surgery," 1918.

adhesive extension applied thereto, or in which adhesive extension had already excoriated the surface.

These were a source of considerable trouble and worry and were productive of very discouraging results. Applying the knee calliper to the malleoli was adopted as one way out of the difficulty.

The method is subject to the disadvantage inherent in every form of traction applied below the knee; it is indirect and involves risk of stretching the knee structures. In this it resembles screws or pins through the tibial shaft as a means of traction; but, unlike them, the callipers do not open up medullary tissue.

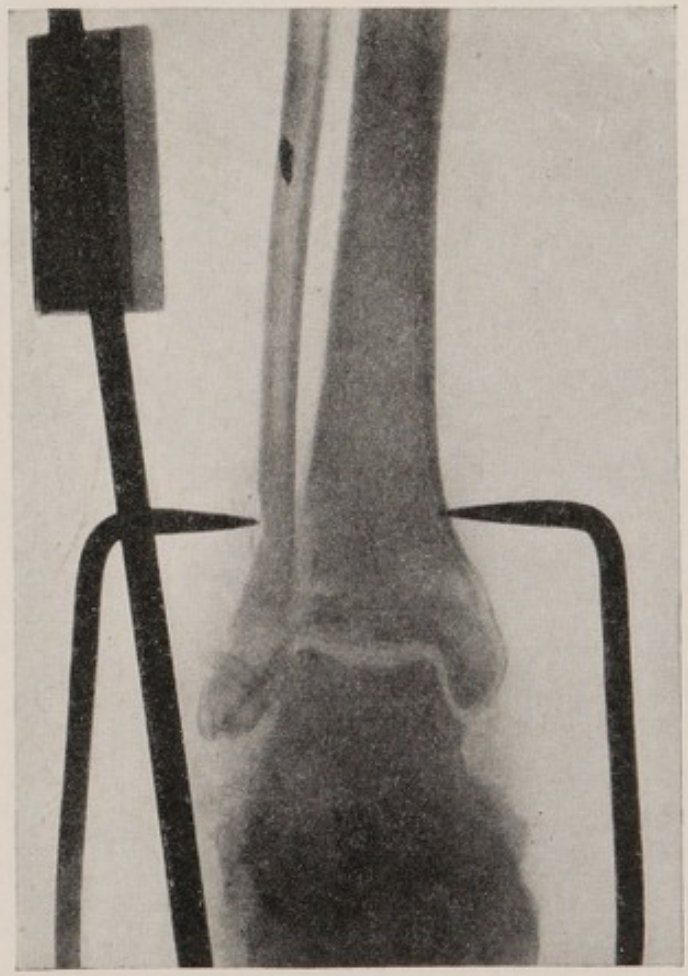


FIG. 26.—Callipers applied above the malleoli as for fractured tibia or for some exceptional cases of fractured femur.

The operation is more lengthy than that of applying the callipers to the femur, and requires to be done very exactly as regards the fibular region. Therefore it should be done under a general anæsthetic.

The subcutaneous situation of the bones facilitates exactness of application, and when properly applied the callipers are peculiarly painless.

Application.—The skin is carefully prepared as for an aseptic operation and a general anæsthetic administered.

The points selected on either side are really not on the malleoli, but on the shafts of the bones $\frac{1}{4}$ inch above the malleoli

A small incision is made down to the bone, the points applied and firmly gripped, and then they should be tapped in lightly with a mallet to the depth of about $\frac{1}{8}$ inch. This is essential to prevent slipping, and especially so on the fibula where the bearing surface is narrow. The weight is then affixed and the screw adjustment set to prevent further penetration.

The fact that the external malleolus is somewhat posteriorly placed

with regard to the internal malleolus, usually means that the callipers are placed obliquely, but this in no sense affects their efficiency.

If the points are introduced into the cancellous tissue of the malleoli, they "drag" gradually and become exceedingly painful, whereas, as above mentioned, when correctly applied they do not drag and are absolutely painless.

Fig. 26 shows callipers in position at the end of eleven weeks. The slight

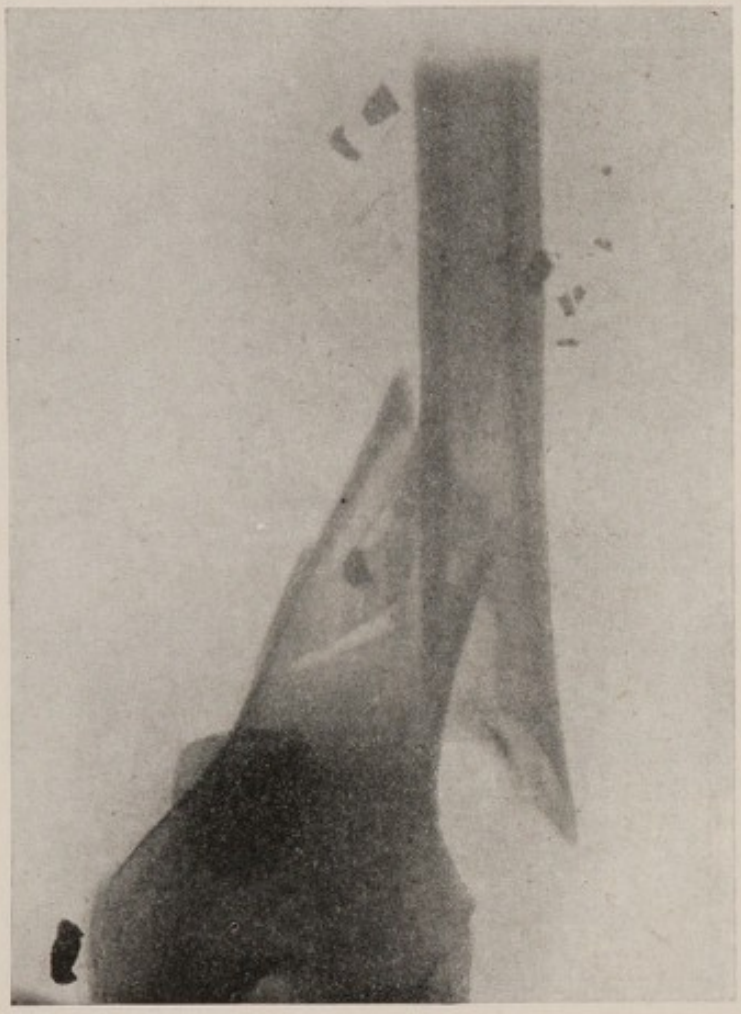


FIG. 27*a*.—Very septic fracture of lower third as admitted more than six months after being wounded.

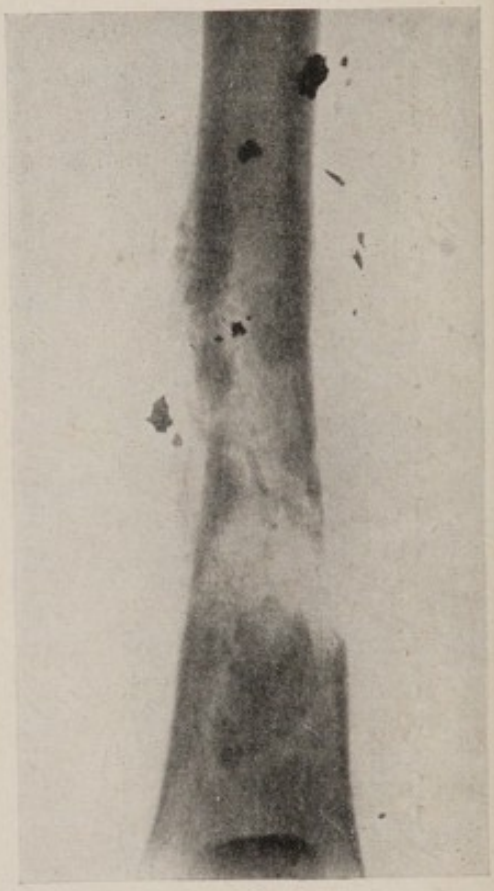


FIG. 27*b*.—Same case two months later; union firm, 1 cm. lengthening. Callipers had been applied to malleoli owing to the extremely septic conditions around the knee.

damage to the fibula was probably caused by some splintering at the time of the original application.

The case exhibited was one of extremely septic fracture of the femur, the patient having had persistent septic diarrhœa for several weeks. The conditions round the knee precluded the use of callipers there. Septic wounds of the leg forbade the use of adhesive extension.

The foreign body seen in Fig. 26 lay at the bottom of a discharging sinus partially embedded in the os calcis.

Nevertheless, the callipers gave no trouble and were removed at the end of eleven weeks. The two perforations closed within forty-eight hours, and the foreign body was removed with fragments of bone on the following day.

The condition of the fracture of the femur before and after the application of the callipers is shown in Figs. 27, *a* and *b*, which demonstrate the efficiency of the method.

Movement of the knee was carried out in the reverse manner to that usually adopted. The flexion piece was kept stationary, and by gradually raising and lowering the rigid " Thomas " the range of movement was increased and the knee kept mobile.

The result in this particular case was firm union in perfect position with 1 cm. of lengthening.

The authors are in this work concerned only with their methods in the treatment of fractures of the femur. But they cannot leave the subject of the application of callipers to the malleoli without drawing attention to the great value this method has in the treatment of fractures of the tibia and fibula.

Their experience of the method as so applied is more than encouraging. The efficiency of the extension and control of the lower fragment is perfect; the use of the knee flexion piece relaxes the gastrocnemius and combats shortening; the knee can be kept mobile from the first by raising or lowering the rigid " Thomas " while keeping the flexion piece horizontal in the line of the extension, and the ankle by supporting the foot as shown in Fig. 15, the appliances being, in the main, the same as those used for fractures of the femur.

CHAPTER VI

TREATMENT OF SPECIAL VARIETIES OF FRACTURES

Upper-Third Fractures.—The common displacements of the upper fragment in all fractures near the lesser trochanter are abduction, flexion and some external rotation, the amount of each varying with the nature and exact position of the injury. Flexion, for instance, is more acute if the upper fragment contains the insertion of the ilio-psoas, whereas abduction is likely to be greatest if the fracture runs obliquely downwards and outwards above the lesser trochanter—a very common variety of fracture.

To secure union in good position, therefore, we must raise the lower part of the leg well above the bed and abduct it widely; how widely one can only estimate by radiography; it is rare to find that more than 30° of true abduction is required. If a limb is put up with this amount, it will be found that the deformity has been over-corrected in the vast majority of cases, and that it is necessary to reduce the abduction. Repeated radiography alone will tell when the correct angle has been obtained. Fig. 28 shows a convenient method of fixing the limb in the desired position.

There is a point in connection with the abduction of these high-up fractures which is of great theoretical and practical interest. It has been a very general though not universal practice to fix both legs in the position of abduction even where one only is injured, on the supposition that if this were not done the patient would voluntarily or involuntarily tilt his pelvis downwards on the sound side and so defeat the object aimed at. This is a pure hypothesis, founded probably on the false analogy of the tubercular hip joint or on the supposition that the abducted position is painful. In the case of the fractured femur, we abduct the limb, not at the joint but at the fracture, we are restoring the limb to its natural line, the position of greatest ease, that is, in line with the already abducted upper fragment. The patient has no inducement to try to "dodge" it, but rather the reverse, he prefers it. As a matter of fact, he does *not* tilt

the pelvis. We have satisfied ourselves of this by examining, repeatedly and without warning, a large number of upper-third fracture cases with the injured limb alone fixed, and in no case have we found the pelvis tilted as judged by the position of the anterior superior spines of the ilia. To prove this, we had the goniometer shown in Fig. 29 made. By using the line between the iliac spines as its base line, this instrument

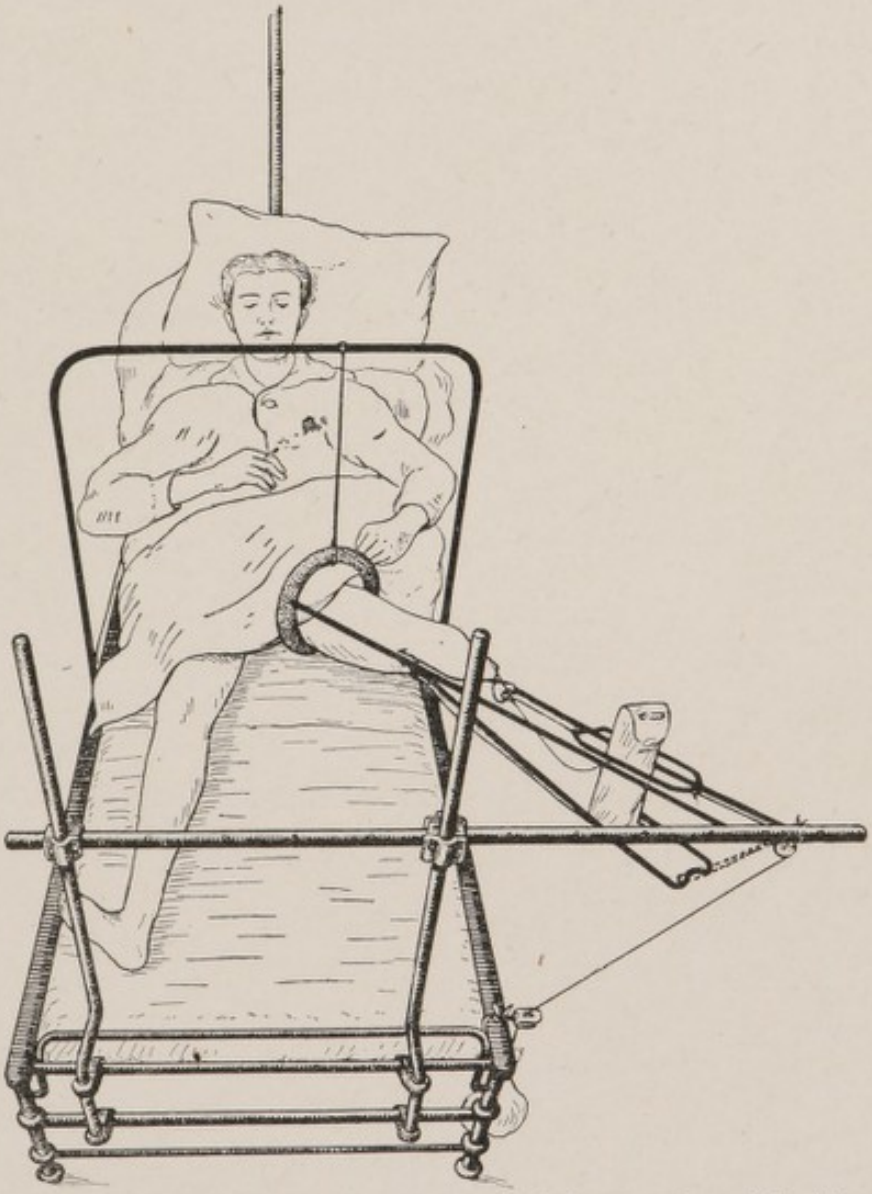


FIG. 28.—Method of treating upper-third fracture by abduction and flexion of one leg only, the other being left free.

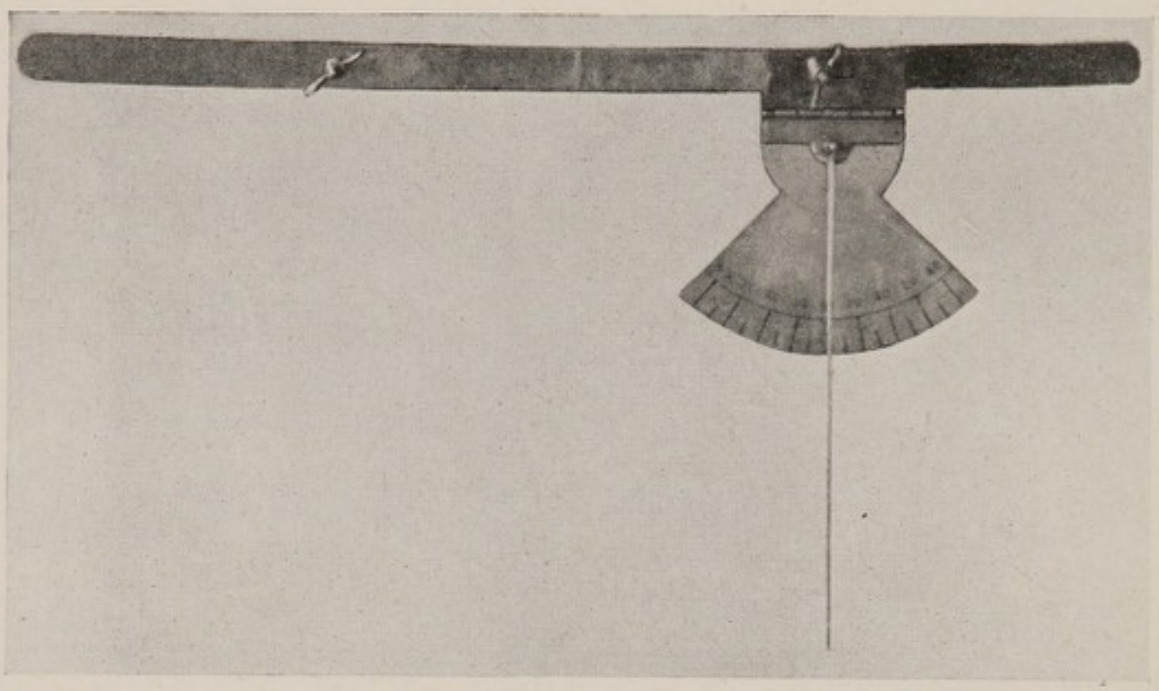
gives a very fairly accurate measurement of the degree of true abduction of the limb. There is no difficulty in getting 30° of true abduction of the injured leg without fixing the other leg or the pelvis, and in practice, as already stated, this is more than is usually required.

We are quite prepared to find that this statement does not meet with universal acceptance. It has been doubted by many visitors and workers

in our wards until they have convinced themselves by actual observations of many cases.

It is probable that wide abduction would be painful in old standing cases where considerable union has occurred. In these cases tilting of the pelvis to circumvent the attempt may be expected, so that something approaching forced abduction is necessary. Even here it is unnecessary to fix the sound leg if the excellent splint shown in Fig. 30, *a* and *b*, devised by Capt. D. Crile, is used.

This is of far more than theoretical interest. Not only is it a great comfort to the patient to have one leg free in bed while he is ill, but it



(*a*)

FIG. 29.—Goniometer for measuring degree of abduction of leg. The cross-bar touches both anterior iliac spines: the lower end of string (*a*) is attached to the big toe.

makes nursing easier and, most important of all, it gives him one good leg to get about on directly he is able to get up. There is no advantage in fixing both legs ; there are many serious disadvantages. Most particularly do we deprecate putting screws into the tibia of the sound leg as a means of traction, as has been done in some cases.

There are cases in which the upper fragment is extremely abducted and the endeavour to bring the lower fragment into line by swinging out the leg succeeds only up to a certain point and then the adductor group holds the lower fragment. The result is that though angulation is abolished and the two fragments are in parallel lines, yet they are not end to end (Figs. 32, *a* and *b*).

Screw Pressure Pads.—To meet this contingency, we have devised a pressure pad which clamps on to the lateral bar of the Thomas splint. By means of this, direct pressure is brought to bear on the upper abducted fragment, so that it can be forced inwards and brought into line with the lower fragment without pain or discomfort to the patient. A similar pad placed on the inner side can be used to hold the

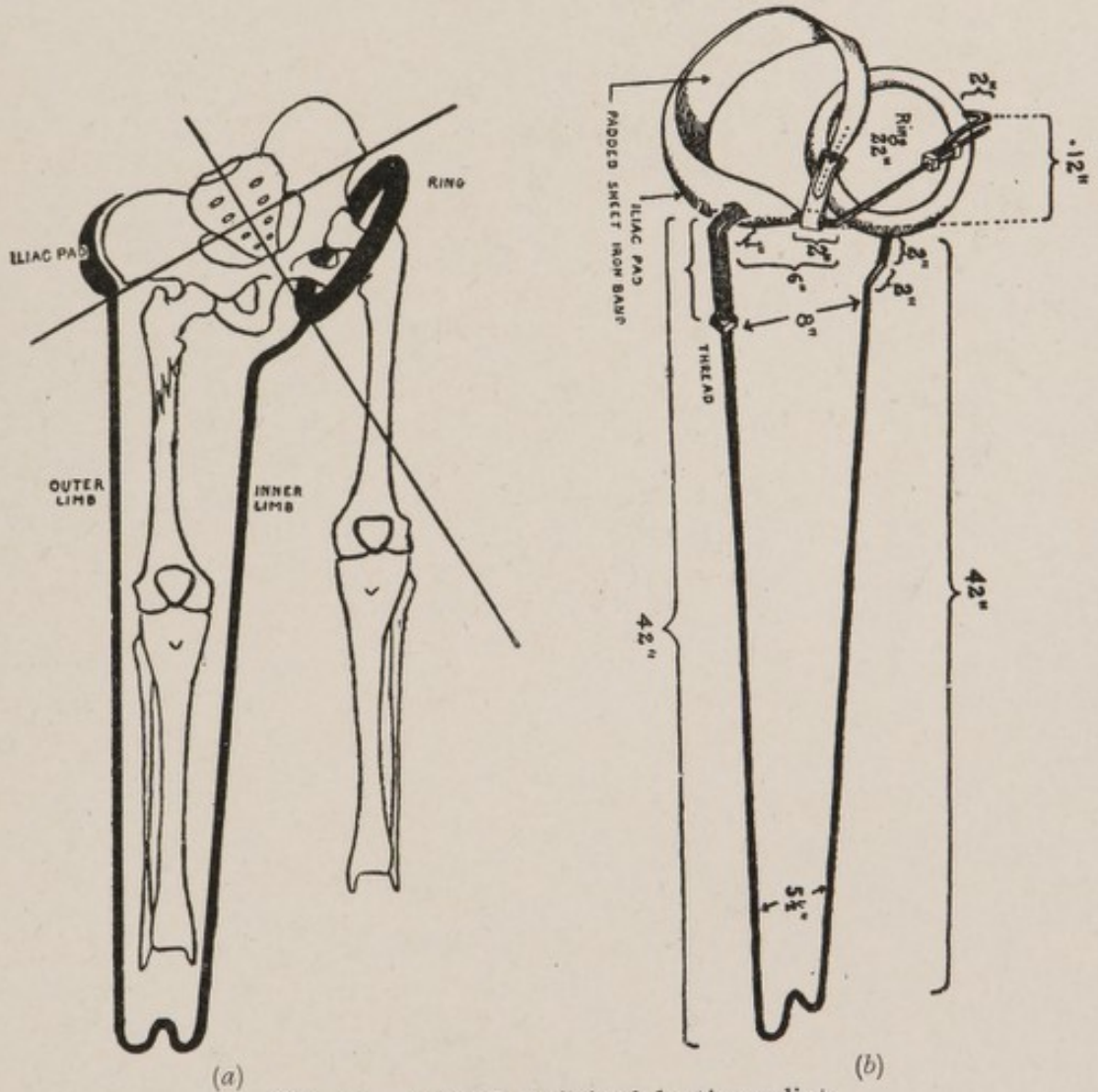


FIG. 30.—Capt. D. Crile's abduction splint.

lower fragment in position or to force it outwards to the line of the upper fragment.

The screw pressure pad shown in Figs. 31 and 32 *c* consists of an adjustable stem with a light troughed plate of metal attached to it by a ball-and-socket joint. The plate is oval and about four inches long, padded with rubber-sponge on its hollow surface, which is applied to the thigh. The device is rather surprisingly efficient and comfortable, even when applied directly over a healed scar.

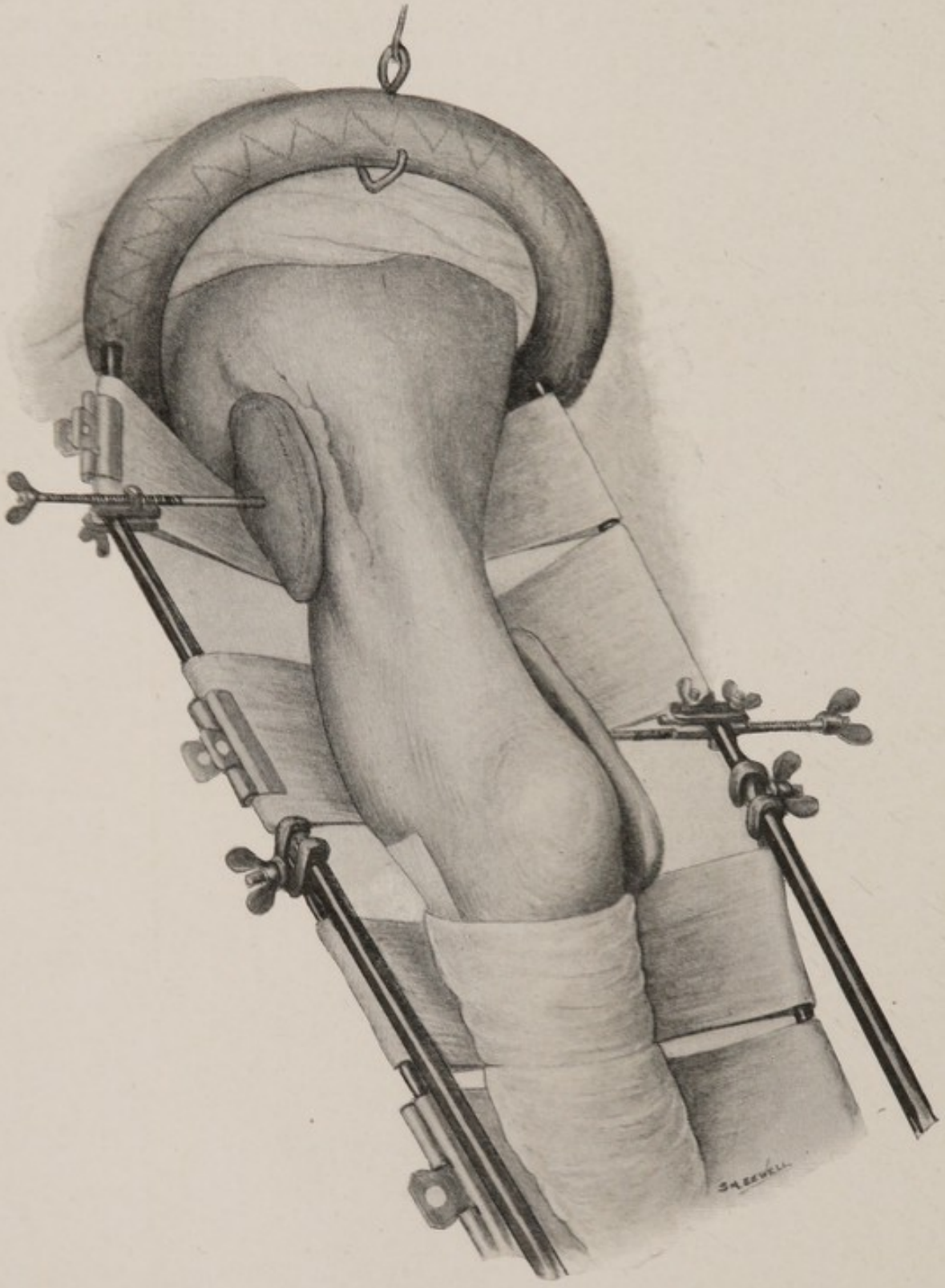


FIG. 31.—Screw pressure pads, applied as for correction of outward bowing.

FIG. 32*b*.—The same case after abduction of the limb. Large gap owing to drawing in of lower fragment by adductors.

FIG. 32*a*.—Upper-third fracture before abduction of limb.

When apposition is attained, it is maintained by leaving the pads in position, for weeks if necessary, until union has taken place.

The external rotation of the upper fragment in high-up fractures is another point much argued about. It is a difficult thing to estimate. except by radiography. Direct measurement is very unsatisfactory. The ultimate test is the position of the foot after union has occurred, and it is undoubtedly true that the in-toed deformity has been very common, indicating outward rotation of the upper fragment insufficiently allowed for before union. Great stress has therefore been laid upon the necessity for rotating the limb well outwards in these high fractures. By bending the knee a very accurate and powerful means of rotating the lower fragment is provided, but reference to Fig. 34 will show at a glance that when a Thomas splint is used and the ring suspended as here advocated, the external rotation of the upper fragment is to a great extent prevented. The ring of the "Thomas" pressing on the posterior surface of the upper fragment acts as an internal rotator. So that when the ring is properly suspended, as we advocate in all cases, outward rotation of the leg and foot to any great extent is not necessary.

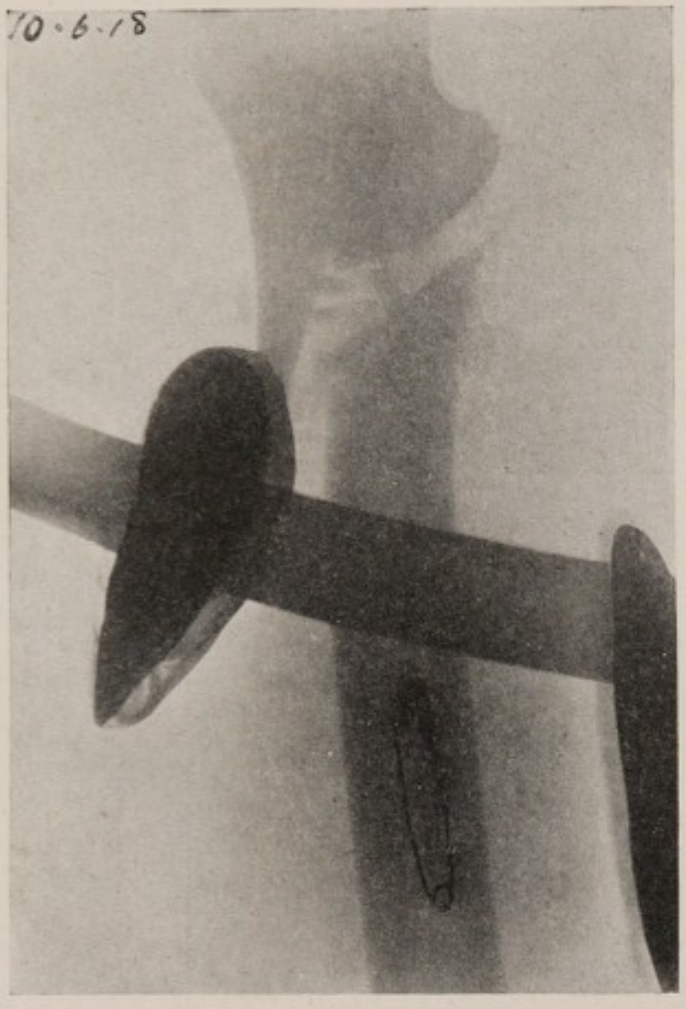


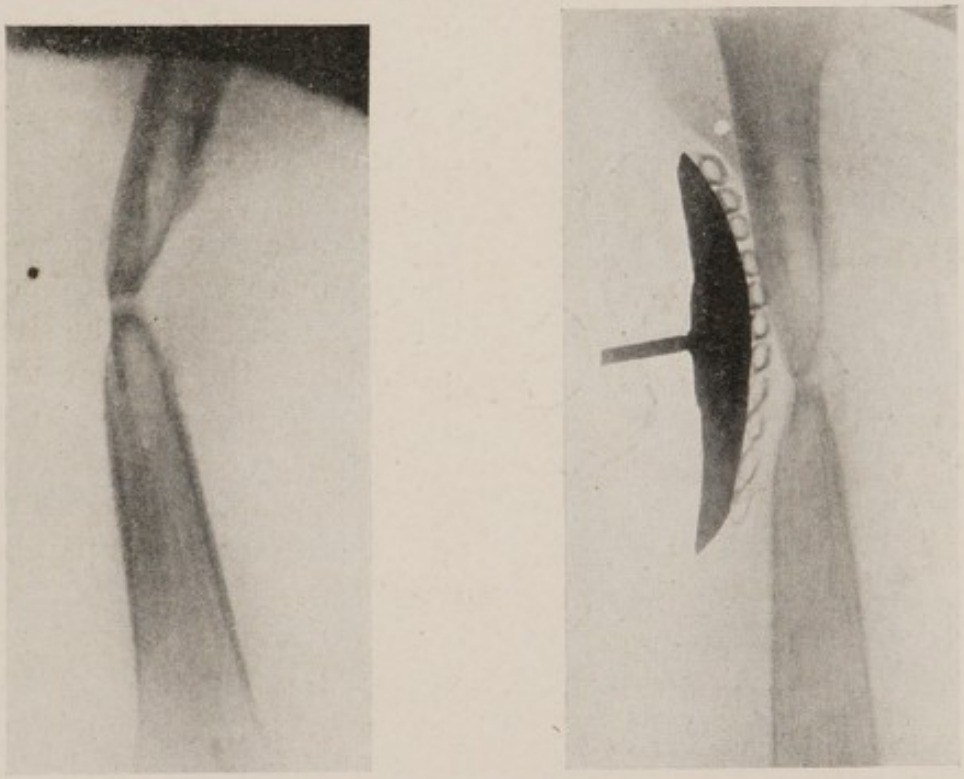
FIG. 32c.—Same case after application of two screw pressure pads to approximate the surfaces. Good union occurred.

Flexion or cocking forward of the upper fragment by the ilio-psoas is often very marked; it is essential that the leg and lower fragment of the femur be elevated so as to bring the lower fragment into line with the upper; to attempt to treat these cases with the leg properly abducted, but lying flat on the bed or nearly so, is to court trouble. It is frequently done, and the result is thoroughly bad. A very considerable degree of elevation of the leg must be used.

Existing deformity as related to the upper fragment is inseparably dependent on the action of the glutei, ilio-psoas, adductor brevis, etc.

There is propounded a statement that, given complete immobilisation of the fracture, these deforming muscles will relax and deformity subside. While this is an excellent theory and has evidence in its favour in certain cases, we have had repeated experience of the fact that in spite of control of the fracture by splints, extension, etc., deformity, as concerned with the upper fragment, persists.

It must be realised that in early cases no movement of the lower fragment is going to affect the flexed position of the upper fragment.



(*a*) (*b*)

FIG. 33.—(*a*) An outwardly bowing fracture with imperfect union.
(*b*) The same case after application of pressure pad.

In later cases after soft callus has developed between the fragments a pull or leverage exercised through the lower fragment can be used to effect a change in position of the upper fragment.

The question is, How to counteract deforming influences in early cases? We conclude that this can be done by treating the patient in the semi-sitting position and that the well-known treatment of elderly patients in this position had more in it than the avoidance of hypostatic pneumonia.

In this position the ilio-psoas will be relaxed and the cause of the tilting of the upper fragment neutralised. The leg will still require

abduction or adduction according to the kind of lateral deformity persisting.

The suggestion is put forward tentatively. We have had no practical demonstration as yet of its efficacy, but propose to try it and would be glad to know of the results of other workers using the same device.

As a practical device, it must be modified by the ability of the patient to maintain the position and his immunity from pressure sores, etc. It will be realised at once that if it does result in a relaxation of the ilio-psoas and a correction of deformity, and if it can be maintained even for six weeks until callus forms between the fragments, then we have a means of controlling the upper fragment through the lower fragment and can therefore allow the patient gradually to resume the prone position, watching for any recurrence of deformity during the process.

FIG. 34.—Diagram to show how suspension of the ring prevents external rotation of the upper fragment.

Upper-third fractures (other than the intra-capsular variety in old people) unite well, but bending is very apt to occur at the site of the union when the patient begins to get about and put weight on the limb, or even before that, when the abducted limb, although still in its splint, is first brought parallel with its fellow. In these cases particularly, walking callipers must be persisted in long after the patient gets up.

Abduction should be reduced gradually. During the process the site of fracture should be frequently X-rayed so as to detect any occurrence of deformity.

Middle-Third Fractures.—The commonest displacement is a *backward sagging*, the result of gravity. With proper care, this should never happen. A "sagging" femur is a reproach to the surgeon, none the less because it occurs so gradually that it often goes unnoticed.

In the method of splinting advocated (page 28), three bandage slings support the thigh between the knee and the ring of the splint. The middle one is of greatest importance. By keeping it sufficiently tight, the natural forward arch of the femur is maintained. It must be so arranged that it does not block the drainage opening which may exist at the back of the thigh. Damage is generally done during dressing if more than one sling is let down at a time for dressing purposes. In

the rare cases when it is necessary to loosen more than one, a temporary support of thin aluminium tape should be applied alongside the slings and before they are loosened.

The ordinary sling support must be efficiently adjusted after dressing. There is no need for wooden or metal back splints, the removal of which is difficult without unduly disturbing the fracture.

Lateral bowing, especially outwards, occurs in the late stages when traction has been lessened in the belief that there is firm union. Screw pressure pads attached to the side bar of the splint are invaluable in restoring proper alignment. In most cases they should be used in pairs. See Fig. 31.

The other common deformity is *shortening*, which can be got rid of by calliper and weight extension in all early cases and can be reduced even in comparatively late cases. The relaxation of the hamstrings attained by flexion of the knee is an invaluable asset in assisting reduction.

Lower-Third Fractures.—The special difficulties in treatment of these, due to their proximity to the knee-joint, to the large amount of cancellous tissue in the neighbourhood, and to the brittleness and small reparative power of the popliteal surface, have been already dealt with. In these cases above all others calliper traction is valuable. The proximity of the wound, even a septic one, is no contra-indication to its use. We have, in fact, applied callipers *through* a large open wound over the inner condyle without exciting complications of any sort.

Callipers are applied in the usual position above the condyles. The usual backward displacement of the lower fragment is corrected partly by flexion of the knee and partly by pressure of the sling behind it. The knee is flexed so that the gastrocnemius is relaxed in order to mitigate the tendency to backward tilting of the lower fragment. Outward rotation of the lower fragment is prevented by proper position of the "flexed" leg, which is maintained by slinging the foot in the vertical position. The pull of the callipers in the straight line of the femur draws the lower fragment down into position and, the calliper points being on diametrically opposite sides of the bone, this straight pull usually corrects lateral tilting. Should this last deformity prove obdurate there are two devices for dealing with it.

Either—

(1) Take the cord from the callipers round a lateral pivot on the splint and thus produce a lateral levering of the lower fragment;

or

(2) Attach the knee flexion splint obliquely—higher on one side than on the other, and direct the pull on the callipers in the line of the flexion piece.

The deformity having been overcome, the knee flexion splint can be adjusted to a nicety in order to maintain correction, attention of course always being paid to posterior slings.

The quadriceps tendon, made taut by flexion of the knee and the pull of the weights, acts as a splint on the front of the fracture. Tilting forward of the lower fragment does not occur unless the callipers are applied far forward.

Effusion into the knee-joint must be got rid of before applying callipers, otherwise landmarks are obscured and the synovial pouches may be so distended that the lateral safe areas are encroached upon.

When confronted with the problem of T-fracture into the joint we are guided by the state of the wound and of the joint. If the wound is clean and the joint not infected it is good practice to apply callipers. Their lateral pressure jams the fragments together and helps to seal off the joint from the wound. In short, success is dependent on the possibility of sealing off the joint from the wound before infection can spread from the latter. It might be a justifiable procedure to adopt even when the situation shows a healthy joint with a septic wound of the shaft.

Movement of the knee in the early stages of all lower third fractures should be very limited. When callus has formed and union has begun, gradual extension of the range of movement should be made by the surgeon himself, as there will always be some risk of re-fracture. A band tied across the front, between the bars of the splint, will limit forward tilting of the lower fragment as the knee is flexed further and will diminish danger of re-fracture.

Simple Fractures are treated by exactly the same methods of splinting and traction as compound. They require greater weights to pull them out to the full length, probably because the muscles are less injured. But provided that a portable X-ray apparatus is available, correct apposition is obtainable almost with certainty, and when secured is easily maintained.

CHAPTER VII

NURSING AND GENERAL MANAGEMENT

Success in the management of all fractures, and especially in femur cases, depends on the amount of care bestowed on them. No method will give uniformly good results except by constant attention to the details of its management. No method allows the surgeon to dispense with close personal attention, which must be very frequent in the early stages. The nurse's part is of the utmost value, so is that of the masseuse, but unless the surgeon knows the difficulties of both and keeps a constant eye on endless details of their work, as well as on the position and mobility of the limb, on apparatus, radiography, the condition of the wound, and the possible need for operations, his ultimate results will be poor; indeed, disasters may occur, and in any case the patient will suffer much unnecessary discomfort.

Duties of the Surgeon.—In the first place, the surgeon should remember, and compel others to remember, the importance of delicacy of touch and movement. Rough handling during dressings is a crime. Bumping against beds is clumsiness excusable only in the untrained.

The actual control of the fracture will entail a considerable amount of work on the part of the surgeon.

By inspection, palpation, radiography and measurement he will get complete information as to his success or otherwise in correcting the disability or deformity.

He will find that in many cases he has to make alterations in the position into which the limb was originally put. In most cases he will have to make daily minor adjustments at first.

These adjustments consist of increase or decrease of abduction or adduction, more or less flexion of joints, tightening of posterior slings, progressive use of pressure pads, attention to cord and pulley, etc.

Above all, it is his special duty to carry out the daily movements of the knee-joint. It is our practice to begin this on the earliest possible day after the injury, *i.e.*, immediately the patient is fitted with his permanent splint, knee-flexion attachment, and calliper extension. In

our earliest cases, we began by moving the knee through a considerable angle once in the day: the result was a rise of temperature. We then adopted the plan which we have since adhered to. Assuming that the case is a recent one, we begin by lowering the foot an inch or two a day until the heel reaches the bed, by which time the knee will have been flexed through, say, 40°. This may take a week. We then work upwards an inch or two a day until the upper limit is reached, after which wide movements can be carried through every day. The process is quite painless, but it must be done gently, slowly, and with discrimination, watching the patient's face for signs of pain and telling him beforehand what is going to be done. If manipulations are done suddenly, if the patient is in fear of some unexpected action, his muscles will be taut, movement will be limited, and the results of examination will be misleading.

These movements should not be delegated to others, and must be done regularly and adequately. If the knee is left unmoved for a week at a time some mobility will be lost and will have to be regained gradually. Later, when traction-callipers have been discarded and some union has occurred, the movement of the leg can be relegated to the patient. A cord from the foot of the leg-piece, passed upwards, over a pulley and along to the patient's hand enables him to flex and extend the knee himself, and he amuses himself by doing so (see Fig. 38).

Movements of the ankle and toes must be attended to also; with the foot suspended as shown in Fig. 15 there is no impediment to voluntary movement and no loss of mobility during treatment; the patient can move ankle and toes freely and must be instructed to do so. The hip rarely gives trouble except when the fracture is very high up with much callus formation or directly involving the joint; a considerable degree of limitation of movement is compatible with comfort and agility owing to compensatory increased range of movement in the lumbar and lumbo-sacral joints, just as an arm may be functionally useful in spite of even an ankylosed shoulder if the scapula has a free range of movement on the chest.

The surgeons need not carry out movements at the hip joint; the patient will do that himself by sitting up and lying down, and by moving about in the bed; he will regulate the extent of these movements by his own sensations, which are a very safe guide.

Radiography and Measurement.—Radiography rightly claims a larger share in the recently improved final results of femur treatment than any other factor. It should be very freely used, not only in exactly diagnosing the original condition, but afterwards, as a routine measure, at frequent intervals. Without this one cannot get accurate information or hope for accurate results. A portable

apparatus worked by accumulators or from the main electric supply is essential. To carry the patient from his bed to the X-ray room probably does more harm than good. With the bed described above, radiography is very easy. The movable section of the bed being let down, the tube is placed underneath, and the plate above, the thigh. We make use of stereoscopic postero-anterior exposures, rarely of laterals. Where large numbers are being dealt with, it is not sufficient to keep a rack of exposed plates. Stereoscopic skiagrams should be taken and prints made, brought down to a convenient size by a reducing lantern and camera, and these prints should be hung at the bed-foot as a constant reminder of the deformity to be corrected. They should be repeated frequently, say an average of once in three weeks, to constitute a radiographic history of the case. An ordinary hand stereoscope completes the necessary outfit.

The process is simple and more rapid than it sounds. Two orderlies often radiograph twenty cases in a ward in one afternoon, and can have stereoscopic prints ready, reduced and mounted, in from twenty-four to forty-eight hours if required.

Measurement provides another indication of progress. Measurements should be made in as routine a manner as taking temperatures, and, like the latter, should be charted. In each of our wards one day of the week is appointed for the purpose, and on that day every femur is measured, and shortening or lengthening charted on a form similar to that shown in Fig. 35. If measurements are made with a sliding scale (Fig. 36) the margin of error is extremely small. There is no need to disturb dressings, nor does the curve of the thigh falsify the result. The upper point should press against the anterior superior spine and the lower on the upper margin of the patella. It is essential that both limbs be put into the same position before measuring, and that muscles should be relaxed.

Results of measurements are very interesting and sometimes surprising. The first case in which we used calliper extension was pulled out from 1½ inches of shortening at night to 1½ inches of lengthening next morning, the weight used being 20 lb.

Radiography and measuring must be done systematically and regularly, and be continued well into the late stages of convalescence, otherwise catastrophes may happen, *e.g.*, a bad displacement which has occurred may be discovered when it is too late to rectify it, except by operation. It is a great mistake to think that the position of fragments is secure as soon as union has occurred. It is just in the convalescent stages after splints are removed that bending of callus is apt to occur and to remain undetected.

Into the surgeon's sphere of action will crop up the minor operations

associated with the opening of abscess cavities, the removal of sequestra and in late stages the plating or grafting of ununited fractures and suture of divided nerves.

Duties of the Nurse.—Besides attending to ordinary nursing

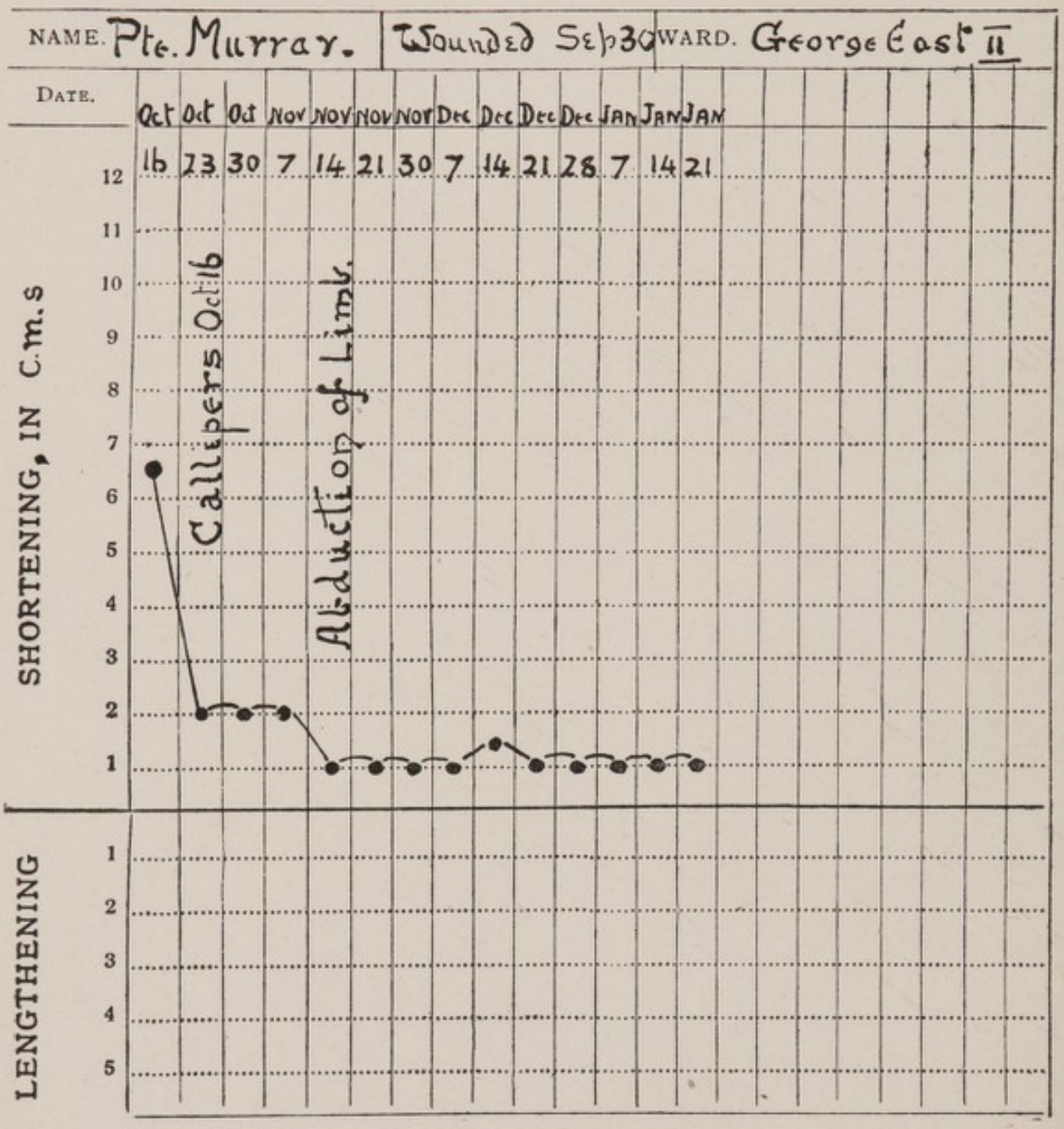


FIG. 35.—Chart indicating alteration in length.

duties, the nurse may be deputed to carry out the surgical dressings. These should be done in a routine, systematic manner.

The fracture bed is constructed so that a movable section under the wound may be let down, with the object of facilitating the dressing.

Before this section is let down, the nurse must see that the ring

of the Thomas splint is neither too far up the bed nor too far down. It should rest just on the lower edge of the upper "biscuit." If it is too far up the bed, the letting down of the section does not give free enough access to the thigh. If the ring is too low, then, directly the section is let down, the patient's buttock tends to sag into the opening.

Attention to the calliper points is the first portion of the dressing. As the puncture wounds are sterile, they should be attended to, under strict aseptic ritual, before other, possibly septic, wounds are dressed. It is sound practice to dress all calliper wounds in the ward first, then the clean thigh wounds, and finally the septic thigh wounds. Gauze

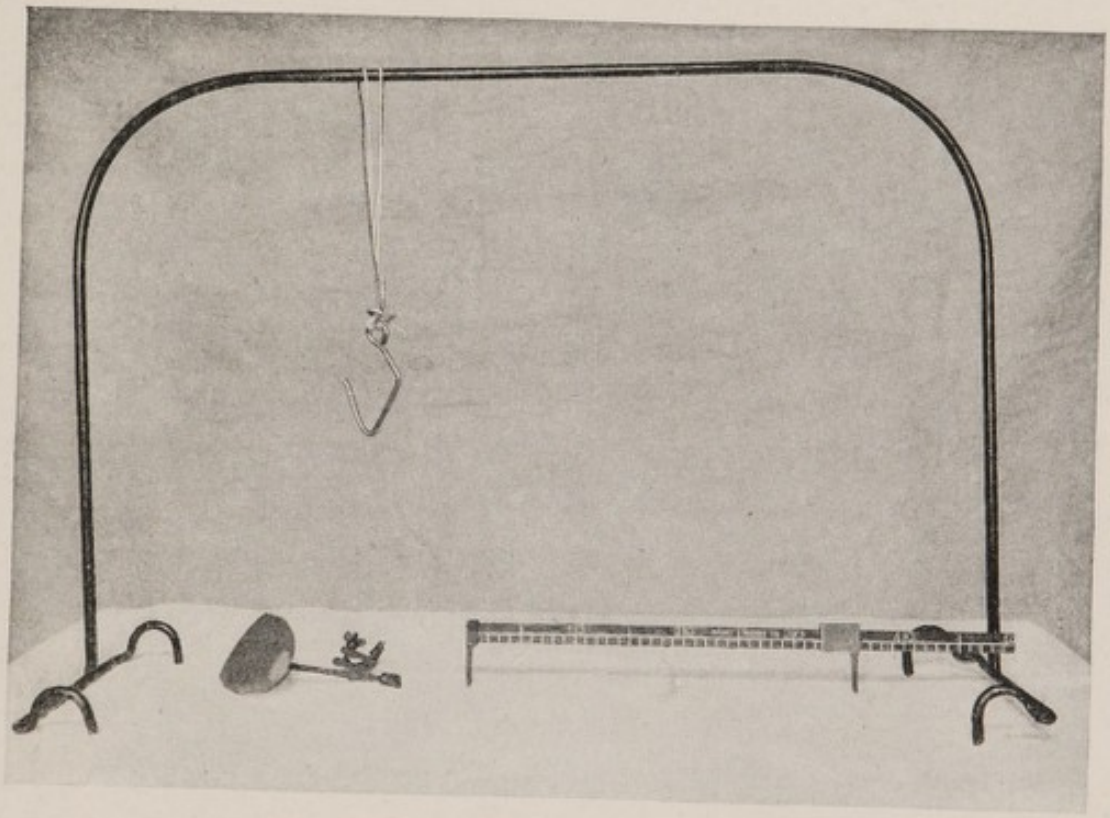


FIG. 36.—Arch, suspension cord and hook, screw pressure pad, and femur measure.

soaked in flavine in spirit solution (1 in 500) has been our usual dressing. It is applied round the points and changed every second day.

Should there be discharge round the points, a fairly common complication, a little of the solution, introduced through the needle of a hypodermic syringe along the side of the calliper point, will control the discharge and in most cases get rid of it after a few applications.

Repeated examinations of this discharge have invariably demonstrated its sterility. It contains merely polymorphonuclear leucocytes and fibrin.

During the dressings, continuous care must be exercised not to disturb

the fracture. The limb is usually supported in three flannel slings above and two below the knee. In the vast majority of cases it is possible to gain access to the wound, without permitting the fracture to sag, by letting down the sling under it. Having dressed the wound, the sling is readjusted. The other two can be released in turn to allow the adjacent skin to be attended to.

Gauze pad dressings measuring 3 inches by 9 inches are used, and are applied transversely. Spiral bandages or large longitudinally placed pads are not used because their removal without disturbing the fracture is difficult. For the same reason we rarely use metal or wood splints below the thigh. Where we do so they are applied *after* the flannel slings have been adjusted.

In the event of its being necessary to let down two or more slings at once, the following simple device may be used.

Two narrow strips of pliable aluminium "tape" are bent over the side bars of the splint and under the thigh, one above and one below the fracture, so as to support the limb. The bandage slings can then be removed without the fracture sagging. The narrow strips do not interfere with observation of and attention to the wound. This device is invaluable also when operating on the patient without taking off his splint or interfering with his extension apparatus.

The whole dressing should be completed without movement of the fracture, and should cause little or no pain to the patient.

Thereafter a prepared strip of calico boiled in soft soap should be passed between the ring and the skin, which are then soaped by a to and fro movement. The soap application diminishes the tendency to pressure sores and keeps the leather of the ring soft.

The back is then rubbed with spirit and the bed section is replaced.

When a bed-pan has to be used, the sectional canvas and mattress are let down. The sound leg is bent at the knee and the bed-pan is passed under and placed in position from that side. The canvas, without the sectional mattress, is then fastened up so that it supports the bed-pan in position.

There is no need to keep the patient flat on his back without pillows. As the acute stages of his illness pass off he will sit up more and more. Convalescence being in any case a long and tedious process, both surgeon and nurse should encourage the patient to cultivate mental and manual employments.

The Masseuse takes her orders from the surgeon. When traction callipers are used her duties must be exactly defined, *e.g.*, to massage the foot and leg up to the knee; the toes and ankle are to be freely moved, passively and actively. On no account is the knee to be moved.

In cases in which there are no wounds above the knee, general light massage to the thigh is permissible. Where wounds exist, massage without encroaching on lacerated tissues should be carried out as soon as acute inflammation has subsided. In all cases, and at all stages, except when acute infection is present, the patient should be encouraged to make contractions of his muscles, even though he does not move the limb. The masseuse should also induce graduated contractions of the muscles by means of the Bristow coil.

In late cases with fairly firm union, after removal of extension apparatus, the masseuse is given a freer hand. She may now move the knee within the limits of freedom, but no attempt to increase the range of movement by actual force is permitted. The methods of attaining a freer range will be described later.

A large part of the success of the whole method depends upon the efficiency of the masseuse. A very little time spent intelligently each day produces surprisingly good results in preventing atrophy. Five minutes a day will be valuable, but, if possible, at least twenty minutes a day should be given.

CHAPTER VIII

INTERMEDIATE AND LATE TREATMENT OF FRACTURED FEMURS

In cases of compound fracture, especially when there has been considerable comminution, operations, at a comparatively late stage in the treatment, are frequently necessary.

In secondary operations on fractures it is important to move the injured part of the bone as little as possible. For this reason the operation should be done, whenever possible, with the splint still *in situ*. Suitable arrangements must be made beforehand. For instance, by means of a cord over a pulley in the ceiling, the lower end of the splint can be elevated until the limb is vertical. This gives good exposure of the posterior surface of the thigh. It can be done without relaxing the pull of the callipers by temporarily making elastic traction through a piece of rubber tub ng running between the handles of the callipers and the lower end of the Thomas splint.

The side bars of the "Thomas" should be covered by a length of large rubber tubing split lengthwise and sterilised. A strip or strips of flexible aluminium, used as already described (page 68) will give all the support needed without unduly obstructing the operating field.

Sequestrectomy.—The indications for sequestrectomy need some discussion. There are some who say that no operations for removal of sequestra should be undertaken for at least six months after the original operation.

This involves a very unnecessary loss of time, because the presence of sequestra keeps up suppuration, and, in the presence of pus, healing is delayed and the callus that is formed is poor in quality.

Our practice has been to remove every sequestrum as soon as radiography shows its presence clearly, provided always that it can be removed without greatly damaging the newly-formed callus. Extensive chiselling operations involving shock and risk of refracture are not to be recommended at the intermediate stage, say within the first three months. They are dangerous and have a very considerable mortality; the newly formed callus and scar tissue ooze blood freely; it is difficult to prevent

this, and if the operation is at all prolonged the total loss of blood, though not really great, is more than can be stood by a man still suffering from the effects of a severe original injury followed by sepsis.

If we found the sequestrum so embedded that it could not be easily removed we have contented ourselves with providing adequate drainage, and waiting. At a later stage, when firm bony union has occurred, the buried sequestrum has become looser, and it is then possible to chisel a way for it without refracturing the bone. The patient is probably in a better state of health to stand the shock of the operation.

FIG. 37.—Cap-shaped sequestrum over the end of the upper fragment.

In the great majority of our own cases we have been able, after enlarging the wound in the soft parts, to "persuade" the sequestrum out of its bed without using force and without chiselling, and the wound has healed soundly. We have rarely had to chisel away one wall of a cavity or to ingraft muscle. But then we have not left our sequestra to become surrounded by hard bone; our sequestrectomies have for the most part been fairly early—within the first three months—and such cavities as we have left by removal of sequestra have had dependent drainage openings; these cavities fill up by growth either of new bone or of fibrous tissue.

Broca's operation is necessary in the large number of cases where sequestra have been overlooked so long that they have become surrounded by hard bone. For such cases a drastic and very thorough operation which lays the cavity widely open is the only possible course. Blind scraping of cavities and sinuses is futile in the extreme. But if radiography is freely used and efficiently interpreted in the early stages while callus is still soft, the need for extensive chiselling operations at any stage will be rare.

As a general rule it may be said that any old-standing wound that

discharges pus freely is a danger to life and requires operative interference. The fact that there are no constitutional symptoms, no pain, no temperature, proves nothing except that the pus is nowhere under pressure. Having free exit, less of its toxin is absorbed. These are deceptive and dangerous cases, especially when the pus overflows from a wound on the anterior surface of the limb. It is in such cases that unsuspected tracking of pus along the muscle-planes and vessel sheaths occurs, followed often by secondary hæmorrhage. Posterior (dependant) drainage almost eliminates secondary hæmorrhage by preventing this accumulation and tracking of pus.

Plating.—For the reasons mentioned previously this operation has no place in the early treatment of compound fractures, but may prove useful in dealing with ununited fractures.

Before using this device all septic wounds should have been healed for at east six months. There should be total absence of œdema of the tissues, and finally the end to be attained must justify the means. For instance, it is doubtful whether union with 4 to 5 inches of shortening is worth obtaining. In such a case bone-grafting or even amputation might lead to better capacity for walking. The technique is more difficult in late than in early plating. The bone is often porous and soft and screws will not grip. In such cases an exceptionally long plate must be used, or a pair of plates with bolts traversing the bone.

The results have been disappointing. In spite of the greatest care many of the cases suffer a recrudescence of the previous septic process, and all the work may thus be nullified.

Bone-Grafting.—The same remarks apply to this as to plating. A great deal of the success depends on the complete immobilisation of the fracture and graft. Scar tissue in the neighbourhood of the proposed grafting operation should be excised as a preliminary and separate procedure.

A graft is not intended to fix the fracture, but must be treated as part of the fracture and the whole must be immobilised by extrinsic apparatus.

The graft must be long enough to reach into healthy vascular bone at each end, well beyond the sclerosed or porosed ends of the fragments.

Nerve Suture.—During early treatment of a case in which the sciatic or external popliteal nerve is involved the greatest care must be taken to prevent foot drop and trophic sores on the foot, and also to maintain free mobility of the knee-joint. If the knee becomes fixed in extension, suture of the nerve at a later stage, when a part of it has to be removed, may be very difficult or impossible.

Mobilisation of Adherent Muscles.—This is deserving of mention. Very often, especially after a septic process, the muscles become adherent to each other and to the bone either directly, or, more often, through the intermediary of a thick scar. Considerable stiffness and disability may be caused. Early active movements (p. 69) may prevent these in large measure. Later on one may excise the scar down to the bone, suture the wound, and institute early movements during healing.

Management of the Limb after Union has Occurred.—We have now to consider the routine late management of a case. When there are signs of fairly firm union the traction callipers may be dispensed with. One cannot dogmatise as to when this will be, but in the average case it is about eight to ten weeks.

It was our practice at one time, when apparently firm union had occurred, to take the limb out of the splint and begin flexion of the knee over a pillow. This proved to be a mistake. The extra latitude permitted to the patient by the removal of the splint, while apparently desirable, actually contributed to the defeat of the end in view.

The pillow needed repeated adjustment. If the patient found the position irksome he slid the pillow down to support the calf or turned his leg on the side. It was found thereafter that in some cases the unsupported thigh sagged backwards or bowed outwards at the seat of fracture and the work of months was marred and to a certain extent nullified.

The method was rough, incapable of accurate control, inefficient and altogether unscientific.

The present method has been found to satisfy all the requirements.

On removal of the callipers we find that the knee has usually an effective range of movement of 30° to 40°. This can be increased to 90° in a simple way.

"Anti-Aircraft" Position.—The rigid Thomas splint is cocked up like an anti-aircraft gun (as shown in Fig. 38). This allows a greater range of movement to the flexion piece, and the range can be increased from time to time by advancing the upward tilt. In this way, a movement through an angle of 90° can be attained in a week's to three weeks' time. It is an excellent device to tie a cord to the foot of the flexion piece, bring it up vertically, through a pulley, to the patient's hand. He can then move the knee himself. During this period the thigh is supported in its slings and any tendency to sagging thus prevented. Tendency to lateral bowing can be controlled at the same time by lateral bandages or screw pads if necessary. The graduated tilting of the splint has the added advantage of flexing the hip more and more and thus restoring its antero-posterior movement. In the new type of bed the overhead bar will support the splint adequately at any angle.

The next stage is the fitting of the patient with the modified Thomas knee splint, also called the walking calliper.

Indications that the Walking Calliper may be used with advantage.—The wounds should be healed, or nearly so, and

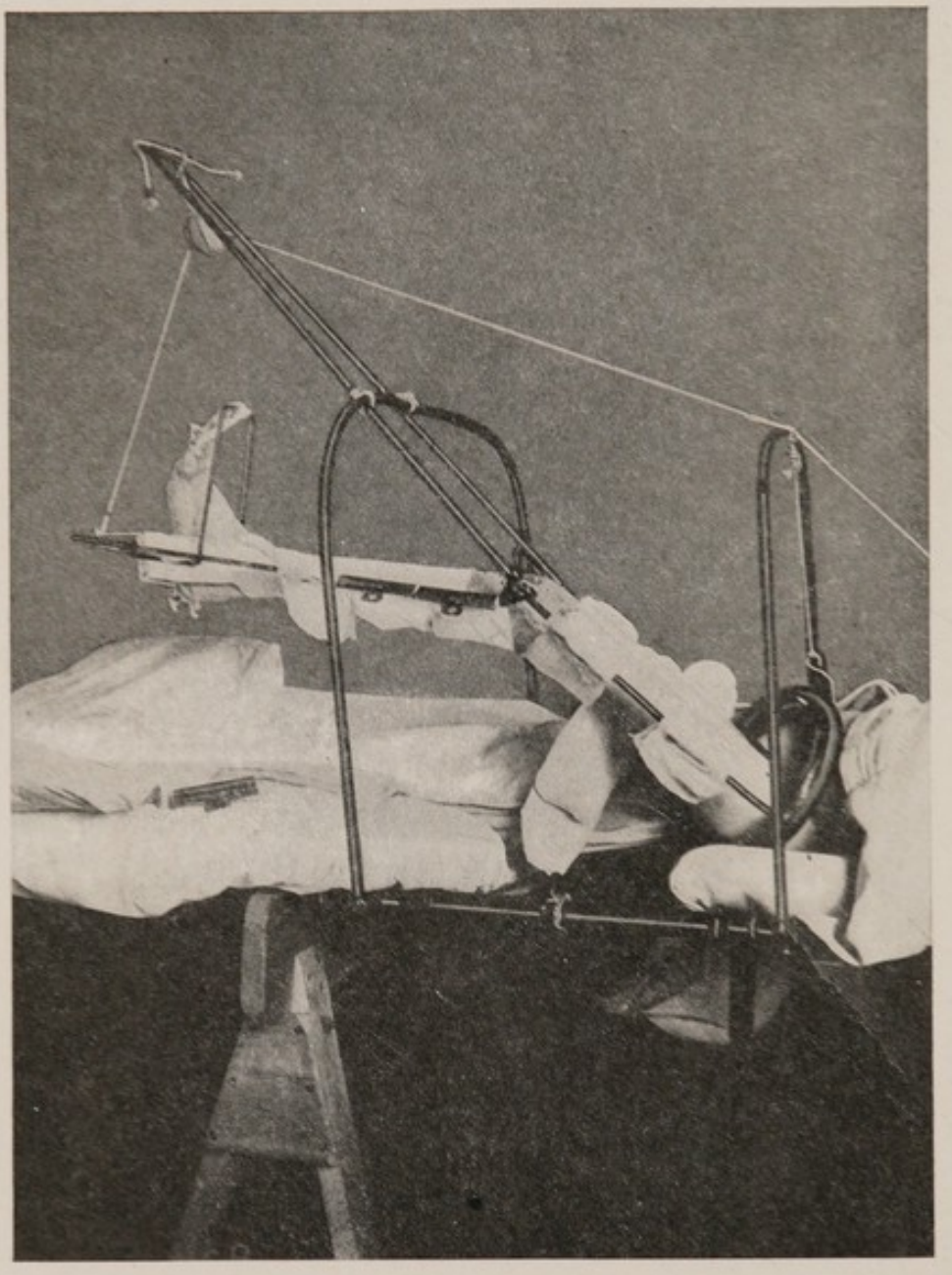


FIG. 38.—"Anti-aircraft" position, enabling the patient to move his own knee through an increased angle.

the union of the fracture firm; attempts at lateral bending guide as to the firmness of the union. During the week or more after extension was discontinued and the knee was being moved through the wide angle, there should have been no tendency to shortening or bowing. The

callus should be plentiful and not tender to pressure. And, lastly, in a recent radiogram the position of the fragments and the amount, distribution, and, most important of all, the density and homogeneity of the callus must be noted. Callus that is honeycombed and irregular, no matter how profuse, will not stand strain like that which is homogeneous in its consistency. Honeycombed callus is usually associated with prolonged sepsis and not infrequently with the presence of buried sequestra.

The presence of a sinus is no bar to the use of a calliper walking splint, but profuse flow of pus is.

Walking Calliper Splint.—The walking calliper splint is a modified Thomas knee splint, used after union has occurred. It enables the convalescent patient to walk considerable distances in fair comfort without putting any strain on the young callus. It consists of a leather-padded ring fitting accurately round the thigh below the tuberosity of the ischium; when the patient is in a vertical position the pelvis on his injured side is practically sitting on this ring. Through it his body-weight is transmitted by the two side bars of the splint to the boot and so to the ground.

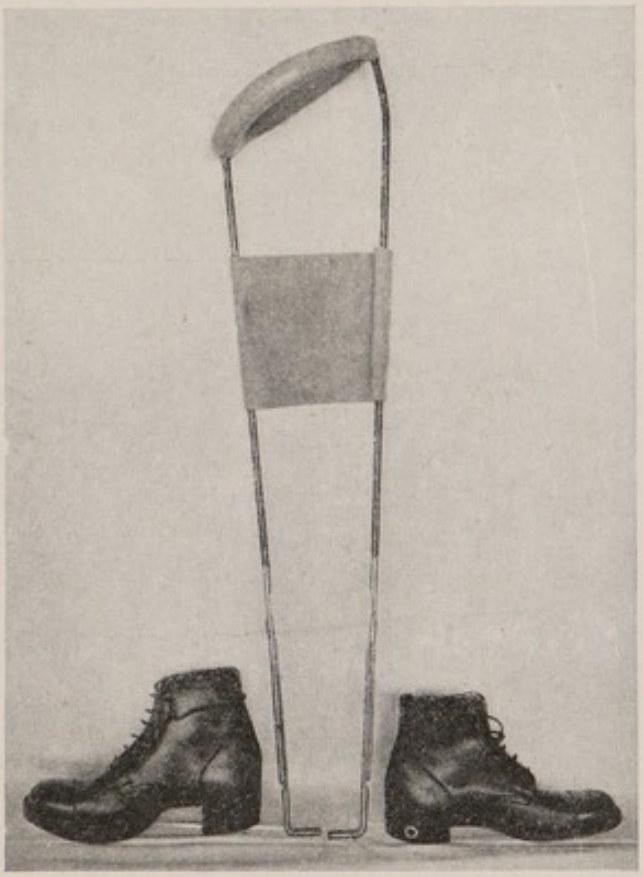


FIG. 39.—Thomas walking calliper and boots.

The heel of the boot is tunnelled obliquely by a metal-lined hole across it, the outer aperture being somewhat further forward than the inner.

The lower ends of the side bars of the splint are turned in and fit into this tunnel and are kept there by the leather support and webbing bands or bandages which surround both splint and leg above and below the knee.

It is essential that the side bars be of exactly the right length, so that when the patient's buttock is resting on the ring of the splint his foot shall fail to reach the heel of his boot. When the patient is standing with his boot on, the lower ends of the side bars in their proper position

turned into the heel of the boot, and his weight resting on the splint, there should still be a clear space of half to three-quarters of an inch between his foot and the heel of the boot. With the laces undone, it is easy to test this by sliding the hand inside the boot and under the patient's heel, there should be a good finger's breadth of free space intervening. There is therefore no weight upon the leg, which indeed simply hangs in the splint, the laced boot keeping up a mild form of extension. After a few days the patient's heel sometimes comes down into contact with the boot and the side bars of the splint then require lengthening. To facilitate this and also to avoid the necessity for making each splint to measure, a form of calliper walking splint is now made with the lower 8 inches of each side bar (including the turned in ends) sliding and adjustable to any desired length.

For hospital purposes a stock of such splints with different sized rings varying from 16 inches to 23 inches circumference (measured inside the leather padding) meets all needs. For private patients where such a stock of splints is not available for trying-on, the following measurements should be supplied to the splint-maker :—

(1) Horizontal circumference of thigh just below tuber ischii.

(2) Oblique circumference of thigh from tuber ischii at the inner side to midway between the crest of the ilium and the tip of the great trochanter on the outer side.

The difference between these two measurements is usually from 2 to $2\frac{1}{2}$ inches.

(3) From tuber ischii to sole of patient's heel.

The boot should be a light and comfortable one.

The patient should wear this splint during the day, and in cases of doubtful strength during the night also, and always with the boot on.

In cases where union is very strong, and where sepsis has not been severe, as in some of the spiral and long oblique fractures, it may be permitted to omit the walking calliper stage altogether and to begin to walk at once with crutches, followed as soon as possible by sticks. The crutch habit is difficult to get rid of, and is to be discouraged from the beginning.

With the walking calliper splint applied, a patient generally requires crutches for the first two days only, then sticks, and in a very few days should walk without either.

Many patients can safely discard the walking calliper after a month ; one must judge of this by the X-ray appearance of the fracture. When there has been much destruction of bone, leaving a gap bridged by callus, and especially in upper third fractures of the femur, great care is necessary ; in these cases three months in walking callipers should be the minimum.

Late bending of the callus is a common occurrence, especially in cases where sepsis has been severe.

In every case the patient should be kept under very careful observation for the fortnight after he begins to walk without splints; here, as before, measurement and radiography must be the tests. With all possible care re-fractures will occur in a certain small proportion of cases; fortunately, union occurs again rapidly if there is no sequestrum or sinus preventing it.

As soon as the patient is free from splints he should begin a course of graduated gymnastic exercises to restore strength to his weak muscles; even while he still uses the walking splint the limb should be well exercised night and morning, both actively and passively.

Non-Union.—Non-union is rarer in the femur than in the humerus; even in war wounds, often with destruction of much bone, the percentage is not more than 2 or 3, and will probably be much less when all measures to secure union have been tried.

In simple fractures operation may be advisable as a primary measure, and otherwise is justifiable if within six weeks there is no sign of union or of callus formation. This will rarely be the case if the surgeon has set himself a high standard of accuracy in adjusting the fragments and has made adequate use of radiography and modern splinting methods. Failing union, it will often be enough if the ends of the bone are rubbed together and forced in apposition under an anæsthetic. If this fails the fracture should be cut down upon and examined, intervening muscle, if any, removed, and the ends fixed in apposition by bone-graft, plate or wire.

In extensive compound fractures with much bone destruction and a long gap it is our practice, as already stated, to maintain that gap on the supposition that it probably contains sufficient *débris* of bony elements to reconstruct the destroyed portion of the shaft. However slender the reconstructed part may be, it will eventually thicken in accordance with Wolff's law and will solidify until adequate to bear its full burden.

But supposing destruction is so complete that the gap is not refilled—what then? If the gap is anything under 5 cm. we would, after waiting, bring the ends of the bone together. In such cases, and in other cases where, without any gap, union is delayed, intermittent congestion treatment by rubber bands is worth trying; also letting the patient get up and about in a Thomas walking splint, putting a little pressure on the fracture at each step; finally rubbing the ends together under an anæsthetic. Failing all these measures, then bone-grafting should be considered, but not until all wounds have been closed for three to six months, depending on the persistence of the sepsis during healing.

CHAPTER IX

RESULTS

It is yet too early to give the end results of the treatment of fractured femurs during the later stages of the war. That the mortality and amputation rate have decreased enormously is obvious; that the functional results will be infinitely better than seemed possible even two years ago is certain. An examination of end results twelve months after the war should give invaluable information, not only as to the respective value of different methods, but also as to the whole policy of the treatment of fractures. For if any large part of the improved results is due to the concentration of femur cases into certain hospitals or wards, then the whole policy of our civil general hospitals as regards all fractures will need reconsideration.

Meanwhile, it may be useful to record some general impressions culled by one of us during visits to fifteen special femur hospitals and some auxiliary hospitals in England after the cessation of hostilities, bearing in mind that in many of these hospitals there were no special appliances for dealing with fractures and no portable X-ray appliances; fractured femurs had been rushed across more quickly than appliances could be supplied. Surgeons were overworked.

Shortening was very variable; in some hospitals there was practically none, in others there were few patients with less than an inch; there were some cases with 5 inches. In general, it was greatest among patients who had had merely adhesive extensions applied below the knee and tied over the end of the Thomas splint. This does not imply that the method is intrinsically bad, but simply that as ordinarily carried out it is insufficient, a conclusion explained and confirmed by inspection of many of the wards where it was used. The so-called extensions were rarely tight.

Weight and pulley, or body-weight extension with tilted bed gave few cases of considerable shortening.

Lateral mobility of the knee-joint, and hyper-extension of the knee (genu recurvatum) were common in cases which

had been treated by traction applied below the knee and with a straight leg. Both of these are serious disabilities.

In several cases there was marked antero-posterior mobility of the tibia on the femur due to stretching of the crucial ligaments, causing a feeling of insecurity in walking and a slipping forward of the body and thigh at each footstep on the injured side. Major Alwyn Smith, D.S.O., is of opinion that excessive and long continued traction below the knee first causes stretching of the lateral ligaments. This disappears in time if tension is released. If, however, the traction is continued the crucials also are stretched, and it is doubtful whether these recover without operative aid. It is a very serious disability and one which can be avoided altogether by applying traction *above* the knee in every case.

Stiffness of the knee and to a less extent of the ankle were usual, in varying degree. Many cases which then had only a few degrees of movement may acquire more later on. Many other knees were so absolutely immobile, even though the injury itself had been far from the joint, that it is difficult to believe there will be functional recovery. We are very definitely of opinion that movement of the joints from the first day of the injury prevents this immobility, even where there has been great destruction of muscle-tissue, and that it should be adopted as a routine procedure in all cases. Even where the quadriceps is so lacerated that there must inevitably be a mass of scar-tissue on the front of the thigh, it is better that that scar should be long enough to permit flexion of the knee than that it should keep the limb fixed in extension. There is always enough of the quadriceps left to extend the knee ; and if not sufficiently powerfully, then the hamstrings can eventually be transplanted on to the patella.

When, if ever, a final investigation of end results of war fractures of the femur is made, the commonest and most serious disability will, we feel sure, be limitation of movement of the knee. Inability to flex is the most usual and most difficult to deal with. Incomplete extension is common if the patient has for long been on a splint with his knee flexed, but in our experience this is more readily got over than inability to flex. We saw many cases with practically no movement in the knee, and this not only when the fracture was near the knee-joint, nor where there was much laceration of muscles.

This stiffness can and should be prevented by early movement.

Backward sagging of the femur, especially in middle-third fractures, was a very common deformity. It is always avoidable. It is caused by want of support of the thigh. Care should be taken that when dressing is completed the sling under the middle of the thigh shall always

be tight so as to secure, not merely a straight thigh, but one definitely arched forwards.

Outward bowing was also very common and often of late origin, coming on gradually after splints had been dispensed with. Upper-third fractures are particularly apt to bend even a year or more after apparent union.

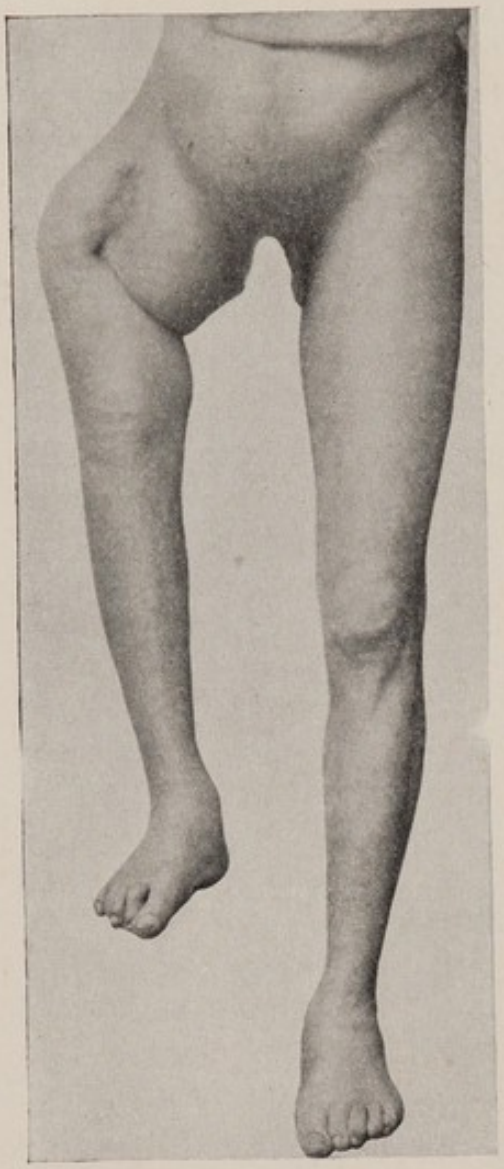


FIG. 40A.—Extreme angular deformity resulting from many changes of hospital and too early discarding of splints.

Fractures into the knee-joint, even where parts of the condyles had been shot away, gave results which were surprisingly good, often with little interference with the use of the joint.

"In-toed" deformity was less common than was expected.

Persisting sinuses into bone, with necrosis, were noticed in several cases where screws had been put into the tibia as a means of traction and in the condyles of the femur where callipers of the penetrating variety had been used, also in the malleoli and in the os calcis under similar conditions.

Extreme angular deformity, such as that shown in Fig. 40A, existed chiefly, but not entirely, in men who had been prisoners of war in Germany. Want of continuity of treatment, repeated removals from one hospital to another, too early removal of splints, and the use of unsuitable splints caused most of the anatomically bad results.

Statistics.—As regards our own results, it is also too early to give final statistics; some of the worst patients are still under treatment. Figures, therefore, can only give approximate results.

In France some of our patients reached us within a few hours of being wounded, some only after several weeks; during part of the time, which accounted for most of the fatal cases, we were acting as a Casualty Clearing Station. Out of a total of 250 admissions for fractured femur in 1918 the death-rate was 7·6 per cent.; amputations,

FIG. 40c.—Lateral X-ray of same case.

FIG. 40b.—Antero-posterior X-ray of same case.

6·8 per cent.; secondary hæmorrhages, 2 per cent. (of which about half were fatal).

At Edmonton cases arrived at a later stage, averaging thirty days after being wounded; this naturally reduced the death, amputation, and hæmorrhage rates, while, on the other hand, it militated against good functional results, for practically all had had their knee-joints totally immobilised up to the time of their admission. One had been twelve months immobilised.

In all early cases callipers and knee-flexion were begun at once here; in older cases with fair union, the existing glue, strapping, or screws-in-the-tibia extension was continued, but even in these cases knee-flexion was begun at once. The mobilising process has been very slow and difficult in the old cases, and some have only about 5° or 10° of movement now. The majority have very good movement; the following photographs show some of them. A considerable number are now walking well without a limp and without a splint, and have returned to duty in the Army or to their civil occupations.

Among these 271 cases at Edmonton in 1918 deaths were 1·3 per cent.; amputations, 0·4 per cent.; secondary hæmorrhages, 1·1 per cent., (one fatal result).

The final anatomical and functional results are difficult to ascertain, as patients are so frequently transferred to overseas units, or elsewhere, in their walking splints.

We have so far succeeded in tracing only sixty-eight cases to what may be considered their approximately final condition; that is to say, they are all patients who have discarded all splints for at least a month. Most of them have been demobilised, returned to duty, discharged by Medical Board from the Army, or sent to their own overseas units for dispersal.

In these approximately completed sixty-eight cases:—

Average period from wound to *final disposal*	29 weeks
Number *without any* shortening (of these five had lengthening averaging 1 cm.)	39
Number *with* shortening (amount averaging 1·5 cm.)	29

As regards mobility, the hip and ankle were in almost all cases normal. Mobility of the knee varied:—

Number having range of flexion over 90°	55
60° to 90°	10
30° to 60°	3
	68

Most of the cases shown in the following photographs had been completely immobilised for at least a month before knee-flexion was begun.

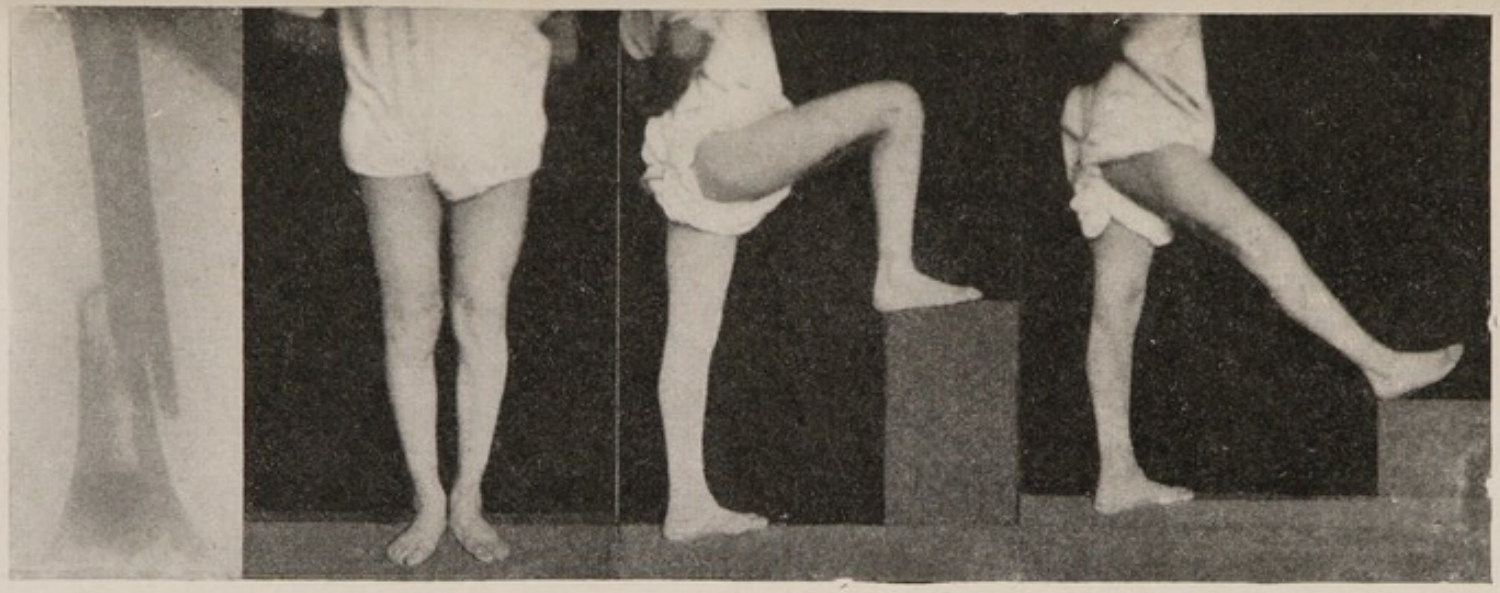


FIG. 41.—Lower-third fracture (right); radiograph taken on admission five weeks after being wounded; photographed four months after wound. Calliper extension. No shortening. Note flexibility and muscular condition. [Case E 140.]

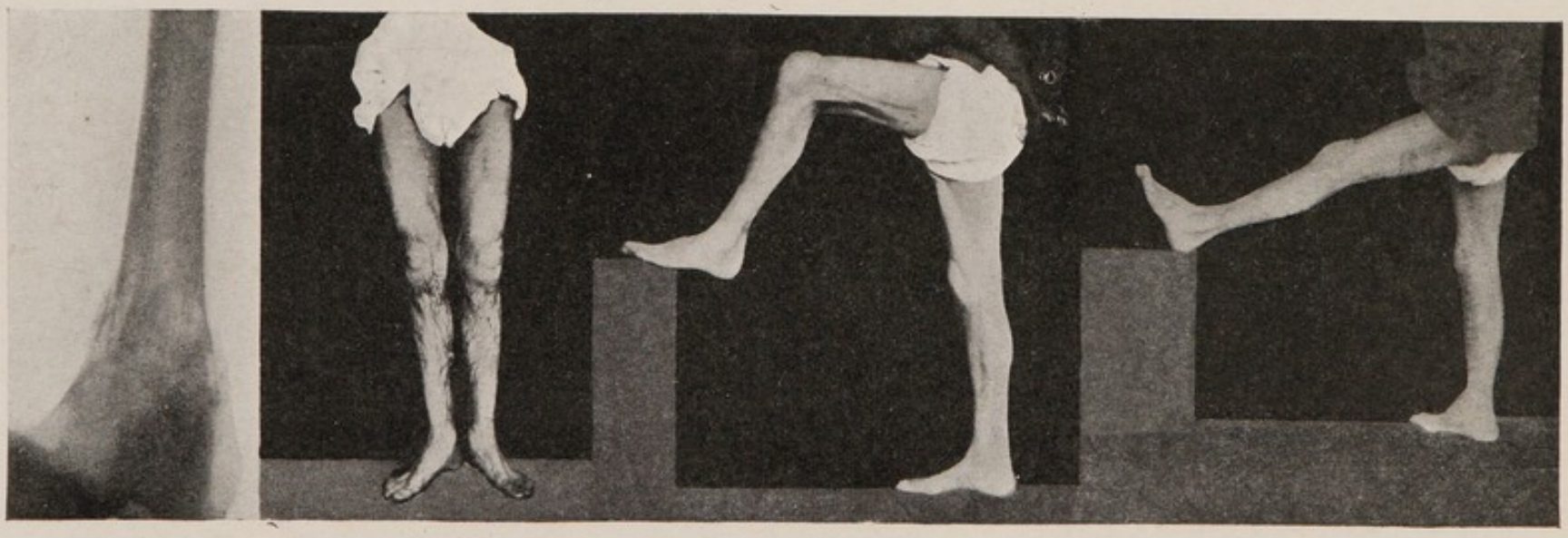


FIG. 42.—Lower-third fracture (left); seven months wounded. No shortening. [Case E 71.]

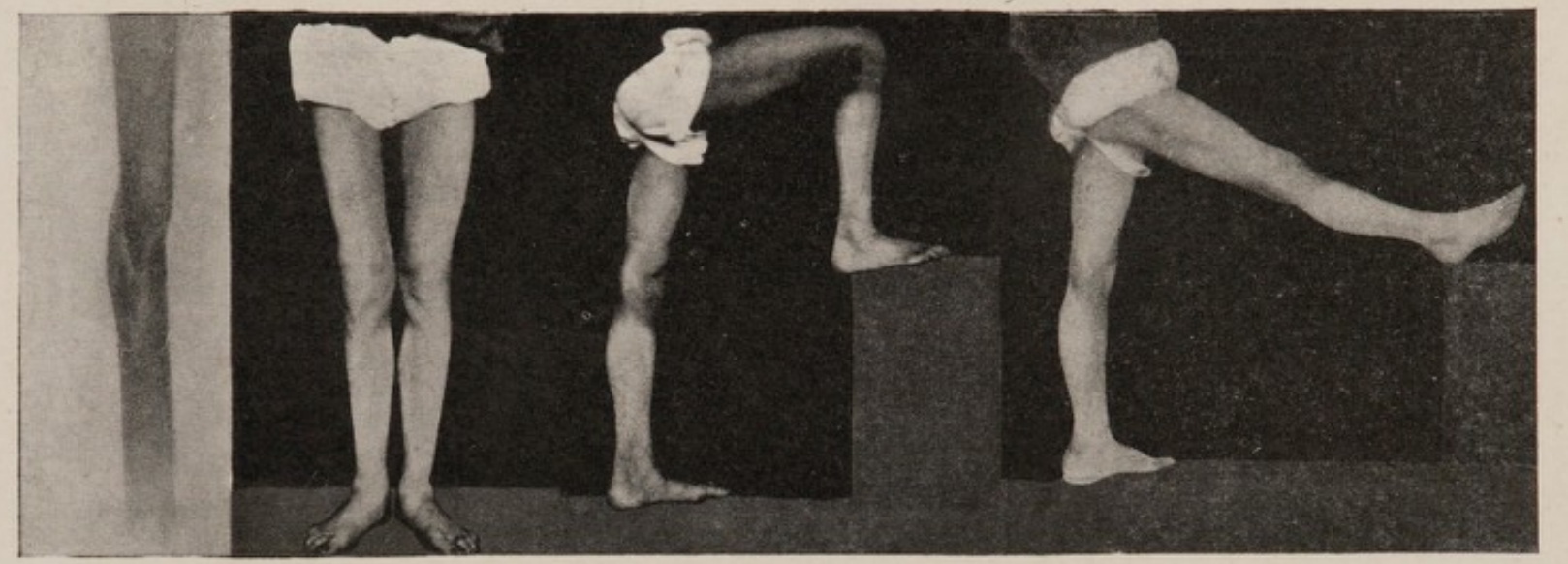


FIG. 43.—Middle-third fracture (right); 8½ months wounded. No shortening. Considerable lateral mobility of knee-joint: extension below the knee by screws in tibia. [Case E 56.]

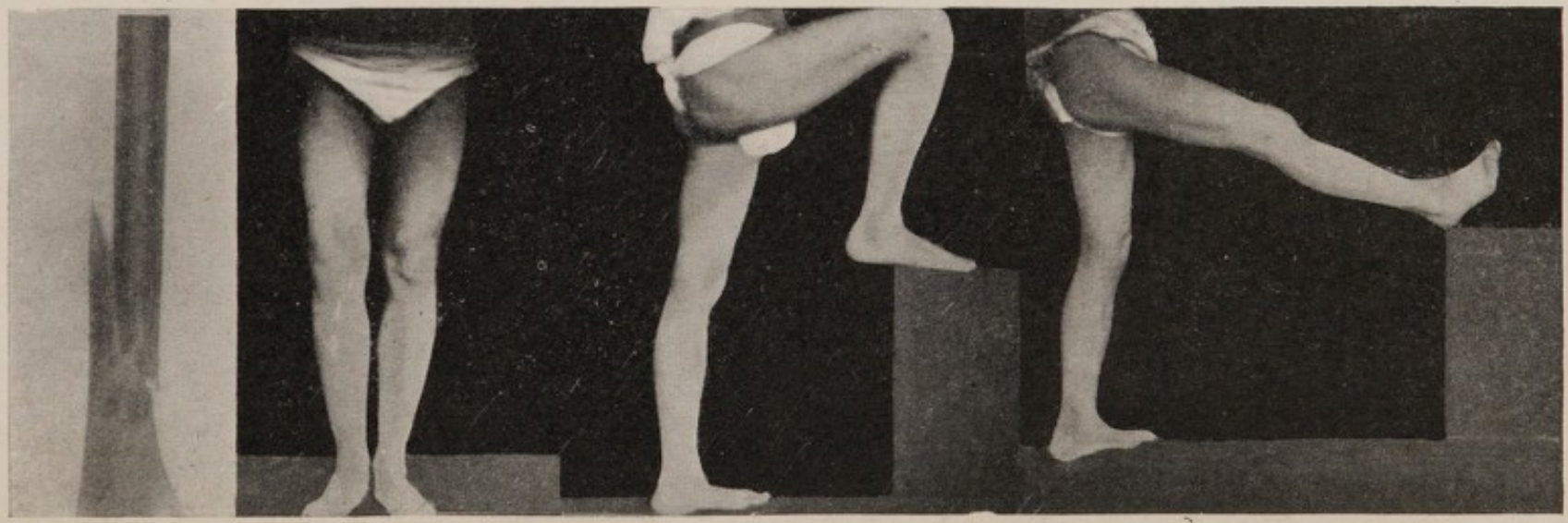


Fig. 44.—Lower-third fracture (right); 5½ months wounded. No shortening.

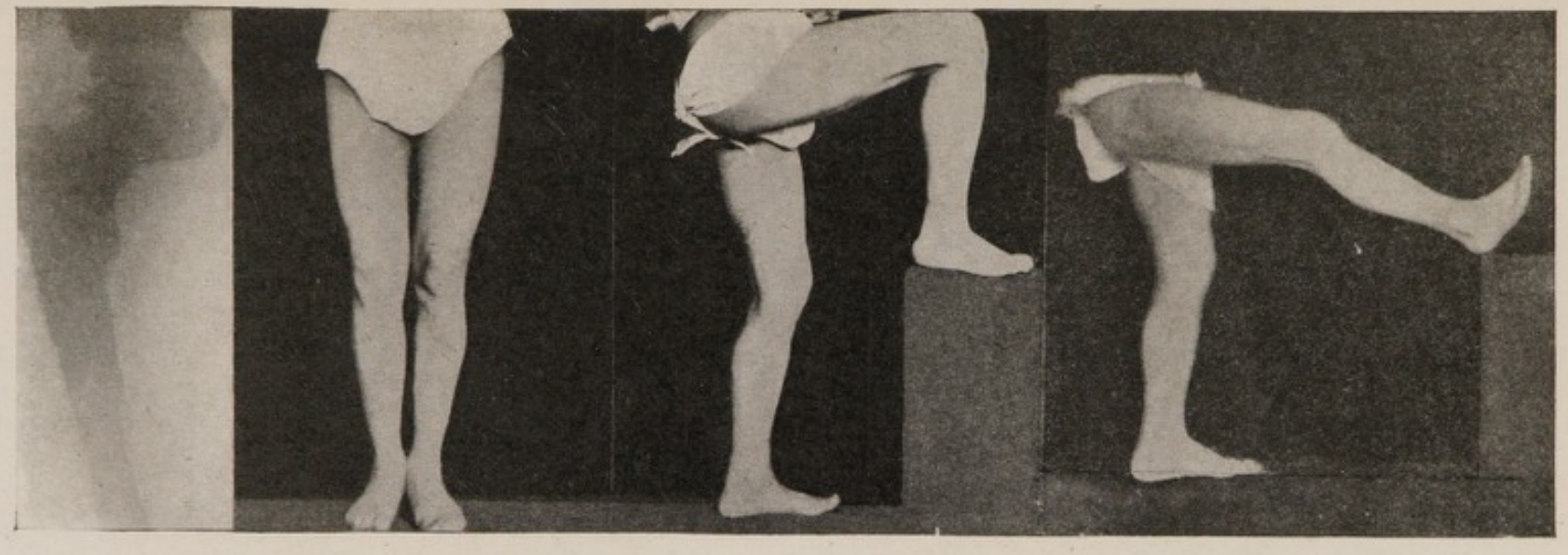


FIG. 45.—Large shell wound of buttock (right), opening hip joint, damaging acetabulum, head of femur, and great trochanter; 5½ months wounded Very slight limitation of rotation at hip. [Case E 9.]

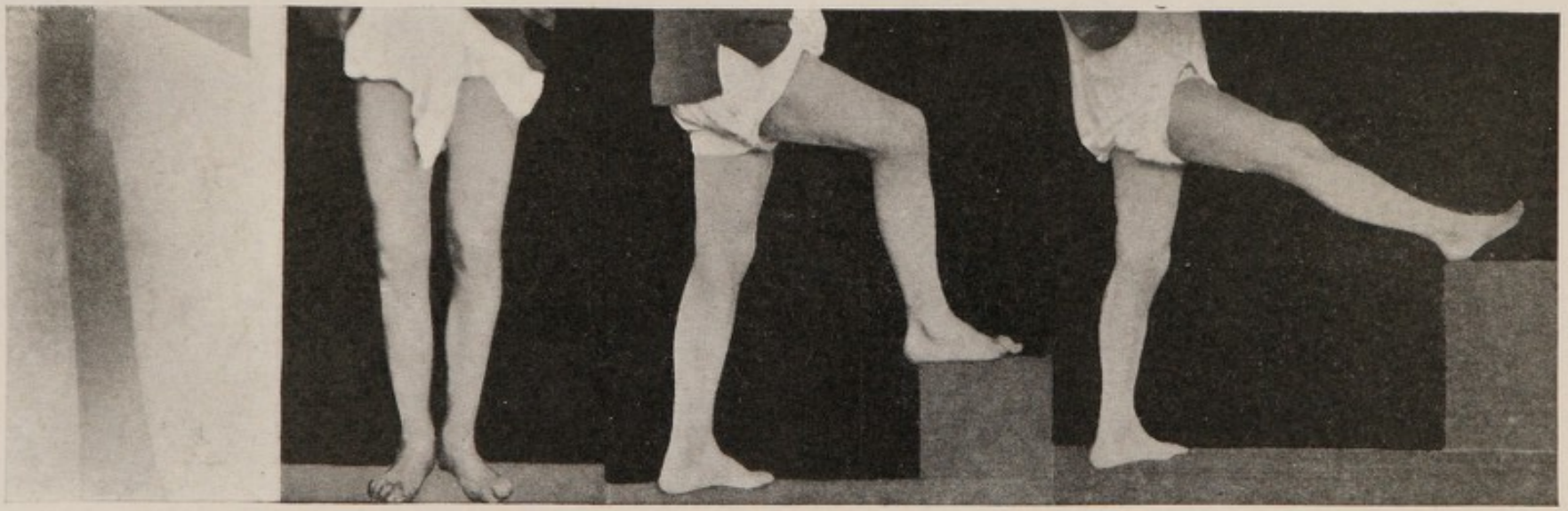


FIG. 46.—Middle-third fracture (right); five months. Shortening 1·5 cm. Knee flexion has since increased to 90°. [Case E 62.]

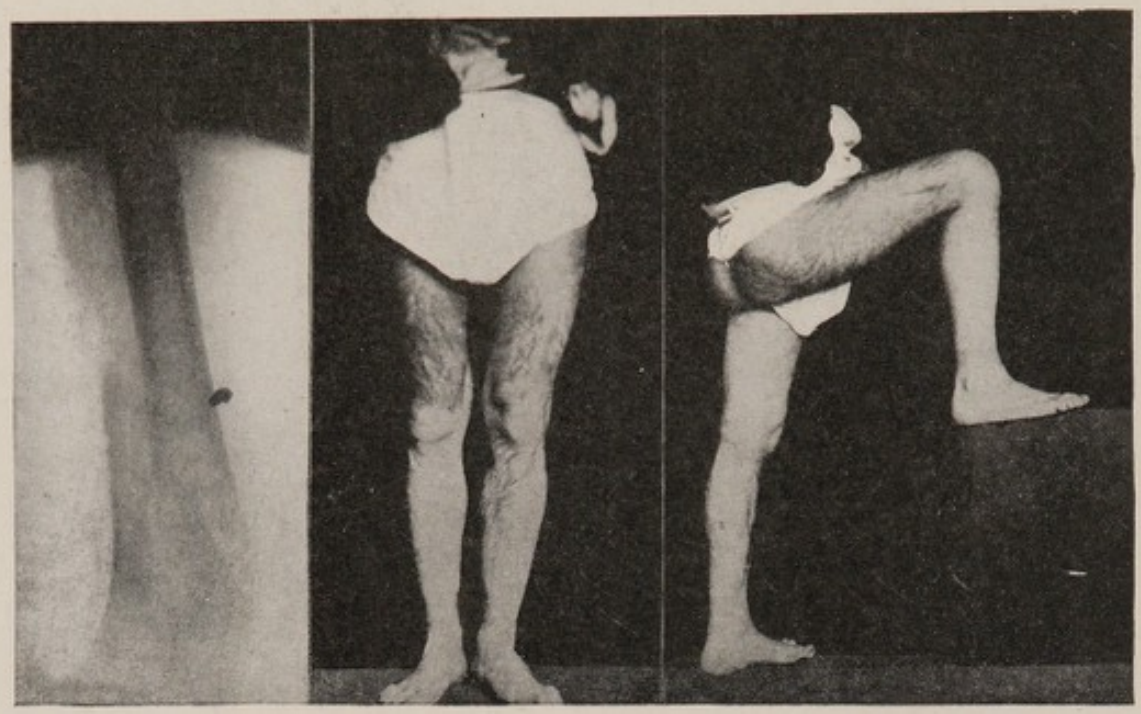


FIG. 47.—Lower-third fracture (right). Had been wounded for six weeks before admission, and anatomical position could not be improved. Photos taken five months after being wounded. No shortening. [Case E 235.]

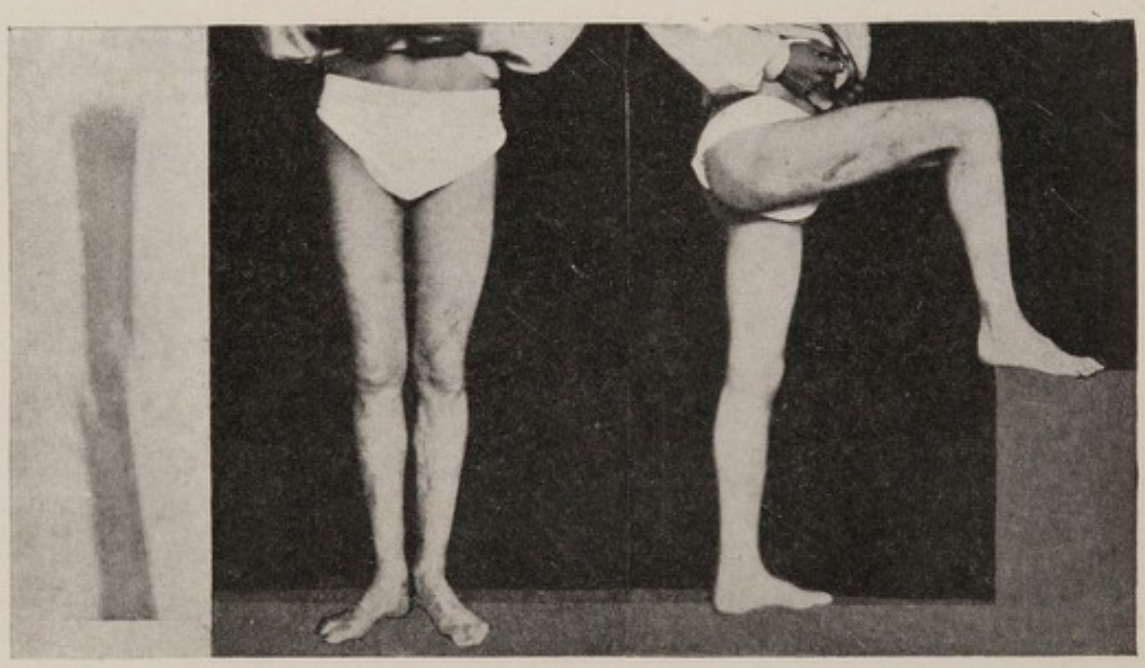
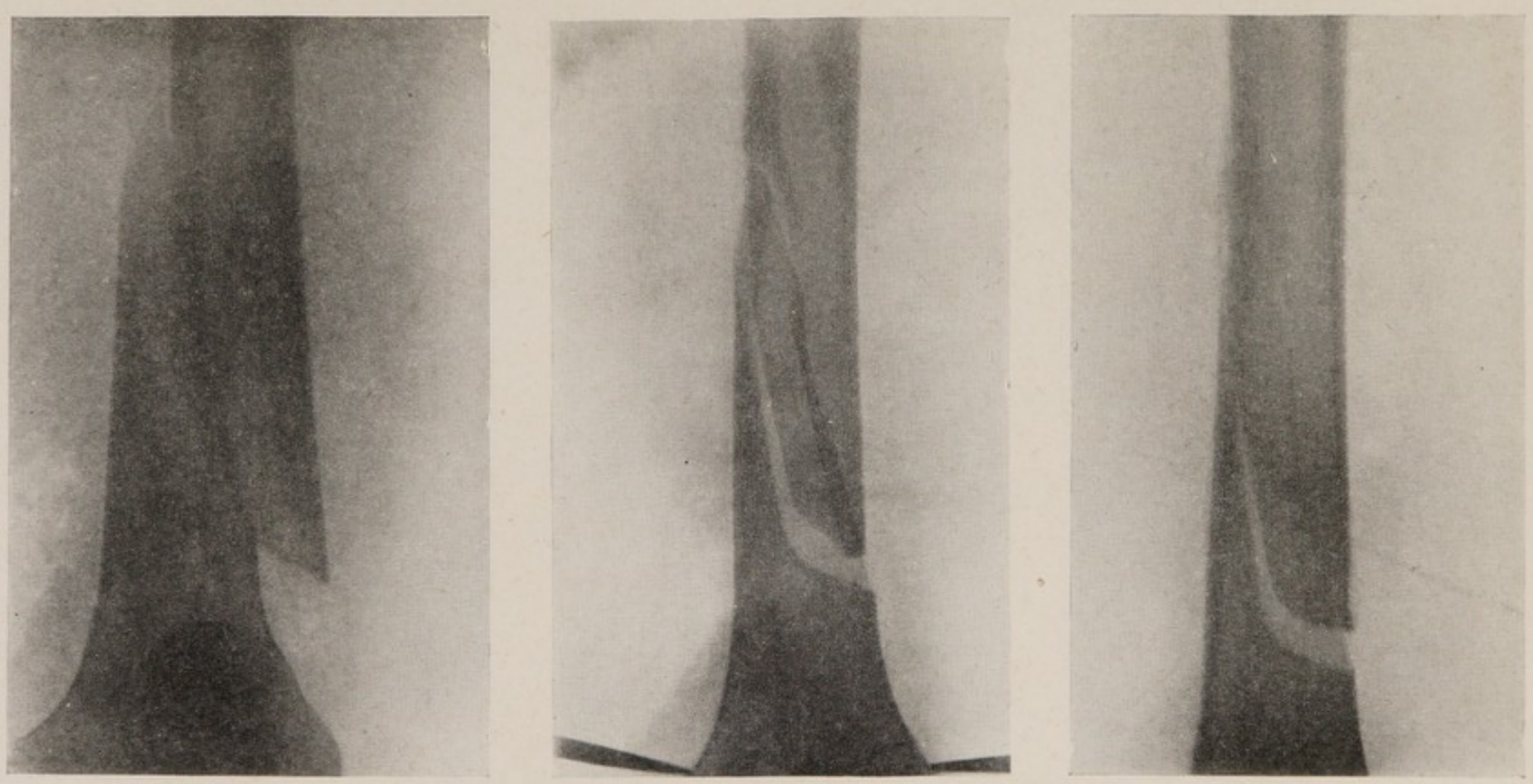


FIG. 48.—Middle-third fracture (right); seven months wounded when photographed. 2 cm. shortening. [Case E 95.]



(*a*) (*b*) (*c*)

FIG. 49.—(*a*) As admitted with tie-on extension and Thomas splint; 2 cm. shortening.
(*b*) After application of callipers and 10 lb. extension.
(*c*) As evacuated to England eight weeks after wound. Firm union, 1 cm. lengthening.
In this patient callipers were applied through a large open wound at the inner side of the knee, without ill-effects.

FIG. 50.—Gunshot wound of femur, upper half. Five-inch gap bridged by callus and débris. Patient was walking without splints ten months from date of wound. No shortening. [Case E 156.]

CONCLUSION

If we may be permitted to emphasise the few points in this method of treatment which we think of most practical importance, we should select—

(1) Traction by non-penetrating callipers above the knee, *with early movement of knee and ankle.*

(2) Suspension of the ring of the Thomas splint.

(3) The use of the sectional bed, rendering complete immobilisation of the fracture possible, and nursing, etc., easy.

(4) Posterior drainage in all septic cases.

(5) The uselessness and disadvantage of fixing both legs in abduction where only one is injured.

(6) The control of the position of fragments by frequent and systematic X-ray examination and by mensuration.

ADDENDUM

The following figures for fractured femurs in France in the last year of the war, 1918, have been given to us by Major-General Sir Anthony Bowlby :—

" The mortality in field ambulances and in casualty clearing stations was about 20 per cent. Of 5,025 cases at the lines of communication in 1918, 547 died = 10·8 per cent. ; 513 were amputated = 10·2 per cent."

It is to be remembered, however, that in these and in all other statistics of war-fractures referred to in this book, *all* fractures of the femur are included, whether there were other injuries present or not, and in the majority of cases there were multiple wounds, so that death may have been, and in many cases was, due to wounds other than the fracture.

INDEX

A

Abduction in upper third fractures, 13, 52
Active movements of muscles, 69
Adduction in upper third fractures, 14
Adherent muscles, 73
Adhesive traction, disadvantages of, 39
Aluminium tape, use of, for dressing and operation purposes, 68
Amputation, 20, 80, 82
Angular deformity, 80
" Anti-aircraft " position, 73
Antiseptics, 19
Atrophy of muscles caused by use of adhesive plaster, 43

B

Bed, sectional, 24, 34
Besley's callipers, 41
" Bowing," outward, 79
Broca's operation, 71
Buttock wounds, 38

C

Callipers, application of, 30
  Besley's " ice-tong," 41
  Pearson's modification of Besley's, 32, 40, 41
  landmarks for insertion of, 31
  sepsis with, 40
  " slipping " of, 42
  rusting of points of, 42
Calliper splint (walking), 74
  measurements for, 76
Calliper-traction,
  advantages and disadvantages of, 39
  duration of, 48
Chart for femur measurement, 66
Classification of fractured femurs, 12
Criles' (Denis) splint for abduction, 54

D

Discharge around calliper points, 67
Drainage, posterior, 22
Dressings, 68
  around calliper points, 67
Duration of calliper traction, 48

E

Esquillectomy, 19
Excision of wound, early, 11
    method of, 18

F

Fixation of one or both legs, 52
Foot suspension, 33
Fracture bedstead, 34

G

" Gaps," treatment of, 20
Genu recurvatum, 78
Goniometer, 53, 54
Grafting, 21, 72
Gymnastic exercises, 77

H

Hæmorrhage, secondary, 21, 82
Hodgen splint, 25
Hyper extension of knee, 78

I

" In-toed " deformity, 80
Intra-capsular fractures, 12

K

Knee-flexion addition to Thomas' splint, 28, 30
Knee-joint, fluid in, as a contra-indication to use of callipers, 62
Knee-joint, fracture involving, 62, 80
  lateral mobility of, 78

L

Lateral mobility of knee, 78
Liston splint, 25
    a cause of outward bowing, 15
Loop of wire as a sling, 21
Lower third fractures, 15
    movement of knee in, 15, 62
    flexion of knee in, 61
    special difficulties of, 61
    tilting of lower fragment in, 15, 61
    use of callipers in, 15

M

Malleoli, callipers applied to, 48
Massage, 69
Measurement, 65
Middle third fractures, 14, 60
" sagging " and " bowing " in, 61
maintenance of arch of femur in, 60
Movement of joints, method of, 64
Moving patient from stretcher to bed, etc., method, 30

N

Neck of femur, fractures of, 12
Nerve-suture, 72
Non-union, 77

O

Operating in splint, 70
Operation, Broca's, 71
Operation, initial, best time for, 17

P

Pain about callipers, 48
Pain and exhaustion as a cause of death, 27
Plating, 21, 72
Pressure pads, 55
Pressure sores, cause of, 29
" Puncture " bullet wounds, 18

Q

" Quick-release " device, 36

R

Radiography, 18, 64
Results, 78
Resuscitation methods, 17
Rotation of upper fragment, 58
Rusting of callipers, 42

S

" Sagging." 15, 79
Screw pressure pads, 55
Screws in tibia as a means of traction, 43
Secondary hæmorrhage, 21, 82
Sequestrectomy, indications for, 70
Shock in transport, 10
Shortening, 78
Simple fractures, 62
Sinuses, treatment of, 71
resulting from penetration by screws, pins, etc., 80
Slipping of callipers, 42
ring of splint, 29
as a cause of pressure sores, 29
Specialisation of femur hospitals, 8
Splint, Thomas, 25, 26
Hodgen's, 25
Liston, 25
knee-flexion, 28
Splinting, 25
importance of good, 10
Statistics of fractured femurs during the war, 6, 7, 8, 80, 82
Steinman pin, 6
Stiff joints, 43, 79
pathology of, 44
Suspension of ring of splint, 28

T

Thomas' splint, introduction into army, 7
Tilting the bed, possible reasons for, 37
Traction, adhesive, 43
by tibial pins and screws, 43
above the knee, advantages of, 43
Transport, difficulties of, 6
method of (Fig. 1), 10
Tubes, large drainage, 22, 23

U

Upper third fractures, 12
treatment of, 52
abduction in, 13, 52

W

Walking calliper, 74
Weight required, 31, 47
in simple fractures, 61
Wire loop for suspending bone, 21