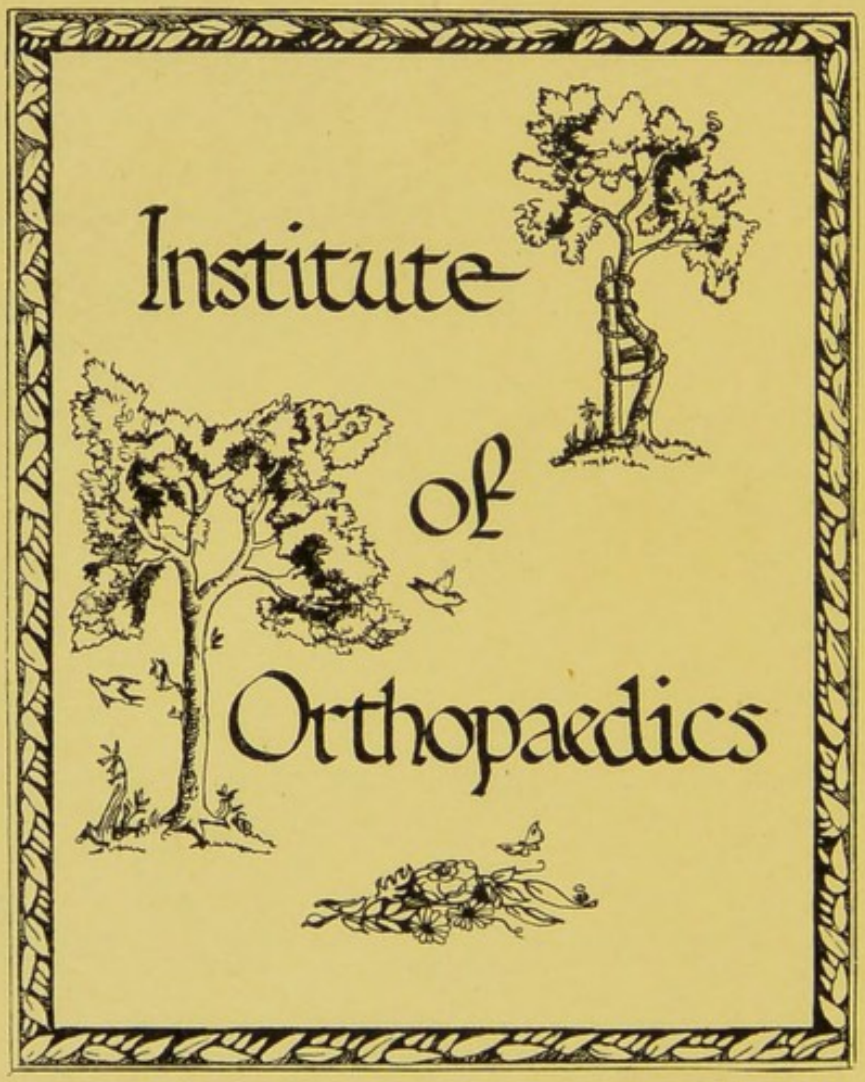
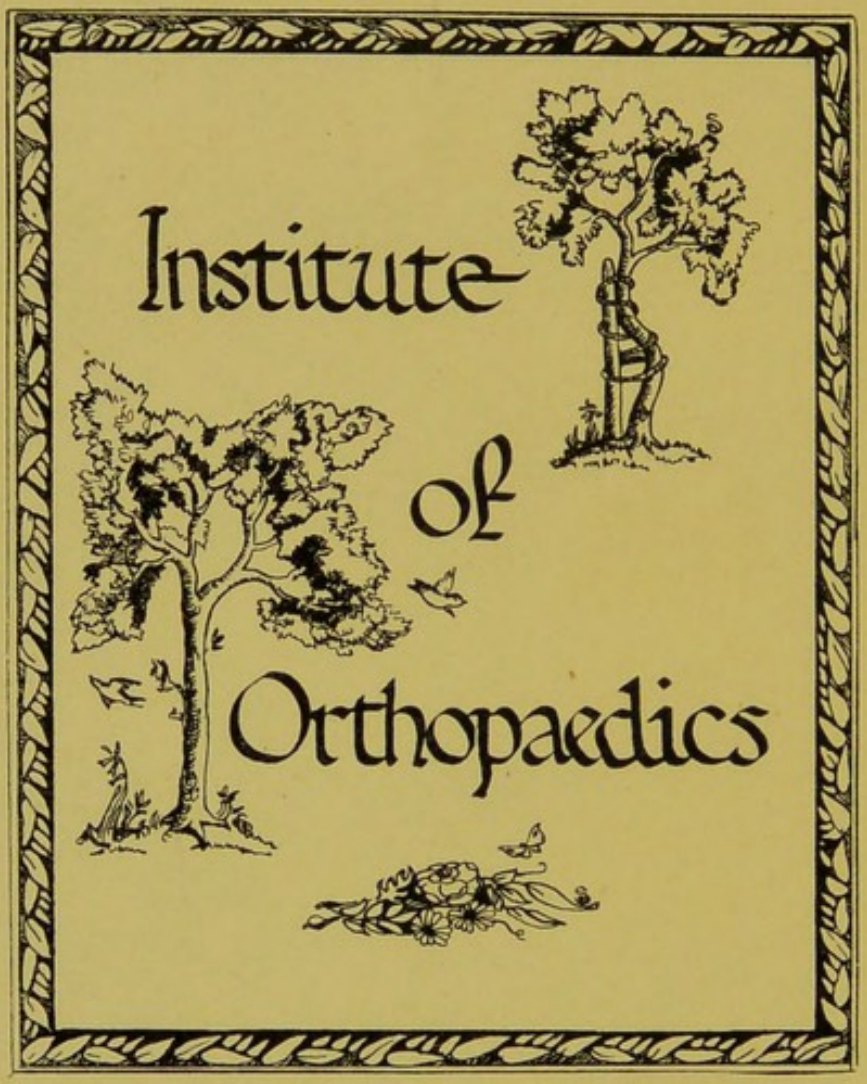
Paralytic deformities of the lower extremities : the principles of their surgical treatment / by E. Noble Smith.

PARALYTIC DEFORMITIES OF THE LOWER EXTREMITIES

E. NOBLE SMITH





PARALYTIC DEFORMITIES OF THE LOWER EXTREMITIES

With the Author's Compts.

PARALYTIC DEFORMITIES

OF

THE LOWER EXTREMITIES

THE PRINCIPLES OF

THEIR SURGICAL TREATMENT

BY

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'VON ZIEMSSEN'S HANDBOOK OF GENERAL THERAPEUTICS' ETC.

WITH 51 ILLUSTRATIONS

LONDON
SMITH, ELDER, & CO., 15 WATERLOO PLACE
1900

INTRODUCTION

The object of this small work is to review the general aspects of paralytic deformities of the lower extremities, and to discuss the questions which may arise in deciding as to the most effectual treatment to adopt. The diseases and accidents which give rise to these deformities are only referred to incidentally.

No attempt is made to describe every particular kind of paralytic deformity, but typical examples are recorded for the purpose of illustrating and explaining the general principles of the surgical treatment of these affections.

E. NOBLE SMITH.

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OF THE

LOWER EXTREMITIES

Of the various kinds of deformity which come before the orthopædic surgeon, a large proportion originates entirely or partially in paralysis, and this is especially the case in deformities of the lower extremities.

In last year's surgical report (1898) of the City Orthopædic Hospital are recorded for the previous year 680 cases of club-foot out of 2,476 new patients suffering from a variety of deformities, and a large majority of these cases of club-foot were due to, or associated with, paralysis of one or more of the leg muscles.

There were other instances of deformity from paralysis not complicated by club-foot, but which required treatment upon the same or similar principles.

The treatment of these conditions involves a special line of study apart from that of the physician, who devotes himself to the pathology and general treatment of the disease.

When any muscle, or set of muscles, is affected with paralysis, the immediate effects are, (1) necessarily, a loss of power to the patient as regards the use of those muscles ; (2) defective nutrition of the affected muscles themselves and also of the surrounding

tissues, including the skin ; (3) lessened temperature of the affected part ; and (4) irregular action, as regards direction, of any muscles which may remain sound.

In all cases of paralysis the muscles which act antagonistically to those which have lost their power, being unopposed, contract abnormally and in time become permanently shortened. When, for instance, the anterior muscles of the leg are paralysed, the foot drops into a position of extension, or Talipes Equinus. At first this abnormal position can be reduced by passive movement ; but in the course of time structural shortening takes place in the active muscles of the calf as a consequence of the absence of action in their opponents—probably also from a morbid condition of contraction. These contractions, or 'contractures,' form one of the chief conditions in paralytic deformities requiring surgical treatment.

If a case is seen by the surgeon before the contracture occurs, then mechanical support should be applied to keep the part from falling into an abnormal position, and by such means deformity may frequently be prevented.

Slight degrees of contracture may, in the early stages of the paralysis, be relieved or cured by firm pressure kept up by splints ; but when such contractures have passed this slight degree, or have existed for long, then further treatment is required. Whatever this treatment may be, the foot or limb will still require mechanical support to take the place of the paralysed muscles, to enable the patient to walk to the best advantage, and also to prevent relapse.

Paralysis may be the result of disease of the nerves or nerve centres, or it may arise from traumatic causes and from surgical affections, such as tumours involving or pressing upon nerves or nerve centres.

Surgical treatment is chiefly required for the former (nerve disease), and I have referred briefly in the following pages to the more important affections in which such treatment of the resultant deformities or weaknesses can be usefully employed.

The traumatic and other surgical conditions which may cause paralysis are not described, because they can be dealt with upon the same principles which govern the surgical treatment of deformities arising from nerve disease.

It is assumed that the surgeon will always inquire into the cause of the paralysis, and will adopt the necessary treatment for such condition.

The various procedures by which we can overcome the resultant deformities or relieve their effects will now be considered.

MECHANICAL APPARATUS

The consideration of the use of mechanical apparatus forms a very important part of our subject.

It has been in the past too much the custom to depend for treatment of paralytic deformities upon the instrument-maker alone, for upon him has devolved the task of devising apparatus to support the weakened parts. Either the instrument-maker has been relied upon to act upon his own initiative, or, in the more severe cases, the sufferers have been left to hobble about on crutches, or to depend for locomotion upon mechanical chairs.

Instrument-makers have shown great ingenuity in providing for the requirements of such patients, but it is impossible for them to cope with all the difficulties which occur without a thorough knowledge of the anatomy, physiology, and pathology of the parts

with which they have to deal, nor are they qualified to judge as to the necessity for operative interference.

It is the province of the orthopædic surgeon to study these matters in a scientific manner, to devise mechanical apparatus, and to apply other treatment to meet the various difficulties which present themselves.

The teaching of the principles upon which mechanical apparatus should be constructed and applied in orthopædic cases does not, I would urge, receive sufficient attention in our medical schools.

If medical students were taught these principles we should in time have less cause to complain of the loading of patients with monstrous and ineffective apparatus, and have a better appreciation of the value of mechanical treatment.

A considerable amount of prejudice prevails amongst medical men, and also amongst the public, against the use of so-called 'supports' or 'irons.'

This antagonism is not surprising: first, the idea of wearing any mechanical apparatus is repugnant, and, secondly, the machines made upon mechanical principles alone, without scientific knowledge of the nature of the deformities, have been heavy, irksome, and to a great extent inefficient, and have therefore created distrust in the minds of those who have had experience of them.

The mechanician's idea is naturally to *support* a weak part, whereas the object of the orthopædic surgeon is—or should be—to transmit power from one part to another, or to economise the patient's locomotive ability. The mechanician binds up a weak joint so as to take away its natural power of action, whereas the orthopædic surgeon devises means to leave freedom of action to the

sound muscles, while he places support only where it is absolutely required.

Undoubtedly many mechanicians have learnt to modify their apparatus, to some extent, in accordance with scientific principles; but I feel it is no reflection upon them to say that it is impossible for instrument-makers to do as much in this way as can a surgeon who possesses mechanical ability in addition to an intimate knowledge of the 'disease.'

As regards the first objection above referred to—the natural dislike to wearing an artificial help—that can only be overcome, if at all, by the patient realising the advantages of such help. The second objection disappears with experience of efficient apparatus.

If a patient be so unfortunate as to lose a leg, he must put up with an artificial one if he wishes to walk about again; and, in like manner, if he loses a muscle or a set of muscles which are necessary for normal walking, he must have some artificial substitute for that muscle or muscles if he wishes to get about in the best possible way, and if he desires to avoid the deformity which is almost certain to develop if he remains unaided. Moreover, the use of well-applied apparatus tends to increase the vitality of the affected part by facilitating the use of the sound or partially weakened muscles; and it often happens that, as the case progresses, the artificial help may be simplified, and perhaps eventually discarded.

As an example of what may be done in this direction I will refer to a typical instance.

Miss B., whose case is described on p. 46, was wearing, when I first saw her, the apparatus shown in fig. 1 (from a photograph). Its weight was 4 lb. After operation upon the foot I used the instrument shown in fig. 2, the weight of which was only 2 lb,

The effect of the latter was to give efficient support, while, unlike the other, it did not interfere with the use of the sound muscles.

For practical purposes it has been thought desirable to defer

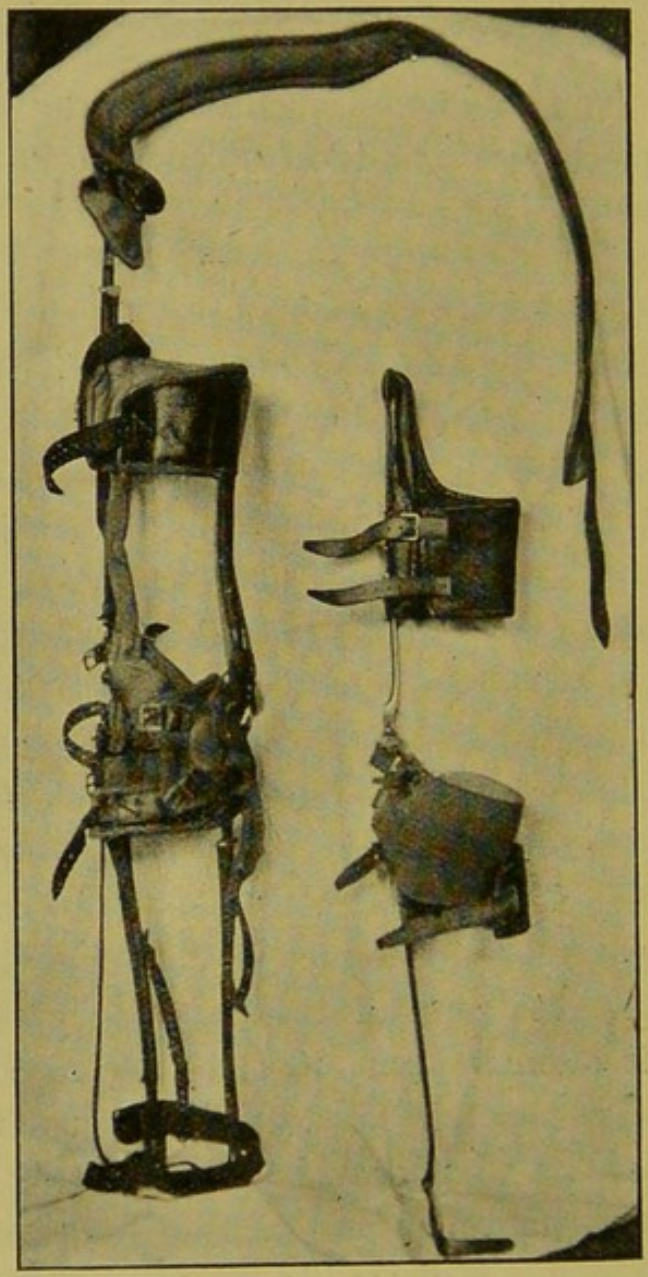


FIG. 1 FIG. 2

FIG. 1.—Instrument devised by a well known mechanician. It was attached to the waist, and consisted of heavy steels on each side of the affected limb. It was fastened into sockets in the boot

FIG. 2.—Instrument devised by the surgeon

the further consideration of this subject until the treatment of various kinds of paralytic deformities has been discussed. This continuation appears on page 71 under the title 'The scientific use of mechanical apparatus.'

TENOTOMY

The operation of tenotomy enters so largely into the treatment of paralytic deformity that it is necessary to deal with this subject at some length.

There is no operation in surgery which is more firmly established, as a sound method of treatment in suitable cases, than that of tenotomy. Before this method was practised the deformities produced by permanent contraction of muscles, chiefly the result of paralysis, were found by surgeons to be almost irremediable, and they were left, practically, untreated. The case of Lord Byron, for instance, is one very generally known. He suffered from a deformity which, during almost any period of his life, could have been relieved by tenotomy, and which certainly could have been cured if he had been operated upon and thoroughly treated during childhood.

The performance of tenotomy as a satisfactory operation dates from the year 1831, when Stromeyer, of Hanover, commenced to divide tendons *subcutaneously* through a minute opening in the skin. Previous to this date tendons had been divided through an open wound, with frequent bad results from suppuration. In recent years, since the introduction of antiseptic surgery, the open method has been revived, and may be safely employed when absolutely necessary ; but for the majority of cases the subcutaneous plan is satisfactory and more simple. The introduction of tenotomy into England, in 1837, was due to the pluck and deter-

mination of the late Dr. Little. He himself suffered from talipes equino-varus, and submitted to treatment at the hands of Stromeyer, in opposition to the advice of every English surgeon whom he had previously consulted.

During the sixty-nine years which have passed since the establishment of this operation, many thousands of tendons have been divided in Great Britain alone, and the results which have followed have been so remarkably good, and attended by so few accidents, that it may be said that, with proper precautions and with a due amount of skill upon the part of the surgeon, subcutaneous tenotomy is practically free from risk.

Accidents.—I have just referred to 'accidents' as being 'very few.' With proper care and some experience they ought perhaps never to occur. I may, however, refer to those accidents which have been known to happen.

1. **The entrance of septic matter into the small wound**, causing suppuration and possibly blood-poisoning, is an accident which, with antiseptic surgery, ought never to take place.

2. **The wound of an artery** (when tenotomy is performed in the region of the feet) is not a serious matter, and only needs extra pressure and a prolongation of the after-treatment. Pricking an artery is worse than cutting it right through, as an aneurism may follow the former accident. Pressure for a prolonged period will, however, cure this latter complication.

3. **Injury to a nerve.**—The peroneal nerve might be injured in the performance of tenotomy of the biceps femoris. If the biceps tendon is prominent, as usually happens when the muscle is contracted, there need be no fear of injuring the nerve; but if the surgeon has any doubt in the matter he had better approach the tendon by an open wound. The same remarks apply to operations in the region of nerves in the ankle and foot.

4. **Non-union of the cut tendon, weak union, and excessive length of new tendon.**—I believe that these accidents, when they occur, are almost invariably due to improper or inefficient treatment after operation.

About thirty-five years ago an English surgeon published a book in which he opposed the operation of tenotomy upon the ground of its being a failure ; and in place of this procedure he advocated the use of elastic traction bands. This attack upon tenotomy was so completely demolished by Mr. Timothy Holmes [1] that I will quote what so eminent a surgeon wrote upon the subject. 'The profession were hardly prepared to hear,' writes Mr. Holmes, 'that Stromeyer's supposed great discovery was all a mistake, and that tenotomy ought not to be used in the cure of club-foot. Yet such, if I mistake not, is the doctrine taught by Mr. ——.' . . . 'I must own myself unconvinced by the theoretical part of Mr. ——'s reasoning. Still, I am quite disposed to concede so much as this : that there are many club-foot deformities plainly caused by paralysis, and that in these cases at least, if the deformity can be remedied without any injury to the muscles not paralysed, it would be most desirable to adopt such treatment as secures this end ; and, further, that the success of the treatment by simple extension in such cases would form a most legitimate argument for extending its use experimentally to cases which are not equally evidently dependent on paralysis.

'Actuated by these considerations, I have given a fair and patient trial to the method of elastic extension recommended by Mr. ——, and have availed myself in some cases of Mr. ——'s own assistance.' . . . 'This experience has not, I am sorry to say, led me to form any great hope of advantage to the surgery of club-foot from Mr. ——'s method.' . . . 'It seems to me that under

[1] *Surgical Treatment of Children's Diseases* (2nd edition). Longmans & Co., 1869. Page 644 *et sqq.*

this method the deformity is peculiarly liable to recur. Thus, in one of the cases above referred to, the foot had been brought into a good position, and the cure was pronounced complete; but the distortion recurred immediately on the cessation of the extension, and, wearied out with the laboriousness of the plan and the great expenditure of time, I found myself obliged to resort to tenotomy. . . .'

'These objections to the principle, and these difficulties in the practice of treating severe cases of club-foot without tenotomy, will, I think, be found very real and very difficult to overcome by any person who sets himself fairly to test the method by actual practice. . . .'

'To sum up this question of treating club-foot without tenotomy, I would say that I approached it with a perfect absence of bias or prejudice, and that I have given the treatment a fair trial, with the assistance and under the direction of the gentleman who most warmly advocates it. The result has been that I believe the doctrine commonly taught to be the true one, viz. that only the less severe or trivial cases can be treated successfully by simple extension without tenotomy.'

I have quoted Mr. Holmes because, besides being an eminent general surgeon, he has also given considerable attention to orthopædic cases, and is well qualified to form an unbiassed opinion upon this subject.

It may be thought by some that in the present day any doubt about the value of tenotomy has long since been dispelled. This is unquestionably a fact as regards the operation in severe cases of club-foot, but in respect to many varied cases of slighter contracture views are sometimes expressed which seem to require a reference to this old controversy.

Speaking generally, it may be said that the operation of

tenotomy is less dangerous than the prick of a pin. The pin will probably be dirty, the surgeon's knife scrupulously and surgically clean.

To soothe a nervous patient's dislike to the use of the knife it may be further stated that so small a puncture and section does far less damage to the parts than an ordinary severe bruise, and that, as a result of the operation, the patient is cured or relieved from a condition of lameness which, to take only one aspect of the case, must previously have constantly jeopardised his limbs or life from falls.

After-treatment.—However skilfully a tendon may have been divided, the ultimate result will depend upon the care and attention bestowed upon the after-treatment.

Correction of the deformity.—In the early days of subcutaneous tenotomy, so great was the fear of non-union and of other bad results that it was customary to fix the foot or limb in the deformed position after operation, and to reduce the deformity only by slow degrees, extending often over several weeks. This practice I described in 'The Surgery of Deformities,' published in 1882, as the orthodox practice in this country at that time; but I had already tried the effect of immediate reduction of the deformity, as then practised by some American surgeons. I soon became convinced of the great superiority of the latter plan, and for the last fifteen years or more I have invariably placed the deformed foot or limb in as perfect a position as I could obtain at the time of operation, sometimes using considerable force in correcting the position. This plan of immediate reduction has the following advantages over the older method :—

1. It simplifies immensely the whole process of treatment; for

at the one 'sitting' is accomplished the work of weeks under the older plan.

2. It saves the patient from a tedious and painful process.

3. It ensures the production of a more perfect piece of new tendon, as shown by the absence of that recontraction which too frequently followed the older plan.

4. It allows a greater degree of reduction in those severe cases of club-foot in which we are unable to obtain a perfect position directly after the operation.

Some surgeons adopt a middle course by putting up the part in the deformed position for a few days, and then rapidly extending by two or three subsequent manipulations, but I see no advantage in this latter method over 'immediate reduction.'

Fixation after operation.—A plaster of Paris bandage is frequently used to fix a limb after tenotomy; but although this method of fixation is simple and very effective at the time, there are serious objections to its employment. It is obvious that it is not practicable to remove a plaster bandage every few days, and yet it is of the greatest importance to watch thus closely the process of repair in the divided tendons. This repair differs considerably in different patients. In some it takes place very rapidly, in others very slowly. The gap between the cut ends may be filled up in three or four days, and the union be tolerably firm at the end of a week. Upon the other hand, there may be no apparent union at the end of ten days, or even a longer time may elapse before the gap is filled in. In some patients we may find the cut ends of the tendon approximating too closely, while in others they recede too far. In the former case we must fix the foot so that the uniting material is more stretched, and in the latter we must approximate the divided ends.

Several alterations in position may be necessary during the first fortnight or for longer after operation.

In a patient upon whom I operated recently for paralytic equinus I could feel no uniting material for a long time, and I therefore gradually extended the foot so as to approximate the cut ends. At the end of the fourth week there was still a complete gap left. I then placed the foot in a position of extreme equinus. A week later a firm union could be felt, whereupon the foot was again brought up to a right angle with the leg. If this child's foot had been fixed in a plaster bandage and left for several weeks there would probably have been a very weak union, or possibly no union at all.

To retain the foot in the desired position, small iron splints, which can be bent into any desired position by the surgeon, suffice. They should be softly padded, and fixed by adhesive strapping and bandages.

Comparison between subcutaneous operation and operation by open wound.—Since the introduction of antiseptic surgery, subcutaneous tenotomy has ceased to have the great advantage which it formerly possessed over the open method; for we have no fear now, with proper precautions, in approaching a tendon by an open wound.

There is, however, no object in making a long incision when a minute puncture will suffice, and in the large majority of tenotomies the subcutaneous operation is perfectly sufficient and satisfactory.

When, however, it is desirable to make an open wound, as, for instance, in transplanting tendons, or to avoid injuring the peroneal nerve in dividing the tendon of the biceps femoris, or to avoid injury to the large veins when dividing the sterno-mastoid in wry neck (a subject which we are not now considering), or for other reasons, we need have hardly any more fear of trouble than when we make the smaller wound.

The desirability of tenotomy in particular cases.—Questions arise as to the advantages of tenotomy in particular cases, and these

questions are of great interest, not only to the surgeon, but also to the patient and his friends. If one case demands division of the tendon of a contracted muscle and another can be treated with undoubtedly good effect without tenotomy, there must remain a border line at which the question for or against this operation requires consideration.

As a typical case for the discussion of this subject we will consider a severe instance of talipes varus, in which the extensors of the foot are paralysed, the sole of the foot twisted inwards so that it turns backwards or even upwards, and the heel drawn up by contracture of the calf muscles. This condition has often been termed 'equino-varus,' as contracture of the heel always accompanies the turning-in of the foot. This deformity cannot be treated too early in the patient's life.

Daily manipulations have been recommended as beneficial, and such treatment may be adopted during the first few weeks of the child's life; but much time ought not to be lost in this procedure by itself. Unless the skin be peculiarly sensitive, simple splints may be used to hold the foot in an improved position. Constant pressure, even if slight in degree, will have more effect in overcoming the deformity than any amount of intermittent force. Treatment by splints may be continued for at least some weeks, or so long as the deformity is giving way with sufficient rapidity. Some slight contractures may be thus overcome entirely by pressure, for it must be remembered that in these paralytic cases much of the deformity depends upon the long-continued posture and the consequent alteration in the shape of the foot as much as, or more than, upon contraction of the muscles. As soon, however, as any one tendon appears prominent and shows an obstruction to the reduction of the deformity, and especially if such contracted tendon ceases to give way rapidly to the pressure, tenotomy is called

for. After operation the foot should be placed in as good a position as possible, and sufficient time allowed to elapse for commencing union of the divided tendon. In a young child further improvement in position may be commenced a week after operation, and the pressure may be continued until another tendon shows itself as forming an obstruction to extension.

The necessity of overcoming the varus deformity before dividing the tendo Achillis.—It is a golden rule in orthopædic surgery to overcome completely the tendency of the foot to turn inwards before operation on the tendo Achillis is performed, because as soon as the latter operation is carried out we lose our power of control of the transverse tarsal joint, the joint at which the twisting of the foot chiefly occurs. To act upon this part of the foot it is necessary that the heel be secured, and nothing secures it better than the contracture of the calf muscles. Cases in which it has been thought necessary to remove a wedge of bone from the tarsal arch, after tenotomy has been said to fail, have been very often those in which it has been attempted to cure the whole deformity by dividing the tendo Achillis before the turning-in of the anterior part of the foot has been overcome.

In the City Orthopædic Hospital Museum we have a number of casts showing some very severe cases of deformity in talipes varus, and the casts subsequently taken, showing that such deformity has been entirely overcome. These results could never have been obtained if the division of the tendo Achillis had not been left until the rest of the deformity had been entirely corrected.

Syndesmotomy.—In considering the subject of tenotomy for club-foot we may also allude to division of the plantar fascia and the internal lateral ligament and posterior ligaments of the ankle, and sometimes of the other deep-seated ligaments. Section of these other deep-seated ligaments is rarely necessary, and is to be avoided

if possible, for the following reason. The ligaments between the tarsal bones simply hold these bones together naturally, and the deformity in this part is situated in the bones and has to be overcome solely by altering the shape of these bones. It is different with the plantar fascia and the internal lateral and posterior ligaments of the ankle, as these structures may be really shortened, and will then restrain the foot from being placed in a normal position.

The transforming of the foot from a condition of talipes varus into that of talipes equinus may be a long and tedious process, but it is well worth the time and trouble which it takes; it is a process of gradually altering the bones from their deformed to a natural shape.[1] The deformity of talipes equinus can safely be delayed, because it only necessitates the extension of the foot and involves alone the hinge joint between the tibia and astragalus.

The above remarks regarding the treatment of severe talipes varus give the general principles which should guide us in the performance of tenotomy. These remarks indicate that much of the malformation of the bones has to be corrected by means of long-continued pressure, and that even when division of the tendons is ultimately required the stretching process has also been necessary. By early and persistent stretching with splints we reduce the deformity as much as possible, until we have brought the contracted tendons into prominence, always bearing in mind that as soon as a tendon appears tight its division cannot be effected too soon. Some muscles may be influenced to a great extent by stretching, but the calf muscles rarely, if ever, give way to this

[1] As the bones in a young child are almost entirely cartilage, their shape can be comparatively easily altered.

remedy. In very young infants, and when the contracture of the calf muscles is very slight, the stretching process should certainly be tried ; but it will be found that in the majority of cases of contracted heel tenotomy will, sooner or later, have also to be performed.

Right-angled contraction of feet.—It is in cases of slight 'Equinus' in which the foot can be easily flexed to a right angle with the leg, but not beyond that point (except by the application of considerable force), that tenotomy is so much neglected. In other words, the existence of the trouble is often overlooked, and when realised the necessity for tenotomy is frequently doubted. This condition is not uncommon in adults, and it may give rise to a great deal of inconvenience. A sense of fatigue after even quite short walks, pain in the ankle, calf, or knee, or in the sole of the foot, and an inclination to trip in walking, are usual troubles. Although there may be no muscular paralysis present, yet it is probable that these contractures have emanated from a slight attack of paralysis in the flexors, a cause which has passed away long before the patient comes under notice. In these cases tenotomy is the only effectual remedy, and it is almost always satisfactory in its results.

In young children prolonged stretching by means of apparatus may in time apparently overcome the contracture, but almost invariably the shortening recurs some time afterwards. The structural shortening is not removed by stretching, but only temporarily relieved.

Tenotomy, on the other hand, is a scientific procedure, as it elongates the tendon to the required extent and leaves the muscle with its contractile action undisturbed. An over-stretched muscle never acts perfectly.

There seems hardly any limit to the powers of repair as regards

the extent of the gap formed in the tendon by replacement of the foot in a normal position, but when this gap much exceeds an inch it is advisable to split the tendon and unite the attenuated ends together. This plan of operation is described on p. 51.

TRANSFERENCE OF MUSCULAR POWER

In paralysis of a group of muscles it is sometimes possible to transplant the tendons of neighbouring sound muscles to take the place of those which are paralysed. See Case IX. p. 54.

This operation has been described as *the transplantation of tendons*.

Nicoladoni first performed this operation in 1881 in a case of paralytic talipes calcaneus. The two peronei tendons were removed from their natural attachments to the foot and fixed to the tendo Achillis. The result was said to be very good. On p. 56 I give the details of this procedure in the case of a patient upon whom I operated in like manner.

In 1892 Parrish in America and Drobnik in Posen adopted this method of operation. The same principle has been applied in dealing with other tendons.

Dr. Goldthwaite, of Boston, U.S.A., published a good paper upon this subject in the 'Transactions of the American Orthopædic Association' for 1895. He remarked very rightly that, 'in certain partial paralyses, the power which remains in the unaffected muscles is a disadvantage rather than a benefit, as these muscles have nothing to antagonise them, and by their contraction pull the foot out of its normal relations with other parts.' Therefore in transplanting the tendons of such muscles we not only make them useful in taking the place of the paralysed muscles, but further often relieve the patient from a particularly inconvenient

action. To take the class of cases just alluded to, in which the muscles of the tendo Achillis are paralysed, the heel drops (calcaneus), and any attempt on the part of the patient to extend the foot brings into action the peronei which produce abduction. In the course of time these latter tendons become displaced from their groove behind the malleolus to the outer side of that bone or even towards the anterior edge. Under such circumstances these muscles produce flexion instead of extension in addition to abduction (fig. 29, p. 55).

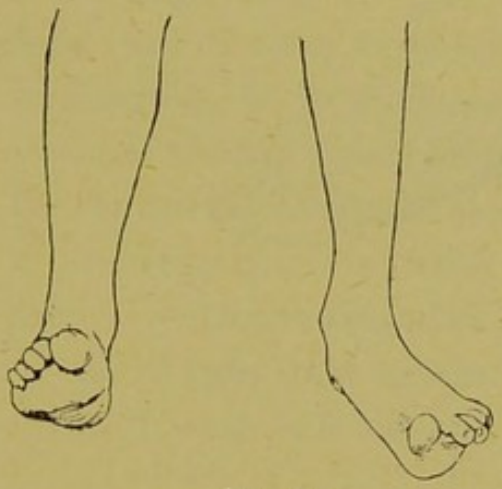


Fig. 3

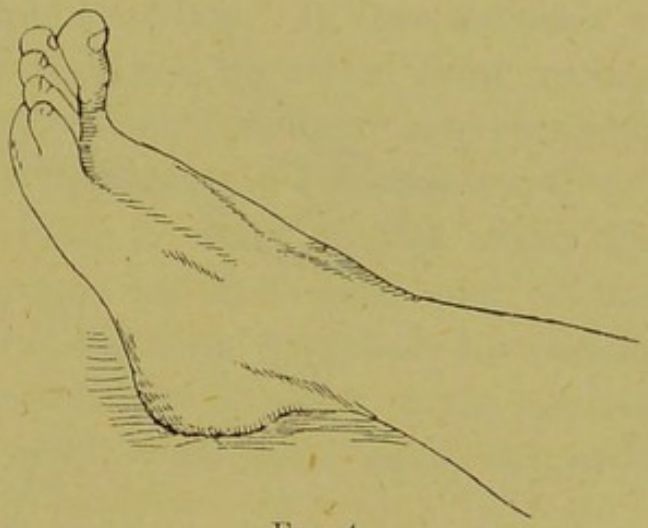


Fig. 4

When the tibialis anticus alone is paralysed attempts at extension also cause abduction (figs. 3 and 4). In fig. 3 the right foot (normal) is simply flexed, whereas the left foot (paralysed) is drawn up and out. The result is that the patient comes to walk upon the inner side of the foot—that is, if no supporting apparatus is used.

In such cases the tendon of the peroneus tertius and the outer segment of the tendon of the extensor communis have been separated from their attachments and transplanted to the tendon of the tibialis anticus, with very good effect. In one case the tendon of the paralysed tibialis anticus was split and attached to the

peroneus tertius, so as to make another attachment for the latter muscle. Fig. 5 shows the appearance of the feet in Dr. Gold-

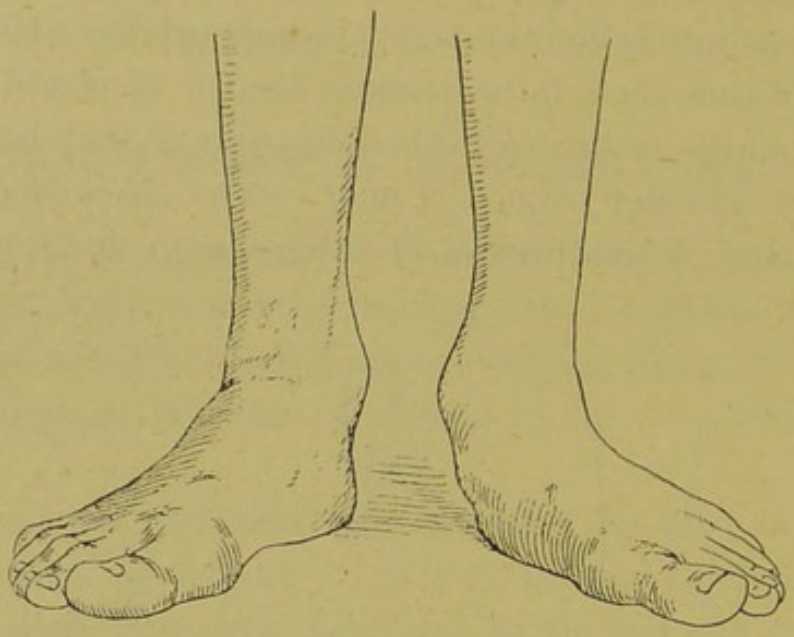


Fig. 5

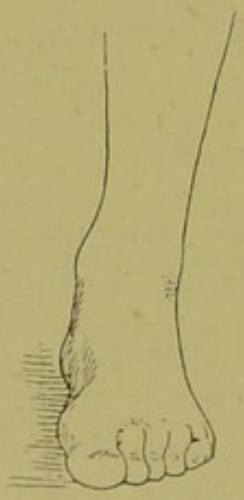


Fig. 6

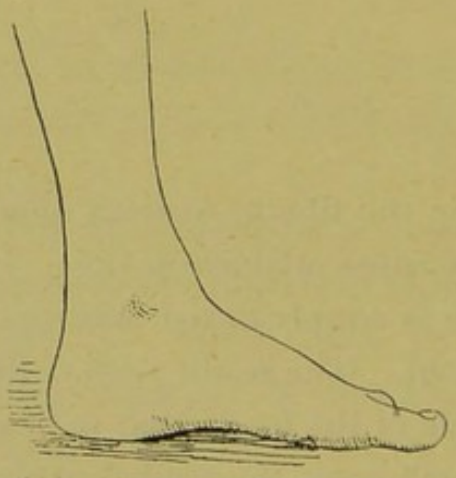


Fig. 7

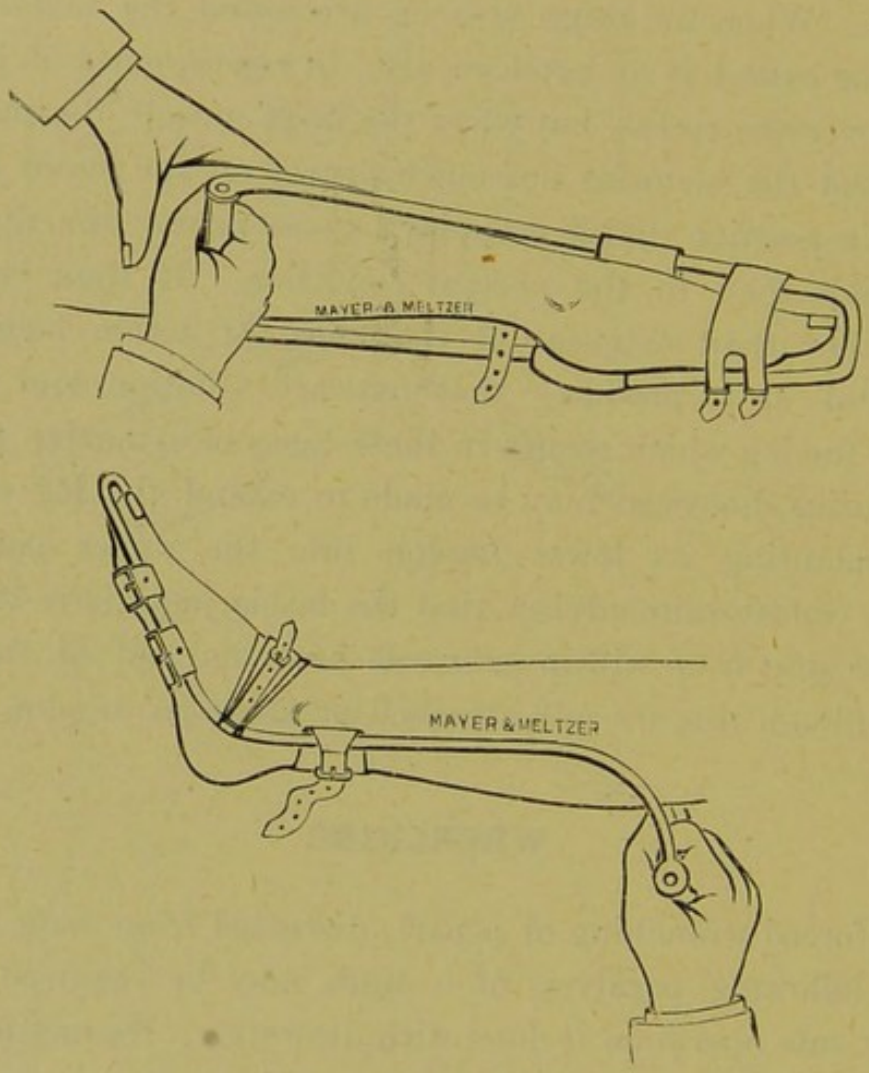
thwaite's case of this kind before operation, and figs. 6 and 7 represent the left foot after operation, the whole weight, in standing, being for the time supported on that foot only.

Paralysis in the quadriceps femoris.—The quadriceps femoris may be paralysed while the sartorius and the tensor vaginæ femoris remain intact. The normal action of the sartorius produces rotation at the knee joint, abduction of the leg, and outward rotation of the thigh. When the thigh muscles are sound the sartorius may act to some extent as an extensor also, in consequence of its raised position over the rectus, but when the large muscle, the quadriceps, is paralysed the sartorius lies much nearer to the femur and is so changed in position that it occupies a place nearer the upper part of the thigh than in the normal condition. It then becomes a flexor rather than extensor of the knee, its action being rather detrimental, as it produces that outward rotation and swinging action of the leg which occurs in these cases of extensive paralysis. The sartorius, however, may be made to extend the leg effectually by transplanting its lower tendon into the upper part of the patella. Goldthwaite advises that the fascia just above the patella should be split from within outwards and the end of the muscle drawn through this slit and attached by kangaroo tendon sutures.

WRENCHING

The forced wrenching of a part, distorted from long continued posture following paralysis of a limb, may be required. It is a perfectly safe operation if done with discretion. Sometimes, at the time of dividing a tight tendon, we may have to use considerable manual force to correct the position of a foot, when we generally feel some deep-seated contractions or adhesions give way. Sometimes this procedure is useful without division of tendons or ligaments. In place of hand pressure it is often desirable to employ mechanical force for the purpose of overcoming such deep-seated obstructions. The wrench invented by the late

Mr. H. O. Thomas, of Liverpool, or, better still, the wrench of Mr. William Thomas, of Birmingham, may be used. For simple equinus or equino-varus a very powerful apparatus has been invented by Mr. Baker.



Figs. 8 and 9.—Baker's wrenches for equino-varus

In young children I have generally found that I can use as much pressure with my hands alone as would be safe to employ with the wrench, and by such means one is less likely to cause bruising of the soft tissues. But there are some instances in which the mechanical wrench is invaluable.

SEVERE CUTTING OPERATIONS

During recent years some very extensive cutting operations have been introduced, involving the division of all restraining tissues down to the bones. Buchanan's and Phelps's operations are of this nature.

In *Buchanan's operation* the tendo Achillis is first divided, subsequently all the soft parts on the inner part of the foot down to the astragalo-scaphoid joint, this joint being opened.

In *Phelps's operation* a point midway between the tip of the internal malleolus and the scaphoid bone is selected for the incision, which is made downwards upon the inner side of the foot, involving about one-third of the sole. The abductor hallucis is exposed and divided, and the internal plantar nerves and vessels are drawn aside. The tendons of both tibial muscles are divided, also the internal lateral and calcaneo-scaphoid ligaments, and the head of the astragalus is then exposed, the tendo Achillis divided, and the foot forcibly wrenched into as straight a position as possible. The gaping wound is then packed with antiseptic gauze, and the whole foot encased with a plaster of Paris bandage.

I have not yet met with a case in which I have thought these operations desirable, because less severe measures have sufficed, and, as I have remarked previously, the division of the ligaments uniting the tarsal bones has no advantage in the long run.

These formidable operations are not altogether without danger, and the results, as far as I have seen, are no better than persistent treatment by tenotomy and pressure, as previously followed by orthopædic surgeons. Other surgeons have somewhat modified these operations, but in any case they remain extremely severe procedures, and for those surgeons who have experience of

the ordinary orthopædic methods they hardly ever seem justifiable, and are certainly very seldom necessary.

OSTEOTOMY

The removal of a wedge of bone from the convex side of the foot in cases of severe varus or equino-varus has been frequently performed, but I do not believe that this operation is ever necessary in young children. In adults it is another matter. I have seen one case in which osteotomy was decidedly beneficial. It is, however, so exceptional that this method of treatment is required that I do not give further details of its performance.

In connection with this subject it is to be remembered that, whatever operation is performed, retentive apparatus must be used subsequently for the purpose of keeping up the improved position for a certain length of time, and if the muscles remain paralysed and the joint is free, such mechanical help will always be required. There is one possible advantage in osteotomy in cases of severe paralysis—it is that, as after such an operation the joints of the foot usually become ankylosed, the foot is thus converted into a prop, on which the patient can walk. This result is akin to excision of a knee joint in cases of absolute paralysis of motion of the knee. By such treatment retentive apparatus may possibly be eventually dispensed with.

COMPLETE PARALYSIS OF THE LOWER EXTREMITIES (PARAPLEGIA)

When the muscles which unite the lower extremities to the trunk are completely and irreparably paralysed, then, obviously, it will be impossible to restore any portion of the walking powers ;

and when the bladder and rectum are involved in the paralysis the life of the patient is seriously jeopardised.

This severe degree of paralysis is exemplified in cases of fractured spine with crushing of the spinal cord.

In those instances of fractured spine in which the cord is only compressed and not crushed, the life of the individual may be prolonged for months or years, the patient remaining in the recumbent posture, absolutely helpless as regards his lower limbs. In these cases, the spinal cord being only partly injured, it is always possible that partial or complete recovery may ensue.

Although it is no part of this work to discuss the original condition causing the paralysis, yet it may be stated that under such circumstances operations for the removal of pressure upon the cord may be undertaken, and if any relief can be given in this manner, and if some muscular power remains, apparatus may be very useful by enabling the patient to get about. Massage and passive exercises will also help by maintaining or increasing the vitality of the limbs (see Appendix).

Pressure upon the cord from other causes may also sometimes be remedied by operation, a fact which I have also exemplified by the record of such a case in the appendix.

When complete or nearly complete paraplegia remains without bringing about the rapid death of the patient, the only means we have of enabling the sufferer to get about is by the use of mechanical chairs, go-carts, and tricycles. We have the old Merlin chair, which the patient can propel by turning the wheels with his hands, and tricycles or wheel-chairs worked by levers by the patient's arms. Crutches are useless to these patients.

PARALYSIS NOT INVOLVING ALL THE MUSCLES BETWEEN THE TRUNK AND LOWER LIMBS

If the muscles connecting the thigh bones to the pelvis remain sound, although all below are paralysed, it will be possible to enable the patient to walk.

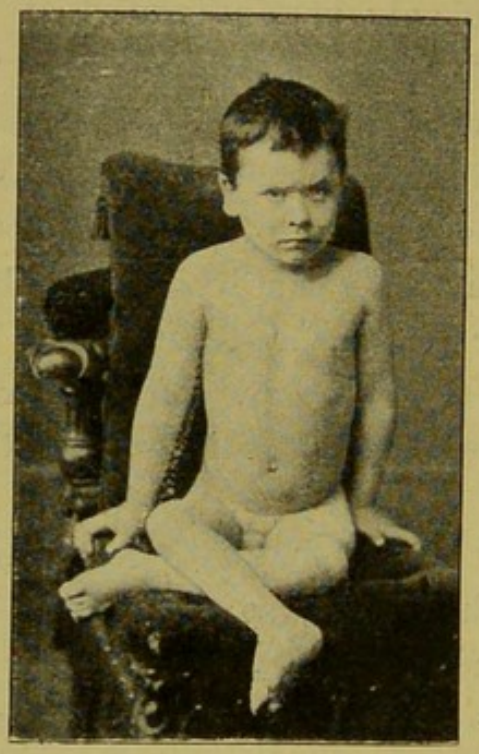


Fig. 10.—Paralysis of all the muscles of the lower limbs except those between the trunk and the upper end of the thigh bone

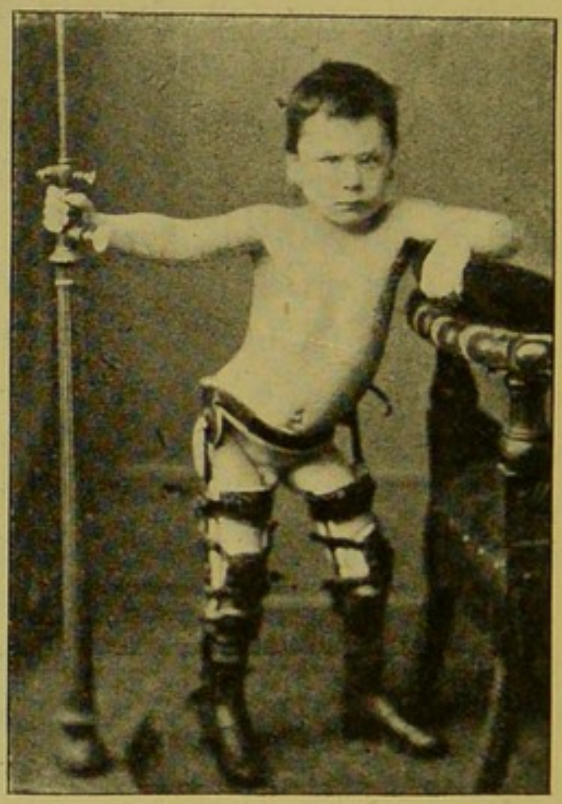


Fig. 11.—The same boy as in fig. 10, the first day of application of a mechanical support. He could walk without any other help than this apparatus

Case I. Figs. 10 and 11 are reproductions of photographs of a child who had been attacked by paralysis in early life, and had never used his legs. He was admitted to the All Saints' Children's Hospital, Margaret Street. He could sit up when placed on a chair, as shown in fig. 10, by supporting himself with his hands;

but his legs were quite powerless. It is many years since I saw him, and I have no accurate notes of the case. His age was about six, and, as I found that the muscles between the pelvis and thighs were acting, I had an apparatus made for him by which he was enabled to walk. Fig. 11 shows his first attempts at standing. He soon improved in his powers of progression.

In considering the appearance of this child in fig. 11 it must be understood that this was the first time in his life that he had rested on his feet. While the photograph was being taken he had to support himself as seen in the illustration (twelve seconds), but he could walk about without other help than the instrument. At first he was very awkward, but in even a few days he learnt to move fairly well, and his delight at being able to walk was very great.

Fig. 12.—Showing the ungainly and painful method of getting about on crutches when paralysis of the lower extremities is extensive

With so much paralysis 'crutches' were useless, and if there had been some power in the adductors and recti even then the use of crutches would have been greatly inferior to the effect of the instrument. Fig. 12, Case II., shows a patient in this latter condition using crutches. He had very great difficulty in getting about at all, but with leg supports he made very good progress.

PARALYSIS IN CARIES OF THE SPINE

This affection generally takes the form of spastic paraplegia. Treatment of the spinal disease is the remedy, and I have never known a case where efficient fixation of the spine, with general treatment of the patient, has failed to remove the paralysis of the legs, unless the spinal disease has, through neglect, become so advanced that it has been impossible to save the life of the patient.[1]

Spastic contraction of the flexors of the lower extremities in patients affected with caries of the spine denotes an extension of inflammatory mischief, pressure upon the spinal cord and consequent myelitis. However severe the contraction may be, tenotomy is inappropriate so long as spasm, denoting an active condition of caries, remains. Pressure on the cord from an abscess may sometimes necessitate the performance of laminectomy, but as a rule the spasmodic contractions resulting will subside under efficient fixation and general treatment. When, however, the active caries has been subdued and consolidation has taken place, then, if permanent contracture remains, it will be necessary to perform tenotomy, particularly of the tendines Achillis.

CEREBRAL PALSIES IN CHILDREN.

These are divided into the congenital or 'birth palsies' and acquired or 'infantile hemiplegia.'

Birth palsy.—Gymnastics and passive movements are usually of advantage in improving the general health of these patients, but as regards paralysis of the lower extremities the treatment, especially operative or instrumental, must depend upon the whole

[1] See *Caries of the Spine*, by Noble Smith, 2nd edit. Smith, Elder & Co., 1897.

condition of the patient. In severe cases, when there is hopeless mental deficiency, and when all four limbs are affected, such treatment may be out of the question, but there are many others in which something can be done to help the walking powers. It has been noted that the brain is less affected when the paralysis is confined to the lower extremities, and under such circumstances light apparatus will assist the patient to direct his own movements with advantage.

Dr. James Taylor, writing in Allbutt's 'System of Medicine,' vol. vii. p. 740, advocates measures being taken to prevent deformities such as talipes and lateral curvature, or, if these deformities have already occurred, he rightly advises operative or mechanical treatment, which 'will tend to correct them, or at least to minimise their effect.' I quote this authority as showing that physicians now recognise more than they did formerly the advantages of these methods.

Infantile hemiplegia.—In these cases one of the most noticeable results of paralysis is the want of development of the affected side, so that in the lower limbs there will be deficient length as well as circumference, necessitating, among other remedies, an addition to the sole of the boot or some other method of lengthening the limb. Dr. James Taylor (*op. cit.*) states that 'the defective development of the structures on the affected side is more probably the result of the disuse which the paralysis enforces than of any direct neurotrophic influence.' If this view is correct we may infer that any mechanical help which will enable the patient to use the affected limb will also help to increase its further development. There is far less often any mental deficiency in these cases than in those of 'birth palsies,' and so we may hope for the intelligent help of the patient in using artificial help. A similar kind of hemiplegia sometimes follows acute diseases, such as scarlet fever and diph-

theria, and the same sort of assistance may be afforded. Gymnastic exercises, passive movements, and massage are also valuable methods of treatment, and will assist in minimising the rigidity which accompanies the paralysis. The question of the division of the tendons of muscles affected by spastic contraction may have to be considered, and the remarks under Primary Spastic Paraplegia also apply to instances of infantile hemiplegia (see p. 31).

When one limb is shorter than the other the deficiency must be made up by adding to the sole of the boot or in some other way (see p. 77).

ACUTE MYELITIS

Patients suffering from this disease, who have been so far fortunate as to survive the acute and pass into the chronic stage, will sometimes be benefited by the use of mechanical apparatus.

Dr. Byrom Bramwell writes as follows regarding the advantages of encouraging patients to get about:

'In severe cases of myelitis recovery is usually very slow; it may be many months before the motor power is sufficiently restored to enable the patient to stand or to walk even with the help of sticks. . . . Whenever recovery has advanced sufficiently far to enable the patient to stand, even with support, he should be encouraged to try and walk. . . . During the early stage of the case, when the acute changes are still in active progress, attempts at voluntary movement should be avoided. But once the acute stage has subsided, say at the end of six or eight weeks, the patient should be encouraged to make regular systematic movements of the paralysed muscles, and when a certain amount of motor power has been regained he should be encouraged to attempt to stand and to try to walk. An enormous step is gained when the patient

finds that he is able to stand, and still more when, with support and help, he is able to walk a few steps across the floor. He then feels himself in an altogether different position; he looks with renewed hope to the future; he realises that he *will* ultimately be able to walk. Although, in many cases of transverse myelitis the patient recovers sufficiently to be able to walk, recovery is very rarely complete when the myelitis has been severe. In cases of this kind a condition of spastic paraplegia usually remains.'

PRIMARY SPASTIC PARAPLEGIA (Primary lateral Sclerosis)

In paralysis of the lower limbs due to incomplete transverse lesions of the spinal cord, we find, soon after the commencement, an excess of muscular irritability, as shown by increased knee jerks, &c., and this gradually becomes a condition of chronic spasm or spastic paraplegia. This condition may be acquired, or it may be congenital, or at least date from the time of birth, and in these latter cases it is said to be due to injury to the brain during birth—in most cases as the result of meningeal hæmorrhage.

Modern writers upon this disease usually advocate massage and exercises, but they are seldom able to show that these remedies have done much or any good, nor can they say that any substantial relief is to be derived from electricity. The difficulties in movement due to the contractions interfere greatly with exercises. In a recent publication dealing with this subject, the late Sir Thomas Grainger Stewart remarks:[1] 'Regulated exercises should not be neglected after the period of rest,' while on a previous page (p. 141) he describes very graphically the difficulties of movement caused by the general spasmodic condition. 'The patient walks

[1] Allbutt's *System of Medicine*, vol. vii. p. 144.

slowly and with effort; he is unable to lift his feet clear of the ground,' and later on 'progression becomes almost impossible,' or, he might have added, quite impossible.

All writers upon this disease refer to the unsatisfactory results of treatment as usually carried out, *i.e.* without operation. The remedies above referred to are theoretically calculated to do good locally, but they are ineffectual on account of the constant, or almost constant, spasmodic contraction which is going on.

Operative measures.—Orthopædic surgeons in various countries have for many years past been trying the effect of division of the tendons of the contracted muscles in this disease. These surgeons have acted with the object of relieving the patients from their more distressing symptoms, and of facilitating walking, and their experience has been, without exception, I believe, favourable to this operative treatment.

Theoretically tenotomy is not an ideal treatment, because the contractions are dependent upon a brain affection and not essentially upon structural shortening of the muscles. In practice, however, we find a distinct benefit from tenotomy in certain selected cases.

In all instances of spastic paralysis the prognosis is extremely unfavourable, and the patients, besides remaining very severely deformed, suffer from the severe spasmodic contractions which occur. Children affected with this disease doubtless suffer frequently from deficient brain power, but many of them are fairly or quite intelligent. When the mental deficiency is very severe, it is probably useless to operate. It must, however, be remembered that parents, as a rule, feel great sympathy for their children when affected in this manner, and are glad to have the walking powers improved, notwithstanding the mental incapacity.

The use of apparatus, without previous operation, is, as a rule,

not only useless but harmful. Such means do not control the spasmodic actions but rather set up irritation, and even produce sores from the constant friction which takes place. By division of tendons we are able to facilitate the patient's powers of movement, and, in some apparently helpless cases, we may even enable him to walk.

The spasms are frequently relieved and sometimes removed by operation on the tendons. There is also often an improvement in the mental condition of the patient following this treatment, a result which may be due to the relief of reflex irritation, from lessening or removal of the spasms.

The muscles which are chiefly involved in the contractions are the extensors of the feet, the flexors of the knees, and the adductors of the thighs. The result is that the heels are drawn up, the knees kept in a bent position, and the thighs held together or even crossed.

In operating we may divide all the contracted tendons at one time, or, as some surgeons think best, at intervals.

If we adopt the latter plan the adductors are first divided or severely stretched. Then, after an interval of a few weeks or less, the hamstrings are cut, and subsequently, after another interval, the feet are relieved by section of the tendines Achillis.

The tendency to walk with the legs crossed from excessive action in the adductors, which may persist after operation, can be lessened by making the patient practise walking with a leg on each side of a plank placed vertically on the floor.

In the following case it may be assumed that without operation the patient would never have been able to stand or walk. There can be no doubt she has derived very great benefit from the treatment.

Case III.—Miss B., aged eleven, was brought to me in

September 1892. She had never been able to walk, in consequence of severe spastic paralysis of the lower extremities. She was also afflicted with severe kyphosis, due to weakness of the back and to the weight of the head, which was much enlarged, the cranial bones being apparently excessively thickened. Symptoms of hydrocephalus had commenced when she was one month old, at which time she also had suffered from an attack of convulsions.

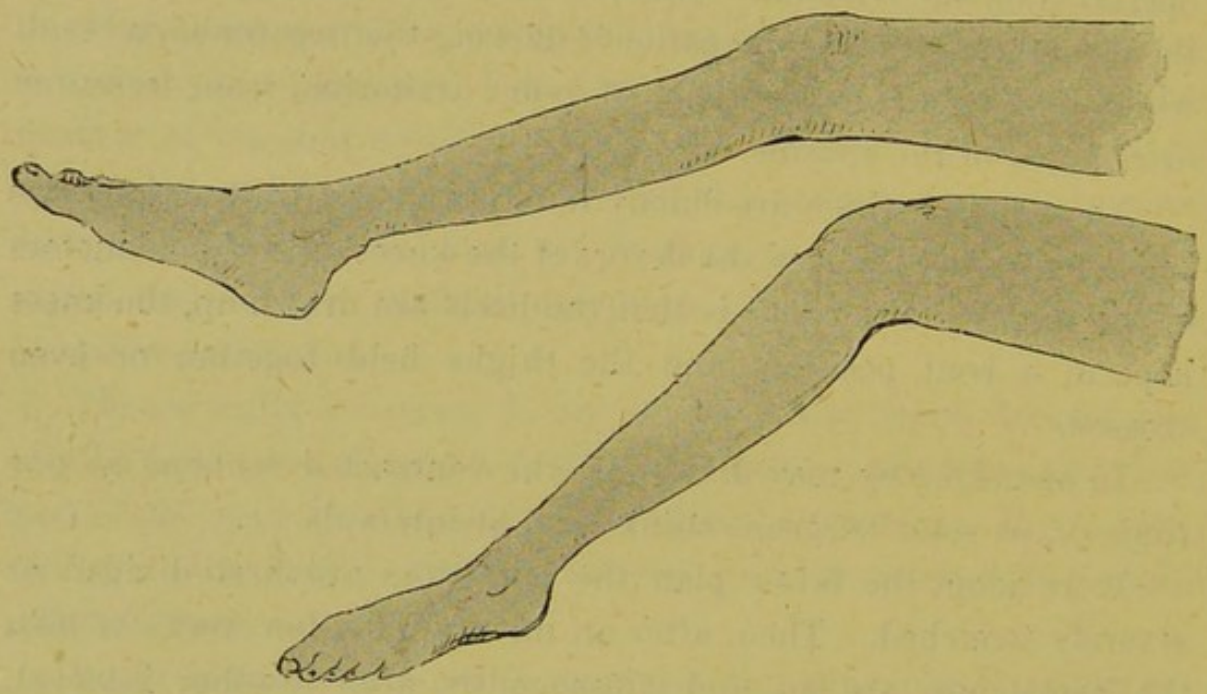


Fig. 13.—Spastic paralysis. The legs were held firmly contracted in the position shown. They could only be slightly extended further by means of very firm pressure

The convulsions recurred when she was a year old, and the head continued to enlarge till the age of seven. Three years later the spasms had become more general and more severe.

The feet were extended in the equinus position and the knees flexed, but the adductors of the thighs were not as much contracted as often happens in such cases (fig. 13).

I divided the tendo Achillis on both sides and brought the feet

up to right angles with the leg. I also operated on the hamstrings of the left leg, which were very tense from spastic contraction. The right knee, being only slightly contracted, was not operated on. With the help of light supports to the ankles I was enabled to get this patient on to her feet, and a few weeks after the operations she was able to walk across the room with assistance. The legs, besides being straighter after the tenotomies, were warmer, there was less spasmodic twitching, and the patient felt distinctly benefited. She had suffered from symptoms of defective circulation in the legs, and especially from severe chilblains. A few weeks after the operations these symptoms disappeared. Subsequently, in consequence apparently of too severe a test being put upon her walking powers, she had another attack of convulsions and lost the power of walking for a time, but there has never been so much spasmodic action in the muscles since their tendons were divided, and the patient and her parents consider that she has been greatly benefited by what was done. Communicating with her mother recently (June 1899), she confirmed my notes of the case, remarking that her daughter 'has certainly benefited by the operations. Her left leg, which was very much contracted in the knee joint, is now quite strong, and she is able to stand and walk a few steps with assistance.'

Indications for and against operative treatment

1. The patient's brain power must be sufficiently good to enable him to make use of the limbs after operation.

2. A severe condition of athetosis might be prohibitive.

3. The co-existence of epilepsy has been mentioned as a reason for not operating, but as the removal of any source of irritation may possibly be beneficial in this disease, I should be inclined to operate if the other conditions were favourable.

4. General rigidity would be an opposing condition.

5. Repeated attacks of convulsions would prohibit operation.

A further result of operation is that the use of mechanical apparatus and massage and exercises can be applied with effect, while, as already stated, so long as the affected limbs are spasmodically contracted these remedies are useless. If, in addition to tenotomy, care be taken that the apparatus is constructed upon scientific principles, the patient will be rather encouraged to use the muscles (so far as they are capable of use) than to leave them inactive. Upon the whole, though we may not be able by operation to absolutely cure the sufferers, we can undoubtedly relieve them.

LOCOMOTOR ATAXIA

The use of mechanical apparatus is very often desirable in this disease. The following is an instance.

Case IV.—Capt. W. was sent to me by Dr. De Watteville, July 3, 1894. During the year 1880 he had begun to develop symptoms of locomotor ataxia. He gradually became worse, until he could only get about in the position indicated in the rough sketch which I made of him at the time (fig. 14). He had experienced the usual symptoms of this disease, and had suffered from lightning pains and increasing inco-ordination. The lordosis and paralysis of the extensors were consecutive to the spinal degeneration.

He complained very much of a feeling of weakness caused by the lordosis, and it was thought that a support to his back might be of benefit. Upon consideration of his method of progression I thought that it would be better not to encumber him with any spinal apparatus, but to support his legs. This was effected in the manner

shown in fig. 15. I have shown sufficient of the apparatus to demonstrate its action. A trough plate supported the upper and anterior

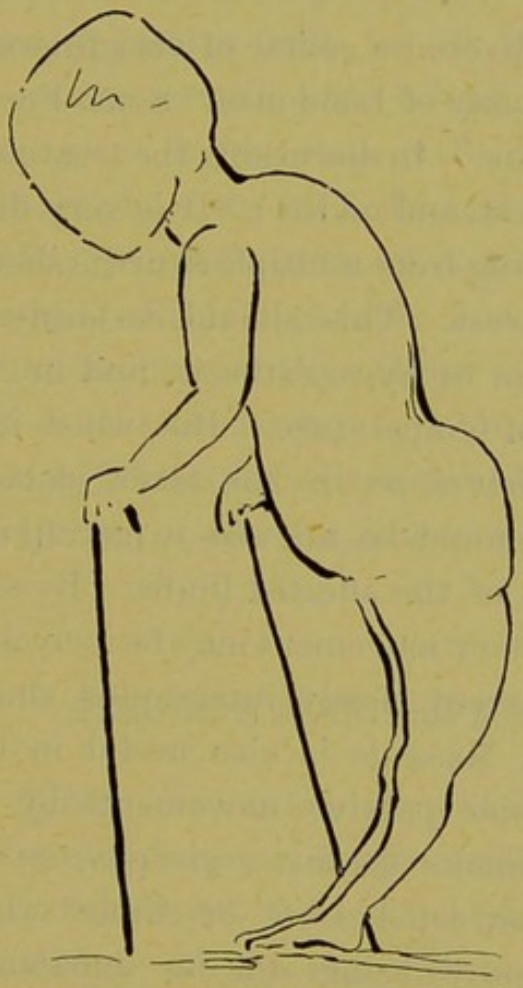


Fig. 14

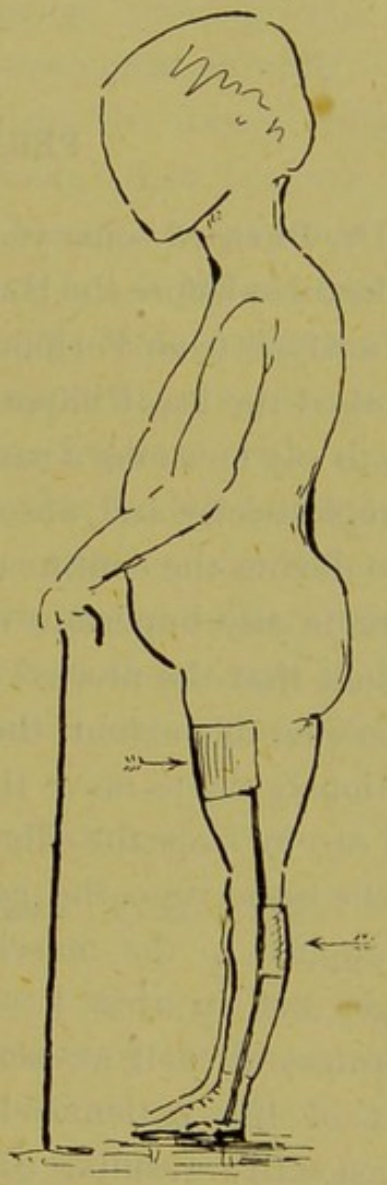


Fig. 15

Positions of the patient in standing and walking without (fig. 14) and with the apparatus (fig. 15)

part of the thigh, and the instrument was attached below to the boot, the joint at the knee was made with a back-stop to prevent the knee bending backwards, and a strong plate supported the calf.

With the help thus afforded the patient was able to adopt a much more upright position, the strain on the back became less, and for the time being he was greatly relieved.

PERIPHERAL NEURITIS

Dr. Buzzard some years ago delivered a course of very interesting lectures before the Harveian Society of London on 'Some Forms of Paralysis from Peripheral Neuritis.' In discussing the treatment he urged the great importance of rest, and added: 'It is very difficult to say how long a patient suffering from multiple neuritis should be kept strictly and absolutely at rest. This should certainly be done during the continuance of pain or hyperæsthesia, and in case there is any important elevation of temperature. But when it is evident that the process of regression or repair has taken place to a considerable extent, the patient should be allowed to get up and cautiously try to move the muscles of the affected limbs. By slow and careful steps the effort at voluntary movement may be increased. At the same time the galvanic current slowly interrupted should be applied to the muscles. . . . . Massage is also useful in this stage, and in this I would include passive movements by the operator, as well as active movements against resistance on the part of the patient. In the contracted state of limbs which occasionally results, the contracture being due to unbalanced muscular antagonism, division of a tendon may sometimes be adopted with advantage. Considerable patience should be employed before proceeding to this measure, as I have known contractures, which were to all appearance hopelessly permanent, yield, without operation, to assiduous massage combined with active and passive movements. Along with the contracture of the muscles, it will

sometimes be found that adhesions have taken place in some of the joints, owing to disuse. These should be forcibly broken down. The aim generally should be to disengage muscles from obstructions to their movement, and to encourage their growth and functional activity by various kinds of physiological stimuli.'

This sums up in a very practical manner the line of surgical treatment to be adopted, and it will be found that the use of a light apparatus will be of enormous benefit to patients who commence to walk after a long period of rest. A patient who can only move a few steps with great difficulty and strain may be enabled, by help of light instruments supporting the knees and ankles, to walk perhaps ten times the distance with greater comfort. Such apparatus is far less trouble to the patient and far more effectual than sticks or crutches; crutches, moreover, are not devoid of danger from their pressure on the axillary nerves. The usefulness of light mechanical supports in these cases is, I am glad to say, quite recognised by Dr. Buzzard.

PSEUDO-HYPERTROPHIC MUSCULAR PARALYSIS

When this disease has existed a long time, and has become 'advanced,' we find contractures of the flexors of the knees, which are attributed to the habitual flexion of these joints. We also find contracture of the calf muscles producing talipes equinus. This may occur early, before the opponents of these muscles have shown signs of weakness. As this disease is always a constantly progressive one, and as drugs are powerless to do good, the treatment of the deformities, although beneficial, is not curative. However, the patients derive comfort from operations upon the tendons, and life may even be prolonged by the relief of the con-

tractures. The patients may be further assisted to walk by the help of light apparatus. Massage, passive movements, and systematic exercises are also beneficial in these cases.

SPINA BIFIDA

In many instances of spina bifida the feet are deformed from paralysis and contractures, the muscles below the knees being those most commonly affected. Often the tibiales antici escape, and then talipes equino-varus is produced. If the spina bifida can be cured by operation, tenotomy may be required to place the feet in a position to allow the patient to walk, and if, as usually happens, some paralysis remains, then apparatus will be necessary.

INFANTILE PARALYSIS. (Acute Anterior Polio-myelitis)

The majority of the cases of deformity of the lower limbs which come before the orthopædic surgeon are those resulting from infantile paralysis.

In the active stage of this disease supporting apparatus (which may often merely consist of simple splints) will aid materially in preventing subsequent deformity. It is probable that if such supports were applied in all cases soon after the onset of the paralytic attack tenotomy would be much less frequently required, but the orthopædic surgeon is rarely consulted in the early stage. It is when the acute attack has passed off and the limb is found to be contracted into an abnormal position that the case is brought before him.

It is commonly believed that these deformities arise simply from the foot or limb being drawn into a wrong position by the

sound muscles, from loss of power in the paralysed antagonistic muscles, but doubtless there is something more than this. There often is at first some spasmodic action in the muscles, which subsequently become permanently contracted. Certain it is that soon after an attack of infantile paralysis, when the contracture is in a progressive condition and the foot by means of firm pressure can be replaced temporarily in its natural position, the state of the contracting muscles is a morbid one, and even if the foot under these circumstances be fixed in its natural posture we shall find subsequently a certain amount of permanent shortening in the contracting muscles. This contractile condition is possibly a continuation of that rigidity which sometimes occurs and which is said to usually pass away rapidly. Sir William Gowers, in describing these contractures, seems to refer to this morbid condition of the contracting muscles by stating that 'it is uncertain how far it' (the contracture) 'is favoured by a slight degree of paralysis.' It must also be remembered that many cases of contracture of muscles occur quite independently of paralysis.

In Case VII. p. 49, such active spasm simulated the condition of spastic paralysis.

Sir William Gowers, in describing the chronic stage of infantile paralysis, during which atrophy of the muscles continues, remarks: 'The duration of this stage is indefinite, because, wherever muscular tissue remains and some voluntary power returns, this slowly improves by increased development of the muscle under the influence of use, and this continues in slight degree for years. This gain is often, however, more than counterbalanced by the interference with growth and by the occurrence of deformities. Even in the slightest cases complete recovery is extremely rare, and the limb remains smaller than its fellow.'

There can be no doubt that the sooner these contractures and

deformities are ameliorated or removed the better, and while it is a fact that the contractures, so long as they remain, interfere greatly with growth, tenotomy will usually relieve this condition and allow development to take place naturally. If the foot or limb be already smaller than its fellow, the deficiency cannot, of course, be made up; but the release of all the contractures, coupled with the improved nutrition which an operation brings about, induces natural growth in the future.

The use of apparatus constructed upon scientific principles—that is, *with the object of directing the movements of the limbs to act remediably*—is also of great value. Such apparatus not only prevents the foot from falling into a wrong position, but induces a systematic use of the sound muscles. Thus the patient is always (when moving about) using his muscles in the best possible way, and a better result is effected than by ordinary exercises alone, and with much less trouble. Generally the addition of passive exercises is also desirable. Sir William Gowers, in dealing with the importance of the prevention and treatment of muscular contractures and the deformities to which these give rise, refers to the influence of posture, and urges carefulness and frequent examination of the patient. He states that to counteract the bad position is chiefly a matter of common-sense and a little ingenuity.

In orthopædic surgery we meet with plenty of evidence showing that as a rule no effectual means are taken to prevent such deformities, and that general directions given to the patients as to the way they should exercise the weak parts have not a very satisfactory result.

In considering the advantages of supporting apparatus, it is necessary to refer to the great weakness and relaxation of joints which occur when all the muscles which act upon or surround such joints are paralysed. In the case of the knee, to such an extent

may relaxation be present that luxation may take place, and it is here especially that apparatus are useful.

Excision of knee joint.—In cases of total paralysis of the leg, in which the knee becomes so lax that the limb is like a flail, some surgeons advocate excision of the joint, to afford the patient a useful leg in progression. In the case of patients of the poorer classes, who are unable or unlikely to manage or afford well-constructed apparatus, this operation is useful, but they have to put up with the disadvantage of a stiff straight knee which cannot be bent for the sitting posture, whereas by means of an apparatus with a ring-catch joint at the knee, a rigid or relaxed joint can be obtained at the will of the patient by an easy manipulation of the catch.

SOME TYPICAL CASES OF INFANTILE PARALYSIS

Extensive paralysis of right leg with contraction of calf muscles

Case V.—Miss S., aged 32, consulted me in June 1888, upon the advice of Mr. J. B. Curgenven. At the age of nine she had been attacked by paralysis which involved the whole of the right leg, and she was quite unable to get about for nearly two years, when she managed to walk a little with crutches. I found that the quadriceps extensor of the right limb was paralysed, the adductors were very weak, and the calf muscles were contracted. The leg assumed the position shown in fig. 16, the upper extremity of the tibia being displaced and bent backwards upon the lower extremity of the femur, but there was no marked contraction of the hamstrings. It will be seen (fig. 16) that the foot was level with the ground notwithstanding the contraction of the calf muscles. While the leg remained in its deformed position in relation to the thigh it seemed advisable not to divide the tendo Achillis,

especially as the whole limb was very deficient in power. This patient also suffered from a very severe lateral curvature, a deformity which was probably due to the general weakness and the giving way of the leg in walking. I had a light apparatus made to support the right leg, taking its bearing from the thigh and foot and

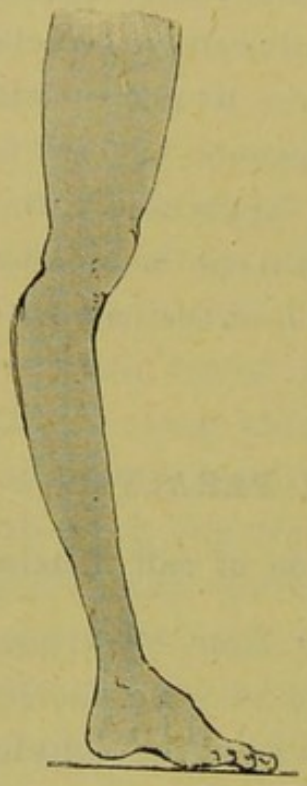


FIG. 16.—Appearance of leg in June 1888. The upper part of the tibia being curved backwards and the calf muscles contracted

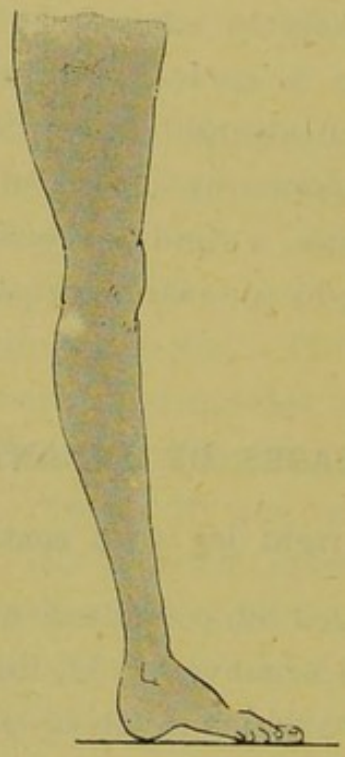


FIG. 17.—Appearance of leg in January 1899. The upper part of the tibia having improved in position but the equinus still remaining

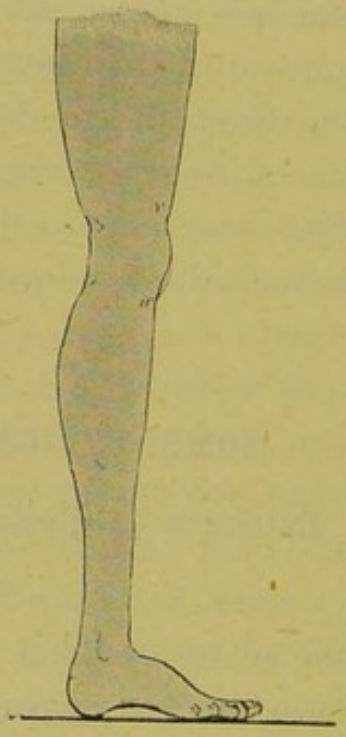


FIG. 18.—Appearance of leg June 1899, after section of the tendo Achillis, the foot being freely flexible

pressing the calf forwards. A ring-catch joint was made for the knee, which allowed the patient to keep the leg stiff when walking and to bend it when sitting down. She was thus enabled to walk about in comparative comfort. Her health greatly improved, and she has remained well since that time. I saw her occasionally, and gradually increased the pressure on the calf, in response to

which the leg assumed, by degrees, nearly its normal position, but the foot remained extended with the heel drawn up about an inch from the ground. This is shown in fig. 17. When I first saw this patient I did not contemplate being able to produce so much improvement in the position of the leg in its relation to the thigh, but applied the apparatus simply for the purpose of enabling her to walk about with less difficulty. Very little attention had been paid to the leg, for the apparatus required but few readjustments. It consequently happened that the amount of straightening of the limb at the knee was not quite realised until April 1899, when I advised section of the tendo Achillis. It was obvious that this was the right course to take, because the patient could not get her foot to the ground except by placing it forwards as shown in fig. 17.

On February 10, 1899, I divided the tendo Achillis, and by the beginning of March the patient was walking about freely and already experiencing very great improvement in her powers of locomotion (fig. 18). The greater freedom of movement to the foot seemed to have already stimulated the muscles to better action. The condition of the muscles was as follows:

February 25, 1899.—'Peronei and extensors of toes act to faradism of moderate strength and also to galvanism. No reaction to either faradism or galvanism obtained in tibialis anticus, calf muscles, or quadriceps extensor of knee. Flexors of knee fairly powerful. There was a very slight reaction of flexors of toes to strong faradism.'

June 1899.—'The patient recognises much benefit from her greater freedom of movement in the ankle, and is improving.'

Infantile paralysis, causing talipes equino-varus, pes cavus, and genu valgum

Case VI.—Miss B., aged seventeen, was brought to me on February 21, 1899. At the age of seven she suffered from scarlet

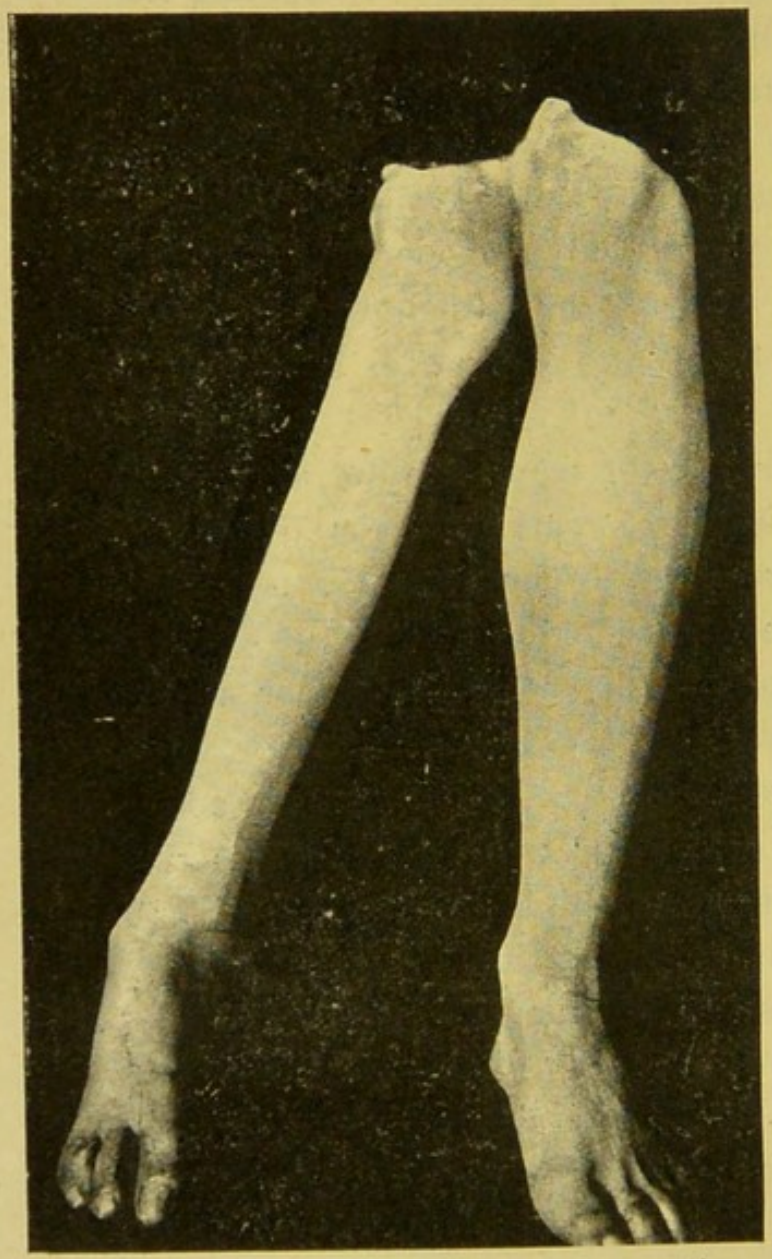


Fig. 19.—Position of right limb before operation. The foot could not be flexed more than shown in the photograph

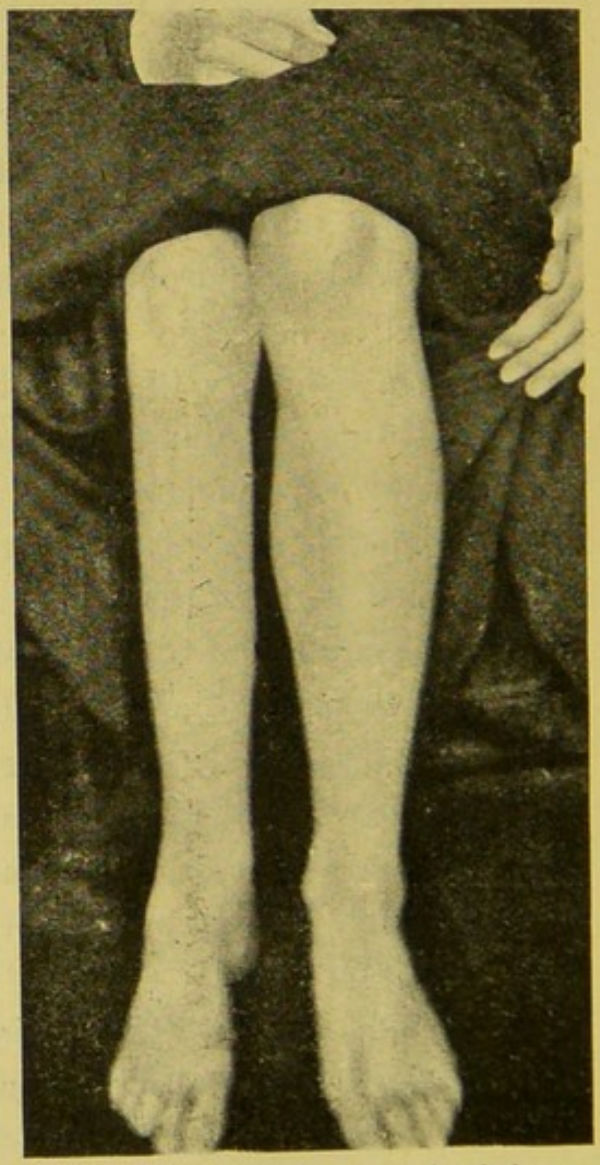


Fig. 20.—Position of the legs in sitting a few weeks after the operation

fever, after which the right leg was found to be partly paralysed. The leg became so much deformed that at the age of ten an

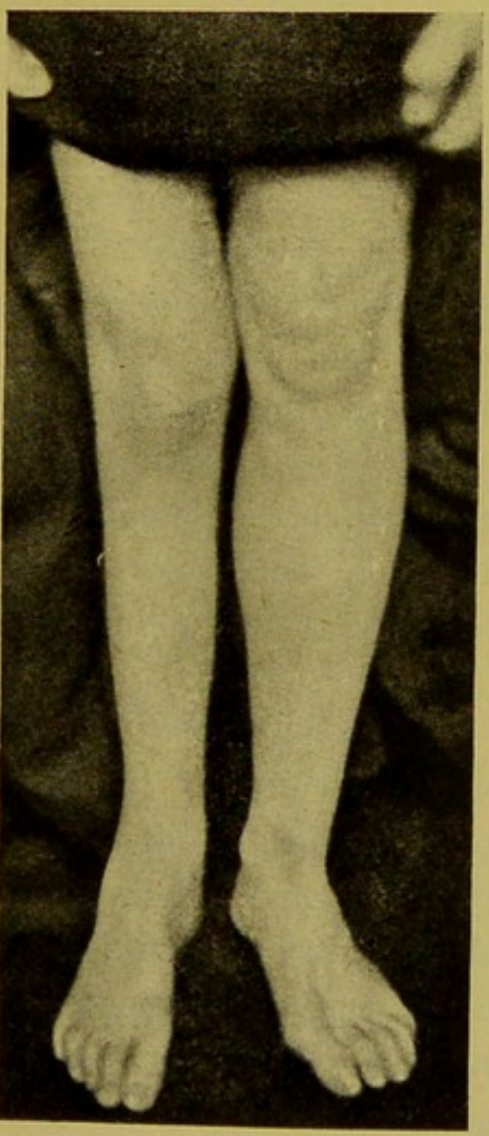


Fig. 21.—Position of the legs in standing after operation

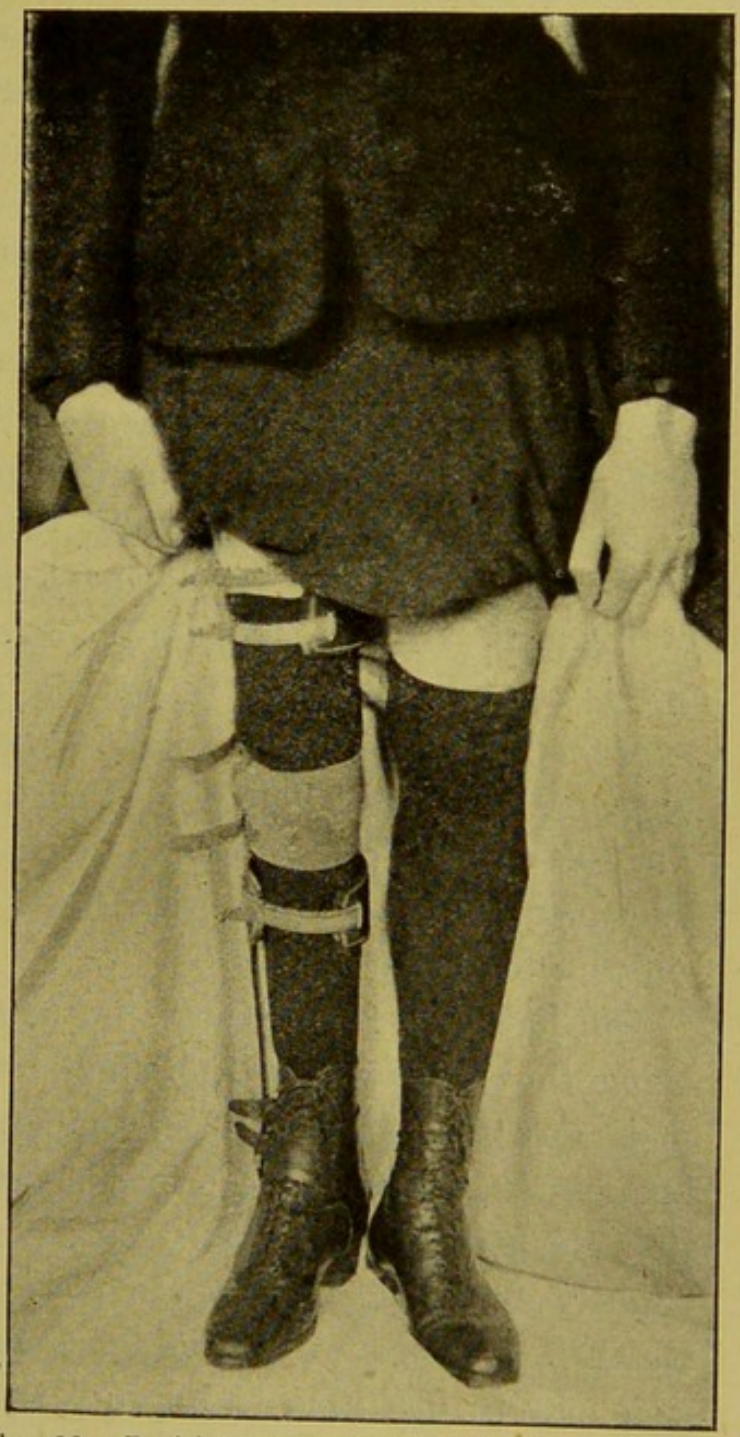


Fig. 22.—Position of the legs in standing and walking with the light support applied, and with extra thickness in the heel of the boot

apparatus was made extending from the patient's waist to the sole of her boot, with a ring-catch joint at the knee and with irons on each side of the leg. This had been replaced from time to time, and had enabled the patient to walk, although with great difficulty. Previous to the use of apparatus she had been dependent upon crutches for getting about.

The electrical examination of the limb showed good power in the flexors and extensors of the knee joint. The muscles below the knee were all much wasted, and the calf muscles much contracted, but the flexors and extensors themselves responded to faradism. There was no reaction of the other muscles of the legs even to a strong current of faradism or constant current. Fig. 19 is a facsimile of a photograph taken before operation. This shows (1) the deficient development of the right leg, (2) the extent of the genu valgum, and (3) the deformity of the foot. The foot could not be flexed by the patient more than appears in this figure, and it could only be altered very slightly by passive movement. The affected limb was $1\frac{3}{4}$ inch shorter than the sound one. The foot and leg below the knee were almost constantly cold. The movements of the thigh were fairly good, except the adductors, which acted but feebly.

On February 24 I divided the tendo Achillis, and was able to bring the heel down considerably but not completely. I did not make any great effort to effect complete reduction on this occasion, because, as the leg was so much shorter than the other, I thought that the patient would for a time get about better with the foot slightly extended. When the power in the leg has increased—which I consider will certainly happen—then a further operation may be desirable to improve the position of the foot and to give greater facility to the walking. *Better effects can be obtained by gradual treatment than by attempting to correct everything*

at once. This is a rule which applies to many of these deformities of limbs.

The history of this case was described by the patient as follows. 'June 11, 1899: I used crutches for about two years, being unable to walk; afterwards I was advised to have an instrument, which was very heavy and cumbersome. I had worn this instrument up to the beginning of this year, being obliged to use a stick also. I am now eighteen, and during the past two years have had great difficulty in walking even a short distance. My foot was very painful, there was no circulation, and it was very cold; consequently I had a great many chilblains. . . . After the operation I was able to walk much better, and am continuing to do so with the lighter support, and am quite free from any pain. My foot and leg have regained circulation and warmth. Day by day I am able to walk farther, and have more strength in my leg. Though I use a stick for long distances, it is not necessary in the house. The relief during the hot weather to have lost my former instrument is so great that my general strength has improved . . . .'

Infantile paralysis, with very active contraction in the calf muscles of the right leg and talipes equinus of the left

Case VII.—Miss G., aged five, was sent to me on February 15, 1898, by Dr. Mouillot, of Harrogate. The child had been quite well up to the end of the previous August, when she was attacked with sudden paralysis. It was said that, with the exception of the head and arms, the patient was entirely paralysed. Recovery had taken place gradually until the end of the year (1897), since which time her condition had remained about the same. I found the right foot extended in a position of severe equinus, and

held there by very active contraction of the calf muscles; there was also intermittent spasmodic contraction of the peronei, tending to turn the foot outwards, but this latter was slight. There was very little power of flexion of the thighs, the left being the weakest. The left foot was contracted in an equinus position to the extent

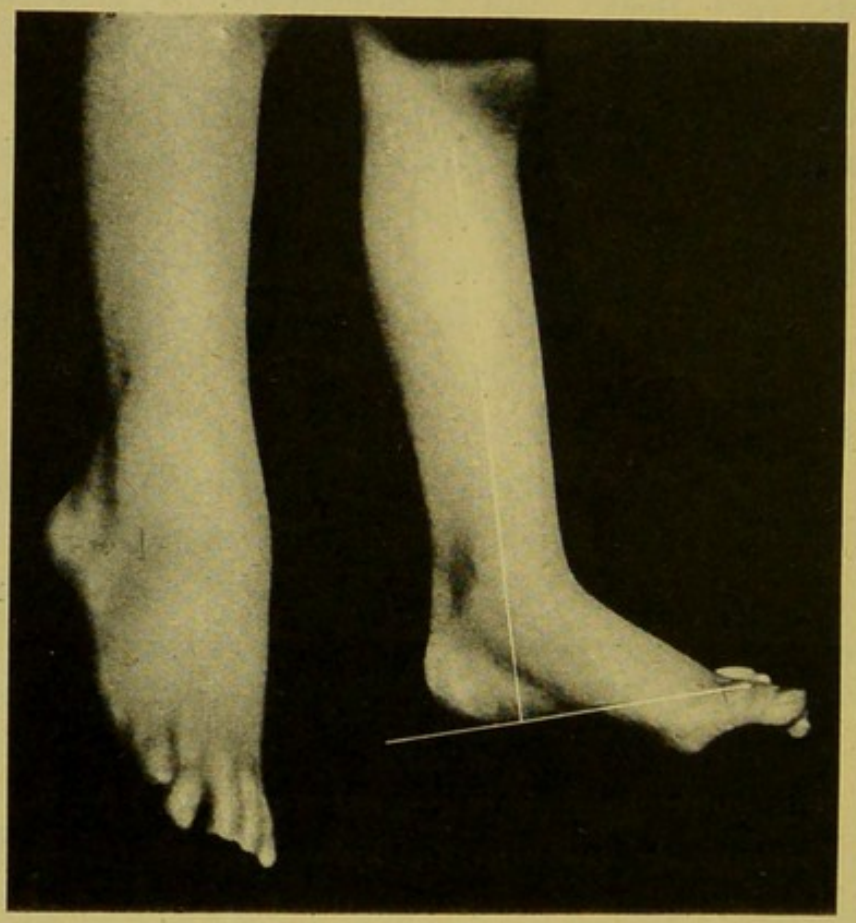


FIG. 23.—From a photograph of the legs before operation; the left foot is being pressed upwards at the base of the toes

shown in fig. 23 (the white lines indicating a right angle with the vertical line of the leg); but in this leg there was no spasm. The anterior tibial muscles on both sides were apparently paralysed.

The left tendo Achillis was operated upon in the ordinary way, and the foot fixed at right angles with the leg. As regards the

right foot, its spasmodic condition would, according to the views of some surgeons, have been a bar to operation; but, acting upon my previous experience of these cases, I determined to divide the tendon of the contracted muscles. I estimated that the separation of the cut ends would exceed two inches in length, and, considering the spasm, it was possible that these ends would retract even further apart if the tendon was simply divided by the ordinary subcutaneous method. I therefore performed an open operation, splitting the tendon and suturing the two ends together with silkworm gut, as shown in figs. 24 and 25.

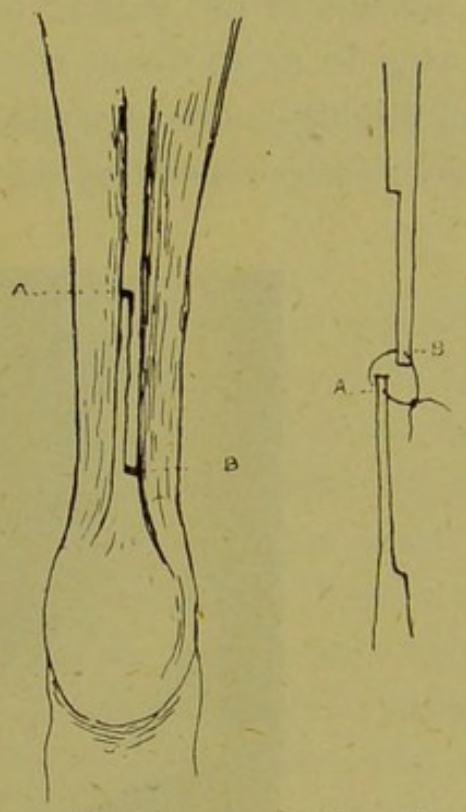


Fig. 24 Fig. 25

Figs. 24 and 25. — Diagrams showing the method of splitting the tendo Achillis longitudinally, and cutting at one end to the left and the other to the right, and suturing the two attenuated ends together

The result was excellent, and a few weeks later the child was able to commence walking, and the feet assumed the appearance shown in fig. 26. With the help of light supports, to keep the feet acting in a natural direction and to counteract the loss of power in the anterior tibial muscles, the child walked about very well and gradually grew stronger. The anterior tibial muscles of both legs, however, remained paralysed, and the peronei on the right side still acted spasmodically and drew the foot outwards. The spasms in the right calf had entirely ceased after the operation. My report of the patient at that time, and my advice as to further treatment, may be stated as follows: The function of the muscle on the front of the leg (tibialis anticus), which should flex the foot, being lost in both

legs, some mechanical assistance will always have to be used, unless and until the power of these muscles can be restored; I therefore advised section of the tendons of these paralysed muscles upon the principles described on p. 63. I also advised division of the peronei on the right side, and it was further necessary to again divide the tendo Achillis on the right side, to obtain a slightly more extended range of flexion than had been effected by the first operation on this tendon. It is very rare indeed that

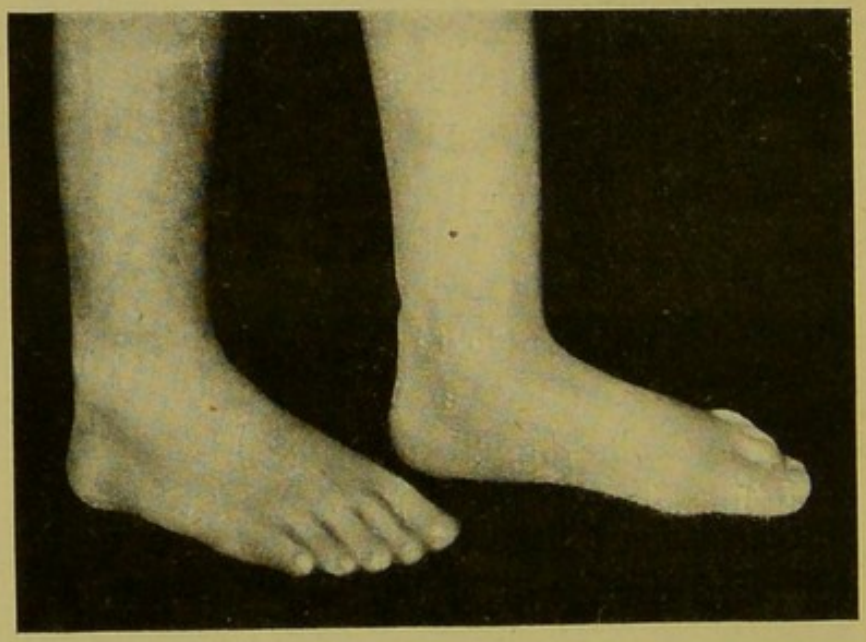


Fig. 26.—The feet a few weeks after operation

I have found it requisite to divide the tendo Achillis a second time, but in this instance the necessity for this second operation was not unlooked for, because it was impossible on the first occasion to regulate the length of the tendon to its exact requirements, on account of the great amount of shortening and also on account of the active spasmodic condition of the calf muscles. The operations described above were carried out, and the result was very satisfactory. The anterior tibial muscles, about a fortnight after

division of their tendons, had regained some power of action. The child is now walking remarkably well, and there seems a good prospect of a nearly complete recovery. The quadriceps extensor on the left side, however, remains weak, although that on the right has improved in power.

Infantile paralysis; paralysis of calf muscles; contraction of plantar fascia; slight talipes calcaneus; treatment by shortening of tendo Achillis, &c.

Case VIII.—Miss C., aged eleven. This patient had suffered from an attack of infantile paralysis at the age of four, when she lost the use of both her legs. Gradual recovery took place, but was not complete. She was brought to me in December 1896, when I found that although there was paralysis of the gastrocnemius of the left leg, the soleus acted normally. There was slight talipes calcaneus and the leg was half an inch shorter than the right, measured at the internal malleolus; also the plantar fascia was contracted. I thought that the heel had dropped at the time of the complete paralysis, and that now that the deep muscles of the calf were acting well the defects would be relieved by the following operations.

Subcutaneous section of the plantar fascia, and subsequent shortening of the tendo Achillis.—The latter operation consisted in cutting down to the tendon, removing about a quarter of an inch of its length, and suturing the cut ends together closely. The result was good, the patient being able to get about subsequently without any defect. A light support was applied to retain the heel in its normal position until the united tendon had become quite strong. I saw this patient two years after the operation, and found that her walking power was perfect.

Infantile paralysis; tenotomy and transplantation of tendons, and the use of apparatus

Case IX.—Master G., aged four, was brought to me January 8, 1890. When he was seven months old he had had an attack of bronchitis, and after that the legs were found to be paralysed. Two months later treatment by galvanism, local heat, rubbing for two hours daily, and hot applications to the spine, followed by a cold douche every night, was carried out.

The patient presented the following condition:

Right leg.—There was paralysis of the quadriceps, so that the leg could not be extended upon the thigh. This was well shown by

Fig. 27.—Talipes equinus in left foot

Fig. 28.—Talipes calcaneus in right foot

seating him in a chair, when he could not straighten the leg. The calf muscles also were paralysed, causing severe talipes calcaneus. His attempt to extend the foot produced action of the peronei, which of course turned the foot outwards.

Left leg.—There was paralysis of the quadriceps, so that the patient was unable to extend the leg upon the thigh. The calf muscles were contracted, and the foot was extended as shown in fig. 27. Upon attempts at flexion of this foot it was turned outwards, whilst the great toe projected upwards beyond the

others. The left leg was half an inch shorter than the right. This leg was dragged in attempting to walk, in consequence of the paralysis of the quadriceps. This patient was practically unable to walk, and could only crawl about in a very ungainly manner.

Treatment.—The first thing done was division of the tendo Achillis of the left leg, to bring the foot into a right-angled position. Apparatus were made to support both legs. The left thigh also was supported by the instruments. As regards the right

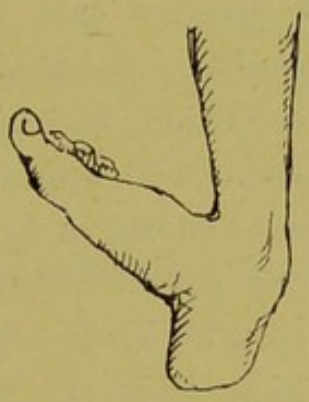


Fig. 29.—Effect of flexion in right foot

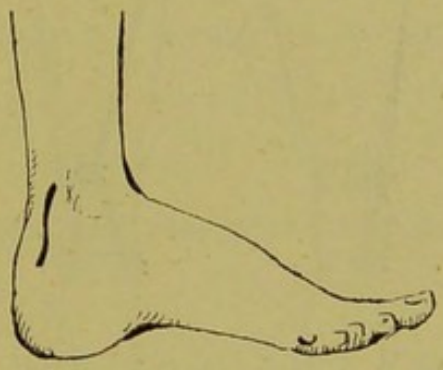


Fig. 30.—Right foot after transplantation of tendons. Foot turned in opposite direction to show line of operation

leg the object of the apparatus was to keep the heel as much as possible in its natural position, and to give a firm support to the ankle joint, so that the patient could place the toes firmly on the ground. The boy was then able to get about, and by means of certain modifications in the apparatus from time to time he steadily improved, so that I only saw him at long intervals.

On April 25, 1898, I again examined this patient. His chief defects in walking were now as follows: The left leg was still dragged, in consequence of the paralysis of the quadriceps extensor. To counteract this condition I attached an elastic band to a belt round his waist, passed it through a ring attached to a

strap at the bottom of the thigh, and fixed it to a band below the knee.

This elastic band took the place of the paralysed quadriceps, and enabled the patient to bring the leg forwards in walking. In such cases when the sartorius muscle remains sound, which frequently happens, that muscle may be transplanted to the patella (see p. 21). In the right leg the paralysed calf muscles had produced talipes calcaneus, as before stated, and this condition had of course not improved. The appearance of the foot was as shown in fig. 28.

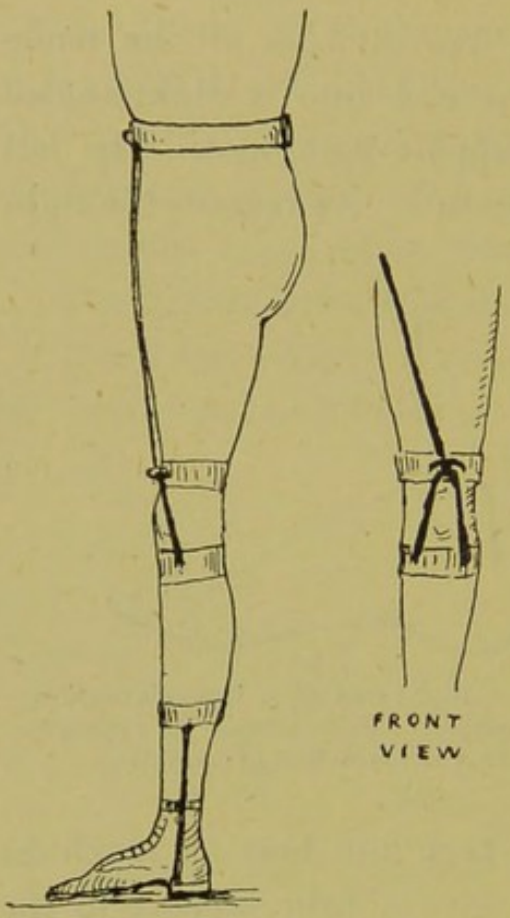


Fig. 31 Fig. 32

Figs. 31 and 32.—Sketches showing the elastic band extending from the waist to the leg below the knee. Also the support to the foot

When the patient attempted to point his toes he made use of the peronei, which drew the foot outwards. These peronei muscles were useless to him in their normal position, so I determined to transplant them to act on the heel, and performed the following operation.

Transplantation of tendons.—An incision was made parallel to the tendons of the peronei, halfway between those tendons and the tendo Achillis. The peronei tendons were divided about half an inch in front of the external malleolus. About one-third of an inch of the tendo Achillis was removed, the lower fragment being cut diagonally. A tunnel was then made beneath the fascia between the tendo Achillis and the peronei, and the

latter tendons drawn beneath and attached to the lower piece of the tendo Achillis, and the upper end of the cut tendo Achillis was brought down and attached to the same place.

The result was very satisfactory. Two months subsequent to the operation the patient was walking about easily, with the heel of the right foot (which previously dropped) in almost a perfectly natural position. See fig. 30, on which the line of operation is marked.

I had thought that there would be considerable difficulty to the patient in making use of his peronei to extend the leg, but this was not so, and I suppose that he had acquired this faculty in his attempts to straighten the leg by using these peronei previously.

Infantile paralysis; extensive paralysis and severe contraction of right leg

Case X.—P. K., aged six and a half, was admitted a patient to the All Saints' Children's Hospital, Margaret Street, at the commencement of 1899. He was described as having been a healthy child up to the age of ten months, when he suffered from what was stated to have been a severe attack of measles. At this time the right leg became paralysed and was gradually drawn up into a flexed and abducted position, and had remained in this position ever since. The photograph (fig. 33) represents the amount of contraction which was present.

Dr. Campbell Thomson examined this patient for me and reported as follows:—'Calf muscles react readily to moderate constant current and very slightly to moderate faradic current; no reaction to either obtained in extensors of knee, peronei, tibialis anticus, long flexors or extensors of toes.'

When the photograph (fig. 33) was taken the patient was resting

in the best posture he could assume. It will be seen that the foot was contracted into a severe equinus position by the calf muscles;

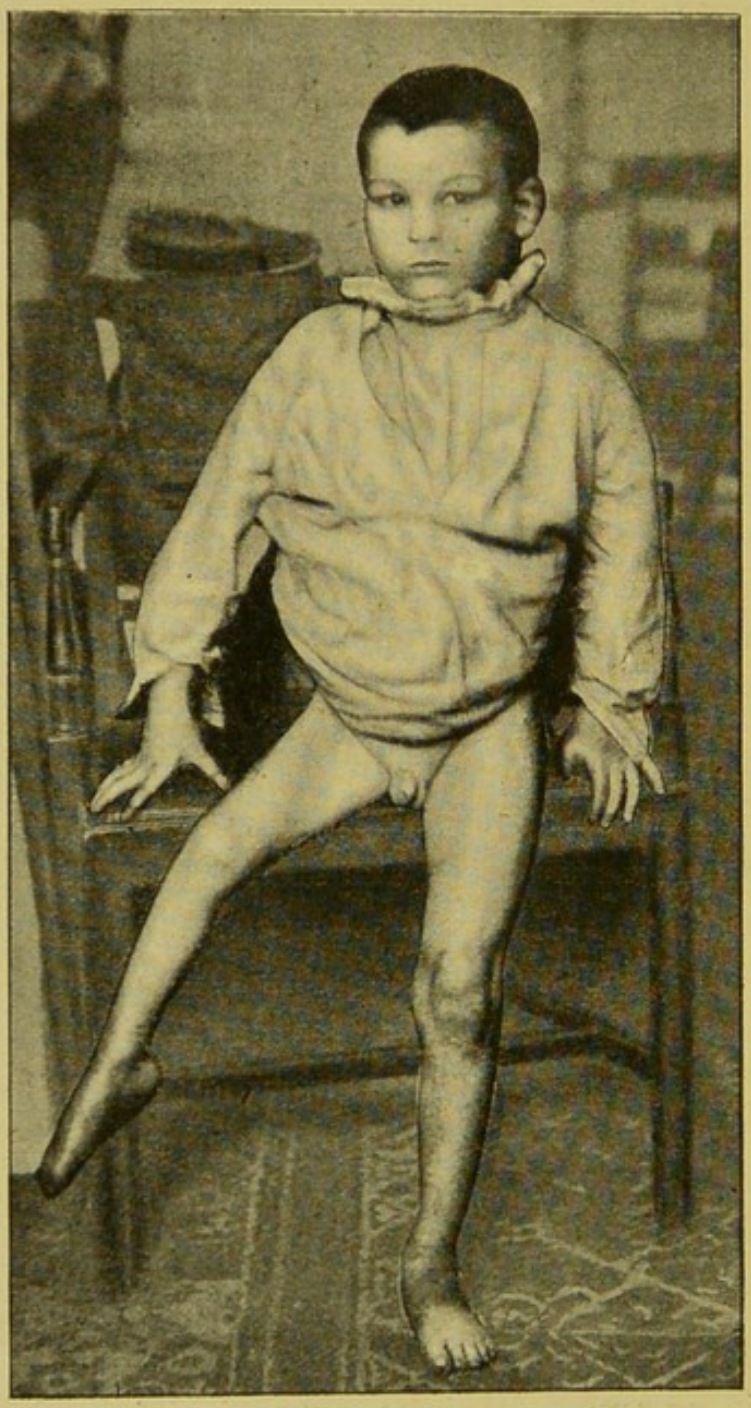


FIG. 33.—P. K. before operation, March 4, 1899. He had never placed his right foot on the ground

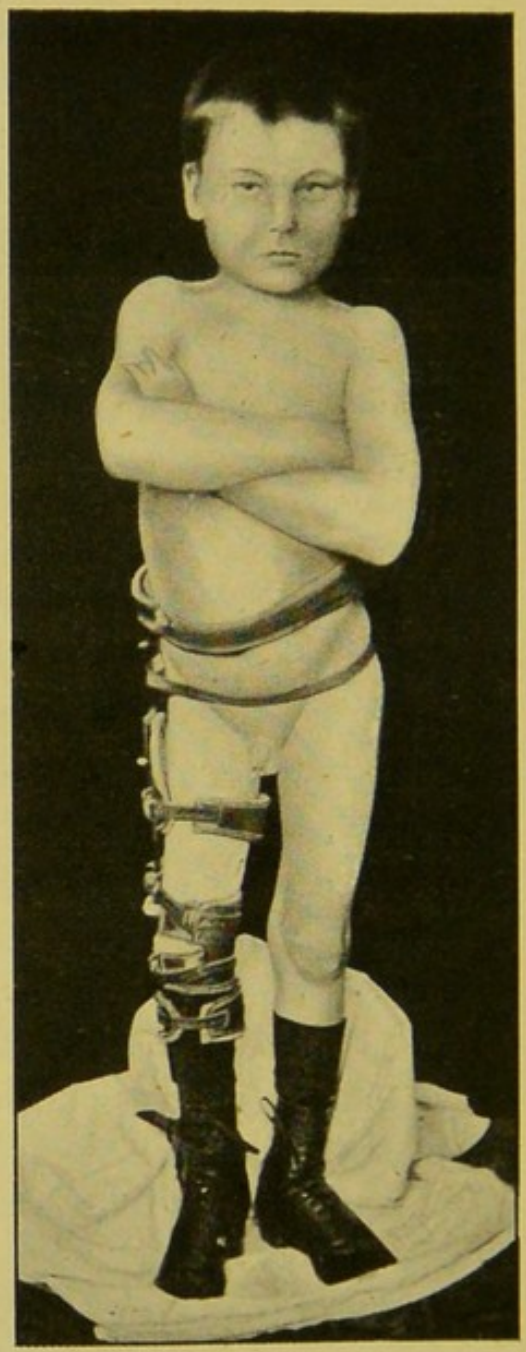


FIG. 34.—P. K. after operation and prolonged extension, the patient walking about with the help of apparatus

the knee was slightly bent, and the thigh flexed and abducted by the tensor vaginæ femoris, and to some extent by the psoas. This position could not be reduced by manual pressure. As the paralysis had commenced at so early an age the child had never walked, but he had crawled about on the floor and hopped on his left leg, the development of which was consequently very good. On March 4 I divided the tensor vaginæ femoris, and some tight bands of fascia on the posterior aspect of the knee, and also the tendo Achillis. I applied a Liston's long splint, but there was considerable difficulty in keeping the leg extended. I subsequently applied a perineal bandage attached to the top of the bed, and a weight and pulley to the foot.

The extension by weight was kept up for about two months, when the tendency to flexion seemed to be overcome. An instrument was then constructed, as shown in fig. 34 (from a photograph taken the day upon which this apparatus was first put on). The apparatus consisted of a light steel extended from the waist to the sole of the boot, a back-stop joint at the ankle to keep the foot from falling into a position of equinus, a ring-catch joint at the knee to make a firm prop of the leg in walking and to admit of bending at the knee for sitting, a band round the waist, and a strap just below this to help in preventing abduction of the leg in walking.

Just before this apparatus was applied the patient made an attempt at walking for the first time in his life. He could just manage to get along by holding the paralysed leg with his hands, but he fell down every few steps. He was photographed by the Mutoscope Company and his method of progression shown by a series of moving photographs. These photographs were exhibited with others at the meeting of the British Medical Association at Portsmouth in August 1899.

By the use of the supporting apparatus the patient was enabled

to walk fairly well, and he is rapidly improving. The photograph (fig. 34) shows him standing without any assistance or any attempt to balance himself with his arms. His easy position in standing, as shown in the photograph, may be compared with his difficulty in supporting himself on a chair previous to the operation. The exposure of the photograph was twelve seconds.

Atrophy of the paralysed muscles and interference with development of the bones in infantile paralysis

A very important result of infantile paralysis is the interference with development of the affected part. Immediately after an attack of paralysis the muscles are necessarily flaccid. In a few weeks' time wasting of the muscles commences and increases rapidly. There is also a retardation of development of the bones of the affected limb, due partly to inaction and general enervation of the part. The feebleness of the circulation and the contractures are other causes of non-development.

Contracture is a very potent cause, a fact which is clearly demonstrated in those cases where the paralysis is very slight and passes away rapidly, but in which contracture of muscles remains. So long as the contracture is unrelieved so long does interference with development continue. For this reason it is very important not to delay operation. Directly the contracture is relieved the development improves, and in the cases just referred to, when the paralysis has disappeared, development continues after operation at the same rate as in the sound foot, *but the normal size is never regained.*

The mechanical treatment of infantile paralysis

It is satisfactory to find in the most recent work upon medicine[1] the following very practical remarks from the pen of Dr. M. Allen Starr, Professor of Diseases of the Nervous System, Columbia University, New York; Consulting Physician to the Orthopædic and some other hospitals in New York. He writes:—

'The use of mechanical apparatus plays a great part in the treatment of infantile paralysis in the chronic stage. It is to be remembered that many weak muscles can do their work only when the limb is placed in an advantageous position, or when they are assisted in their action. Many of the muscles have, as part of their function, to keep the joints in place, and this part can be supplied by properly adjusted braces;[2] hence an apparatus may enable the child to use a muscle or move a joint which it could not do if the joint were unsupported. Again, the result of paralysis of one group of muscles is to allow the joint to be bent by its opponent, or to yield to the influence of gravitation; hence, if a brace be not applied early to correct this tendency, the paralysis is often followed by deformity. There is no disease in which orthopædic apparatus is of more service than in infantile paralysis, and it cannot be applied too early, as it may prevent the development of contractures and of deformities. There is no stage in which it is too late to fix a brace; for even when these deformities have occurred, tenotomy may be employed to straighten and adjust a joint, and then the limb can be fixed by the brace in a proper position. But every case has to be treated skilfully in accordance with its own peculiarities, and the ready-made braces of the shops

[1] Dr. Clifford Allbutt's *System of Medicine*. By many writers. 1899.

[2] A 'brace' is the American term used for any mechanical supporting-apparatus.

are often worse than none. A special apparatus for each case must be fitted under the direction of an orthopædic surgeon; and it is to be remembered that in a growing child such apparatus must be constantly readjusted, its length and size being changed from month to month in accordance with the development of the limb.

'In many cases of deformity, where there is a strong contracture of a fairly healthy muscle overcoming the weak paralysed muscle, the question of tenotomy will arise. Tenotomy will, of course, result temporarily in a replacement of the deformed limb to its natural position; but unless the joint can afterwards be held by a brace in a proper position, tenotomy alone will be of no permanent service. Hence, in some cases, tenotomy is only to be regarded as a preliminary to the proper application of apparatus.'

These remarks exactly represent the views held by all orthopædic surgeons in this country and America.

A NEW METHOD OF RESTORING THE ABSENT FUNCTION OF MUSCLES IN INFANTILE PARALYSIS[1]

All orthopædic surgeons know that in cases of muscular contracture associated with infantile paralysis—as, for instance, when the calf muscles are contracted and their antagonists, the flexors of the foot, are paralysed—division of the tendons of the contracted muscles is generally followed by improvement in the nutrition of the whole foot. Division of the tendo Achillis, in such a case as I have suggested, not only permits restoration of the foot to a natural position, but it also frequently brings about an increased warmth of the skin and subcutaneous tissue and presumably of the paralysed muscles also. This improvement in nutrition has been very little noticed by writers, and when noticed at all it has generally been attributed to the increased movement of the parts which the release of the contracture has permitted. This explanation, however, is not satisfactory, for the improvement in the warmth of the part is found to be present as early as the day after operation, and although it may subside slightly after a few days, it yet remains distinctly present during the period of from two to three weeks or more whilst the foot is kept absolutely quiescent, and continues as a permanent benefit. The late

[1] Published in the *Lancet*, November 5, 1898.

Mr. William Adams referred to this subject in his post-graduate lectures published in 1893. He stated that the result 'might be due to a certain amount of muscular action taking place in the muscles not contracted, after the tendons of the contracted muscles had been divided.' But he remarked that Dr. Brown-Séquard, to whom he mentioned the occurrence, had said that he 'believed it to be due to a direct reflex action of the spinal cord, and that a local increase of temperature probably followed all surgical operations, but it would be most observable in cases of paralysis.'

We know well that additional warmth, whether produced by external heat or by friction, massage, stimulating liniments, or by any other means, has a beneficial effect upon a paralysed limb, and will help materially in restoring the functions of the weakened muscles. That is to say, if a muscle is not completely and absolutely paralysed—or perhaps it would be more correct to say that if the nerve-supply of a paralysed muscle as well as the muscular tissue itself are capable of improvement—additional warmth of the part will greatly assist in such restoration of power. This being so, it is obvious that, whatever may be the explanation of the increased warmth following the tenotomy, the result of such increased temperature must act beneficially upon the paralysed parts. Further, it seems probable, from the rapid improvement in function of the neighbouring muscles which sometimes occurs, that some very direct influence upon the nerves or muscles must take place. After tenotomy of a contracted muscle, in cases in which other muscles have been so far paralysed that they have been beyond the possibility of amelioration, there has yet been a permanent improvement as regards warmth and nutrition. In many instances where the limbs have been cold, and with a tendency to ulceration, these symptoms have to a

great extent disappeared, and almost invariably the skin has lost its blueness.

Operation on the paralysed muscles.—The idea occurred to me that as tenotomy of a sound muscle is capable of producing so much improvement in nutrition in a neighbouring muscle weakened by paralysis, how much more direct an influence would tenotomy of the affected muscle itself have. Acting upon this idea, I have operated in this way on two patients, whose histories I will now record. See also Case VII., p. 49.

Case XI.—A girl, aged seven years, was brought to me on November 10, 1897. Two years and three months previously she had been suddenly attacked by infantile paralysis. There was said to have been complete motor paralysis from the waist downwards; but this began to pass away rapidly, so that in less than a week the patient was able to sit up. The functions of the bowels and bladder were very feeble at first, but became normal at the end of five days; sensation was perfect from the first. She had been under the care of Dr. Suckling, of Birmingham, and had been treated by massage and electricity. At the time of my examination I found the left leg feeble in all its movements; the extensors of the toes (flexors of the ankle) were apparently entirely paralysed, and there was contraction of the calf muscles, so that in walking the heel did not touch the ground. The left leg was a third of an inch shorter than the right, estimated by comparing the internal malleoli, but the heel was so much drawn up by the contracted calf muscles that in standing it was an inch and a half from the ground. This is shown in fig. 35, where the line C D passes through the centre of the leg and is vertical to the line A B. The right leg was quite strong, all the muscles acting well. Before operating I requested Dr. Risien Russell to see the patient, and he reported as follows: 'All the muscles of the left leg respond to faradism,

with the exception of the tibialis anticus and extensor longus digitorum, neither of which muscles respond even to a painful current, and one which, when applied to the motor points of these anterior muscles, results in marked contraction of the soleus and gastrocnemius on the posterior aspect of the limb. All the muscles which respond to faradism also react to galvanism, K.C.C. being greater than A.O.C.; but in the anterior tibial group only an exceedingly feeble response is obtained (A.O.C. greater than K.C.C.) with a very strong current, and one which, applied to the anterior aspect of the limb, evokes marked contraction of the soleus and gastrocnemius. The examination thus shows that there is most pronounced reaction of degeneration in the tibialis anticus and extensor longus digitorum, while the quality of the response from the other muscles of the leg is normal.' On November 12 I divided the tendo Achillis of the affected leg; I also divided the tendons of the tibialis anticus, extensor proprius pollicis, and extensor longus digitorum. In the case of the latter muscles,

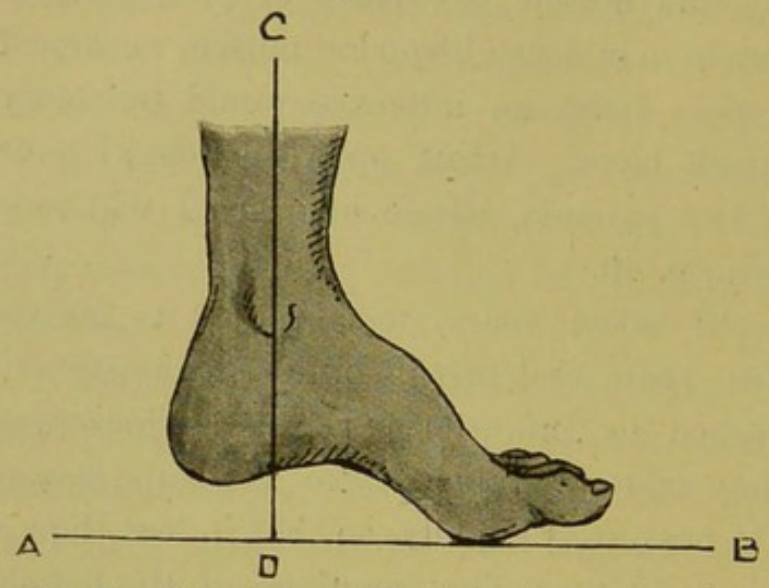


FIG. 35.—Extent of possible flexion before operation

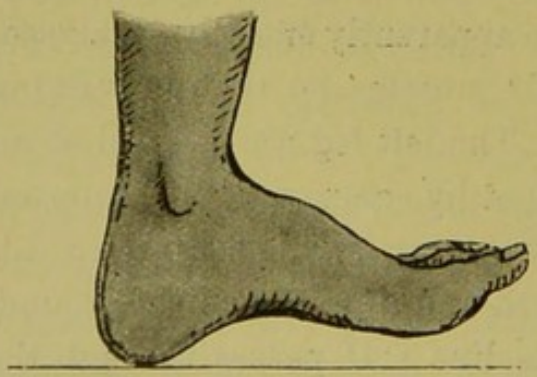


FIG. 36.—Extent of possible flexion after operation

which were considered to be paralysed, there was some difficulty in isolating their tendons. On the 20th I removed the bandage, and tried the action of the foot. Upon directing the patient to try to move her foot there was distinct movement of the tendons of the muscles which had previously seemed paralysed. Being so soon after the operation, I did not allow more than the slightest effort to be made by the patient. On the 24th Dr. Risien Russell again examined this patient, and verified the fact of this restoration of muscular power. The patient made an excellent recovery, and has since been walking about with a light temporary support.

One cannot imagine that after two years and three months from the time of the attack of infantile paralysis, seeing that the reaction of degeneration was present, it would have been possible, under any ordinary treatment, to obtain restoration of function. Therefore I think we may assume that the operation upon the tendons of the paralysed muscles was the direct means of restoring that power.

Case XII.—On November 21, 1895, a girl aged eleven years was first brought to me. She had suffered from an attack of infantile paralysis at the age of three months, and had been subsequently operated upon for contracture of the calf muscles. I was told that during recent years she had grown very much worse as regards ability to get about, the left leg being almost useless to her. The left leg was much smaller than the right and deformed, as shown in fig. 37, and the patient was unable to extend the foot beyond the position there depicted. Two years previous to her visit to me she had given up wearing iron supports and the foot had become more deformed. I found shortening of the limb to the extent of two and a quarter inches, measuring from the heel to the ground, and the leg below the knee was very cold and blue. The extent of the paralysis was as described below. By means of supporting

apparatus she was enabled to walk about with comparative comfort and I only saw her at long intervals. On October 22, 1896, I divided the internal lateral ligament, which held the foot in the varus position, and I was then able to lessen the amount of deformity considerably. On November 3, 1897, the patient was walking

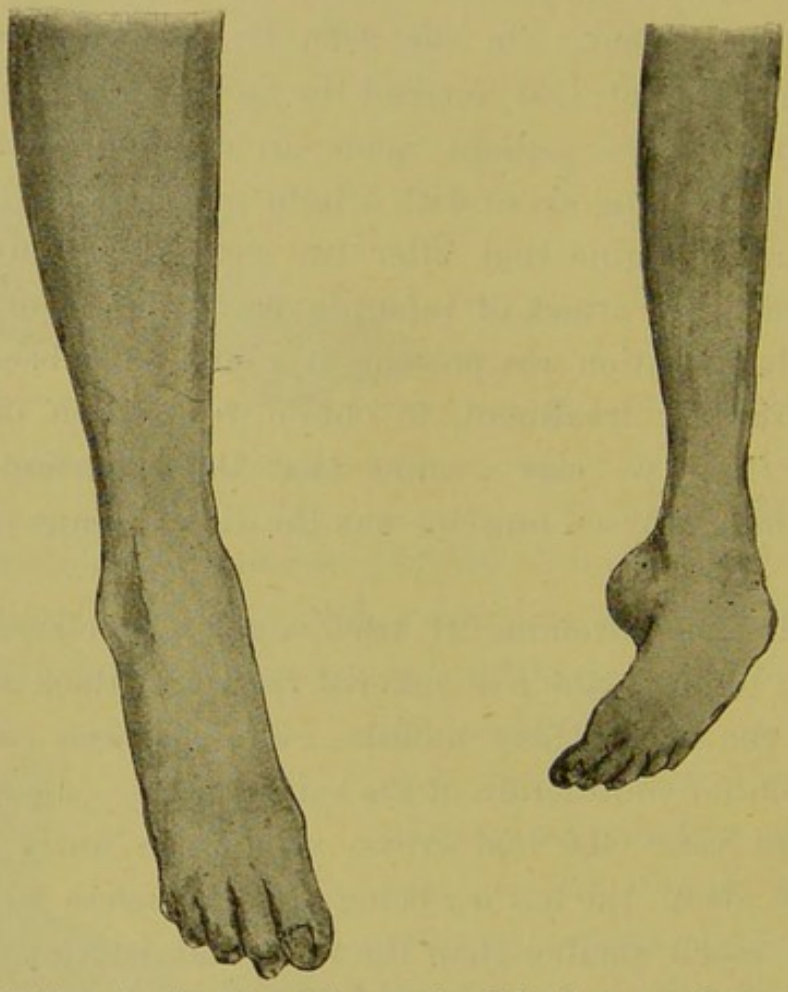


Fig. 37.—Showing the size of the paralysed leg in comparison with that of the sound one

better, but I found the foot and the lower half of the leg very cold and the circulation very feeble. Ulcers were almost constantly forming and healing up again. As so much benefit in position had been obtained by the cutting of the lateral ligament, I thought it worth while to operate on the tendo Achillis and at the same time

to divide the tendons of the paralysed muscles. I asked Dr. Althaus to examine the patient first, and he reported as follows:

'November 3, 1897.—1. *N. tibialis.* (*a*) *Faradism.*—No response on application to the nerve at the back of the knee joint or to the motor points of the gastrocnemius, soleus, plantaris, flexor digitorum communis, and flexor hallucis longus.

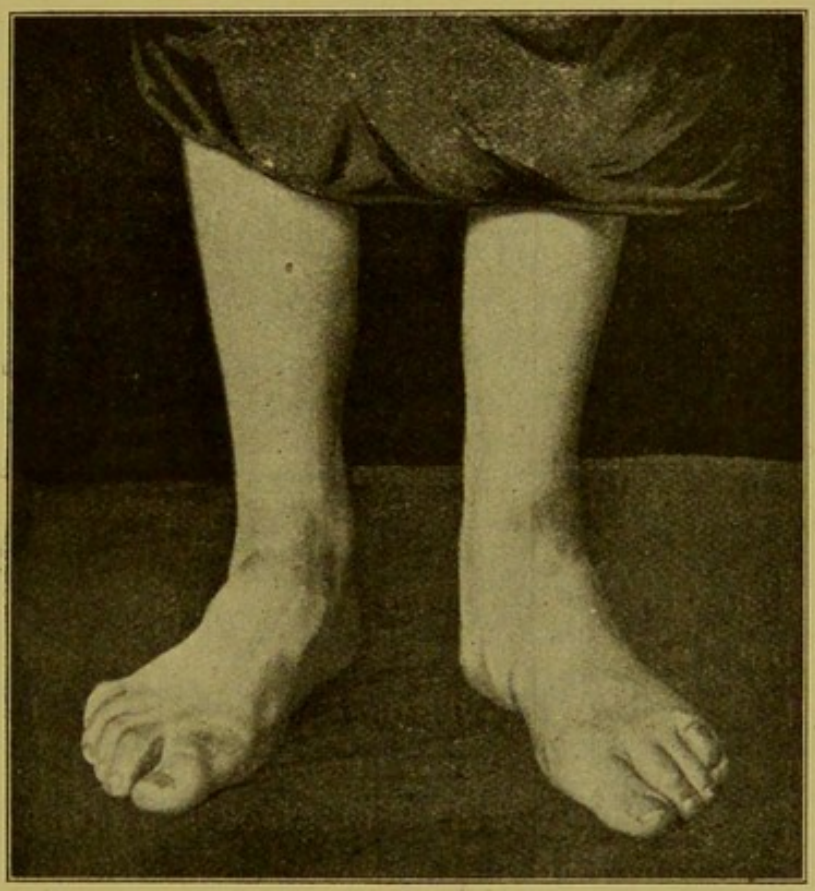


Fig. 38.—Showing present condition, both feet resting flat on the ground

'(*b*) *Constant current.*—Anodic opening contraction (A.O.C.) absent up to fifteen milliampères in the nerve and muscles above mentioned. Kathodic closing contraction (K.C.C.) slightly present between ten and fifteen milliampères. A few voltaic alternatives caused this response to be diminished.

'2. *N. peroneus.* (*a*) *Faradism.*—Fair response with 8 R.A.

Stoehr's induction coil on the nerve, and on the motor points of the peroneus longus and brevis, the extensor digitorum communis, the tibialis anticus, extensor hallucis longus, and the interossei dorsales.

'(*b*) *Constant current.*—Slight A.O.C. on application to the nerve and the motor points of the muscles, and stronger K.C.C. in the same, with ten milliampères.'

In operating I divided the tendo Achillis (muscle acting soundly) and the tendons of the tibialis anticus, extensor proprius pollicis, and the extensor longus digitorum (apparently paralysed), and I also broke down some very firm adhesions which prevented the free movement of the ankle joint. On November 24, three weeks after the operation, I found the leg and foot quite warm, the foot in excellent position, and a great improvement in the action of the muscles. Dr. Althaus reported again as follows: 'November 24, 1897.—Farado-muscular response increased in the sphere of the peroneal nerve, especially tibialis anticus, extensor digitorum, and extensor hallucis longus. No other marked change.' Her present condition, October 5, 1898, is as follows (fig. 38): The patient is now able to walk about with only a very slight limp and suffers no inconvenience. She wears a light apparatus to take the place of the weak anterior muscles and only requires a quarter of an inch extra thickness on the heel and sole of the left boot. The foot and leg are well nourished, and she has not suffered from chilblains or ulcers since the last operation. Dr. Althaus saw her this day and reported that 'the leg seemed altogether better. Electrically less current strength is required to cause muscular action.'

It will, of course, require far more experience than that derived from the above cases to enable us to form a fair estimate of what may be expected from division of the tendons of paralysed muscles.

It is obvious that such a procedure cannot be expected to restore action in muscles which have become absolutely degenerated, nor can we expect absolutely paralysed nerves to be capable of regaining their function. It seems certain, however, that the significance of what is called the 'reaction of degeneration' must be modified, for it would appear that this symptom does not prove that no power of recovery exists. The results in the two cases recorded above are so definite that I cannot see any other explanation of the benefits derived than that suggested. The advantages are obvious and great. In the first case it means the difference between the child being absolutely cured in a few months and having to wear some mechanical support for the rest of her life. In the second case, although some weakness remains, yet the improvement is very considerable, and I would further point out that this improvement is distinctly more than could be expected as the result only of making the joint more free. I could record other cases with apparently similar results (see Case VII.), but as no electrical examination was made before operation I would prefer to confine my chief observations upon this method of treatment to the above two cases, XI. and XII.

THE SCIENTIFIC USE OF MECHANICAL APPARATUS

I have already referred to 'the scientific use of mechanical apparatus,' and will now consider the subject as regards particular cases. There is, however, difficulty in giving details, as it is impracticable to use one pattern of apparatus for any one class of cases.

The chief points requiring notice are:

1. The direction in which the support should be given.

2. The manner in which support can be given where necessary, without interfering with the free movements of sound joints.

3. The guiding of the action of sound muscles so that they shall act remediably.

As an example of what is meant I will describe the treatment of a valgoid ankle. This affection consists in the giving way of the ankle inwards. It often simulates flat-foot, although the latter condition may be quite absent. The instrument maker in dealing with such a case endeavours simply to support the ankle, either by a plate in the boot or by a high boot with stiffening in its sides, or by a boot with iron supports on each side of the foot. Such supports interfere more or less with the movements of the ankle and other of the foot joints, and therefore do not conduce towards an improvement in the strength of the part. The scientific use of apparatus in these cases may be effected by the ordinary T-strap, bearing upon the inner ankle, and keeping the latter supported by being buckled round a steel rod applied to the outer side of the foot. By this means perfect freedom for flexion and extension is allowed to the ankle joint, while the malposition is gradually corrected. If, in such a case, there be partial paralysis or weakness of the anterior muscles of the leg, the joint of the steel rod at the ankle should have a *back-stop*, to prevent the foot from falling into an 'equinus' position. This back-stop is superior to 'accumulators,' or rubber bands which take the place of the weak muscles, because the back-stop allows the anterior muscles to be used, so that any power remaining in them may be developed, whereas the 'accumulators' entirely take the place of the muscles and give them no chance of improvement in strength by individual action.

A moulded leather apparatus with 'accumulators' is sometimes used for slight equinus, and it will help to overcome the contracture (fig. 39). It will be useful for night wear, but very uncomfortable for walking; moreover, it has the disadvantage of the elastic flexion. A better apparatus is made as follows:—A light

steel rod, placed on one side of the ankle, is fitted into a socket in the sole of the boot, with a back-stop joint to prevent extension of the foot beyond a right angle with the leg (fig. 40). The patient can, with this apparatus, wear an ordinary boot instead of an unsightly leather case. Further, the patient's ordinary boot can, as a rule, be adapted for the purpose, and for night the instrument can be used with a light canvas shoe. When the anterior muscles are absolutely paralysed, the accumulators may be used, or a side-spring apparatus may be applied to the boot.

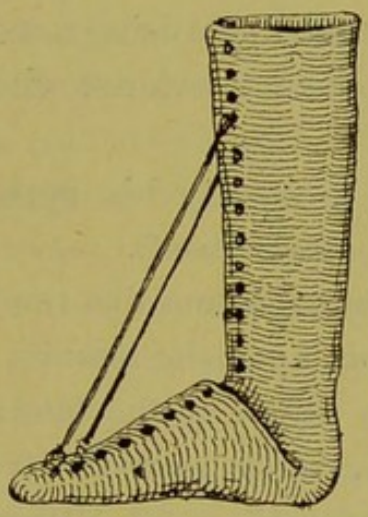


FIG. 39.—Cumbrous leather case

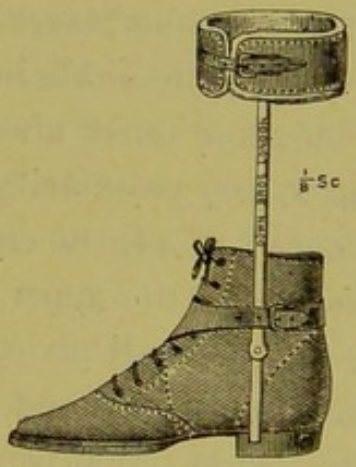


FIG. 40.—Mechanical attachment to boot

In cases in which the knee has to be supported in addition to the foot, as in Case VI., it is quite unnecessary, as a rule, to have iron supports on each side of the leg. Fig. 1 (p. 6) shows such a double iron support, supplied to the patient by an instrument-maker, and fig. 2 shows a much simpler form which was not only lighter but was more efficacious. The construction of the latter included a front-stop joint at the knee, to prevent hyperextension of the leg, and a ring-catch joint to make the apparatus stiff for walking, but allowing the knee to be bent in sitting, a knee-cap to counteract the genu

valgum, a calf plate to support the leg forwards, and a T-strap upon the inner side of the boot to support the ankle. Fig. 22, on p. 47, shows the patient wearing this apparatus.

If we look at figs. 19 and 22 it will be seen that the tendency of the ankle was to bend outwards, and so, theoretically, the T-strap should have been placed on the outer side, but it was found that in the practical application of the apparatus the object could be fulfilled better by departing from the usual custom. However, later in the progress of treatment it became necessary to bring the iron to the inner side by transmission through the calf plate, the iron from the calf plate to the boot on the outer side being removed; if the latter piece had been left it would have interfered with the effort to incline the ankle inwards.

The surgeon must always be ready to modify his apparatus according to any peculiarity which may present itself.

In Case v., p. 44, the chief defect to be overcome was the bending backwards of the upper end of the tibia upon the femur. This required a strong calf plate, brought into action by the lateral bar being fixed to the boot and pressure being made over the front of the thigh. This action is also shown in fig. 15, p. 37, although in that case the weakness involved the whole of the lower limb.

There is a tendency on the part of mechanicians to unduly force the affected parts into a better position, but any such attempts defeat their object. Take, for instance, a foot in a moderate equinus position, like the left foot in fig. 23, p. 50. In such a case we might by strong pressure with the hand force the foot to nearly a right angle with the leg, but if an attempt were made to keep the foot in this position by means of a mechanical boot, sores would very likely be quickly produced and the treatment would be much delayed. During this delay any little advantage that might have been gained in position would be lost. The principle of an

apparatus for overcoming contractures should be to effect only gentle pressure, but this gentle pressure must be kept up continuously, night and day.

Alteration in the shape of apparatus.—Instruments as usually made are constructed of hard steel, so that they cannot be bent without first being softened in a fire. This plan of construction prevents any alteration in the shape of the instrument being made by the surgeon. All the instruments I use are made of steel so tempered that I can, by the use of wrenches, alter the shape of the bars to any extent. It often happens that during the visit of a patient several alterations are made in this way before the support acts effectively or the patient is made comfortable. It will be easily realised what an advantage is thus gained, not only as regards the lessening of trouble and expense to the patient, but also in the success of treatment. By means of several alterations made at one 'sitting' the surgeon is enabled to attain his object far more effectually than if he had to point out what he wanted to the instrument-maker, who could after all only make one definite alteration at one time. Moreover, if the instrument has to go through the fire to be softened the patient has to be deprived of its use in the meantime. There is no comparison in the two plans, and it seems to me extraordinary that surgeons have so long put up with the unsatisfactory methods of the mechanician.

When the surgeon comes to deal himself with the details of construction and readjustment of his apparatus, he will soon find that a large field is open for his ingenuity. He will meet with frequent opportunities for adding to the efficiency of his apparatus or for simplifying its construction. To give one example of this plan, I may refer to a one-side-bar leg instrument in a case of equinus or equino-varus. When I commenced to treat such cases it was customary to support the foot when the patient commenced

to walk after operation by a tin shoe or other apparatus which held the foot in a fixed position. After a time a Scarpa's shoe or other rack-joint machine was substituted, and subsequently this again was discarded for a support which allowed the necessary degree of movement. I have simplified this elaborate and expensive procedure very considerably. In the first place immediate reduction of the deformity after tenotomy renders the rack-joint apparatus seldom if ever necessary. We therefore have to provide for a fixed-joint apparatus when the patient begins to walk, and a limited movement or a free movement at the ankle subsequently. We consider in the first instance what will be ultimately required, say a back-stop joint and free movement anteriorly. Then the joint is made rigid by a steel peg driven through the two steels at the ankle joint, and this peg can be easily removed when we wish to convert the stiff instrument into one with a movable joint at the ankle. This is only one example of numerous useful arrangements which the surgeon will find out for himself during his study of the requirements of each case.

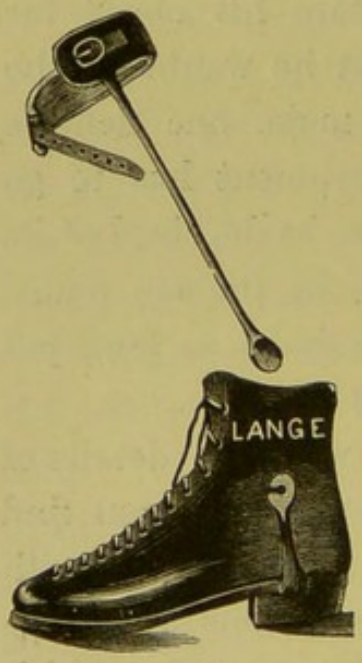


FIG. 41

Attachment of apparatus to boots.—It is a very neat arrangement to have a 'box' in the side of the heel of the boot for the leg iron to be attached to. The instrument can then be removed whenever required, and each boot worn by the patient can be fitted with a box, and so the one instrument will suffice for all boots. In the case of heavy patients or those who have to do much walking this arrangement is very liable to get out of order. The 'box' wears and gets loose in the boot and repairs are rather frequently required. To save this trouble

and expense a detachable joint can be made at the ankle. The lower part of the instrument is then fixed into the sole of each boot firmly by rivets, and the upper piece used for any boot similarly provided with the lower part (fig. 41).

These examples are a sufficient illustration of what I term 'the scientific use of mechanical apparatus,' although they might be multiplied almost indefinitely.

SHORT LEG

One of the most frequent results of paralysis of the lower extremities is an inequality in their development. This, of course, occurs chiefly when one leg only is affected, although when both are attacked there may still be a want of uniformity in their length.

The circumference of a paralysed limb is also necessarily smaller than natural, and the degree of this deficiency depends upon the number of muscles affected and the extent of the paralysis. It is, however, the shortness which chiefly or alone requires our attention.

The effects of shortening.—Lameness, more or less severe, and pain are the chief immediate effects of the inequality, but there are secondary changes which are of very great importance. However slight the inequality may be, the patient is obliged to walk awkwardly—that is to say, that, in order to maintain the equilibrium, some other part of the body must be thrown out of the upright to accommodate the irregularity in the legs. It is the spine which chiefly suffers, and if we can, by removing the inequality, prevent the spine from becoming affected, other irregularities of posture will disappear. Usually some unevenness of the shoulders

or the hips alone attracts the attention of the parents or friends of the patient, but upon examination of the uncovered back, the surgeon will find that these irregularities depend upon lateral curving of the spine. To explain this point in detail we may refer to a shoulder-blade projecting backwards. This projection is caused by the ribs, which also project backwards; the condition of the ribs is the result of twisting of the spine, the twisting of the spine is the constant effect of lateral curvature, and the lateral curvature in such a case depends upon the obliquity of the pelvis caused by the shortness of one leg. The curvature of the spine is by far the most important effect, and very soon, if the cause remains, it becomes a permanent trouble. The bones become changed in shape and all the neighbouring structures follow suit.

If a perfectly normal individual stands with the left leg on a book and the right flat upon the ground, with the knees straight, thus imitating a short leg, it will be found that the spine is curved laterally in order to balance the body, fig. 42. It is, of course, a temporary curve, which disappears directly the person moves his foot from the book and stands evenly, but in cases of a short leg the frequent assumption of this curved position will in time produce permanent changes in the spine. In some cases of hemiplegic paralysis we find one leg and the opposite arm involved, and this affection of the arm may extend to some of the muscles of the same side, and so complicate the matter. The paralysis of the leg alone leads to an artificial shortening and the paralysed side aggravates the result.

Under all circumstances it is desirable to equalise the length of the legs by some means, and if the changes in the spine are not very severe this correction in the length may suffice to cure the curvature of the spine, but if the shortness is great and has continued for a long period it is probable that the spinal

curvature will have produced structural changes in the vertebræ, requiring special treatment of the spine itself in addition to the equalisation of the length of the legs. If in the latter case we observe the effect of equalising the inequality by placing a book or block under the foot of the affected limb, the lumbar curvature will not be removed but will be changed in position, and the dorsal compensatory curve will be exaggerated (see figs. 43 and 44).

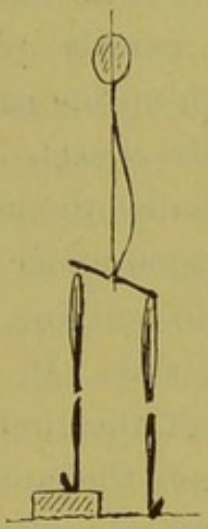


Fig. 42. — Immediate effect upon the spine of an imitated short leg. The curve is diffused throughout the spine

Fig. 43.— Effect upon the spine of long-continued shortness of one leg. The curve is chiefly in the lumbar part, but there is also a compensatory curve in the dorsal region in the opposite direction

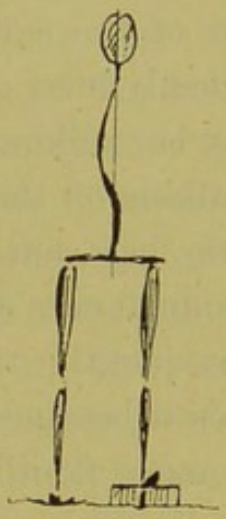


Fig. 44.—The effect upon the permanent curve by raising the short leg

In treating the spinal curvature it is very desirable to restore the equality in length of the legs as soon as possible, in addition to other remedies.

To estimate the degree of shortening.— Seeing that the most important detrimental effect of a short leg is its influence upon the spine, the best test of the deficiency to be made up is the position of the pelvis when the patient is standing. The patient should stand with his back towards the surgeon, with the back and hips exposed, the heels together and the knees straight. The surgeon

should then place his hands upon the crests of the ilia and judge by the eye as to their inequality. It is helpful to carry the eye beyond the patient to the dado of the room or to some other horizontal line Blocks of wood or books can be placed below the foot of the short leg until the pelvis is made level, when the artificial addition to the sole will indicate the amount of shortening.

The above method of estimating the shortness of the leg obviously applies only to those cases in which there is no contraction of the calf muscles, and in which the heel can be placed perfectly level on the ground. If the heel is drawn up the patient may be walking on the front of the foot, commonly spoken of as 'walking on the toes.' This position may even equalise the length of the legs, but, as a rule, the difficulties in progression under such circumstances are so great that the knee is bent in walking, and consequently the pelvis is still lowered on that side. In such cases it becomes necessary to measure the length of the limbs by the more familiar method of using a tape between the anterior superior spinous process of the ilium and the internal malleolus. In taking this measurement an error may easily be made by movement of the skin when holding the tape upon the ilium. It is therefore advisable to indicate this spot by a flesh pencil or pen and ink and to measure from such mark. A simple method of determining the difference in length is to place the patient flat on his back on a couch or bed, taking care that the spine is as straight as possible and the pelvis even—*i.e.* the transverse diameter of the pelvis is to be at right angles with the spine—and then measure the difference in position between the two internal malleoli. There are other methods of measurement, but I think the above will serve all useful purposes.

It is very difficult to judge by the position of the heel alone as to what extent it is drawn up by the contracted calf muscles.

Remedies for short leg.—This subject involves the consideration of the treatment of the case as a whole. To take the more simple condition first, we may have, say, half an inch shortening. Assuming that there is some paralysis—say paralysis of the anterior muscles of the leg, allowing the foot to drop towards an equinus position—without there being any contraction of the calf muscles, the patient ought to wear a steel bar attached to the heel of the boot and to the calf, having a back-stop joint at the ankle to prevent the foot from dropping beyond a right angle, and a T-strap on the side opposite to the iron. The side of the leg to which the iron is to be applied should be determined by observing the inclination of the ankle to turn either outwards or inwards. There is generally an inclination one way or the other, and more frequently it tends to bend outwards; therefore, as a rule, the iron should be applied on the inner, with the T-strap on the outer side. By this means the foot is retained working in a straight position, and is also prevented from extending itself beyond a right angle; elastic tension in flexion is often used in place of a back-stop joint, but my objections to this plan are stated on p. 72. To make up the deficiency in length, half an inch should be added to the heel, but it will generally suffice to add only a quarter of an inch to the sole of the boot. This arrangement acts, as a rule, very well, but, if necessary, the stop joint may be made a little less than a right angle, so that the foot may drop sufficiently to allow a quarter of an inch difference between the heel and sole.

If the shortening is greater, we have to be guided by various circumstances; but it is usually desirable to allow the front part of the foot to drop to a certain extent. When the boots are *made for the patient* it is best that the thickness should be supplied by a piece of cork placed *within* the boot, but in cases where economy or expedition is an object the boot already worn by the patient can be

used, the necessary thickness being added to the heel externally and a slighter amount to the sole. Under the latter circumstances additions have to be made in leather, and the boot will be heavier than when the addition is made in cork. Various plans have been used for these additions, such as an oval iron band forming an arch beneath the sole, placing the foot in a more or less equinus position.

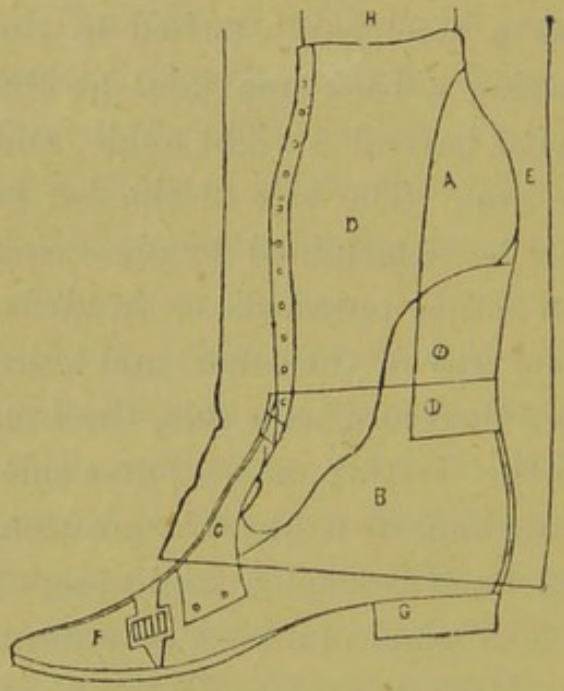
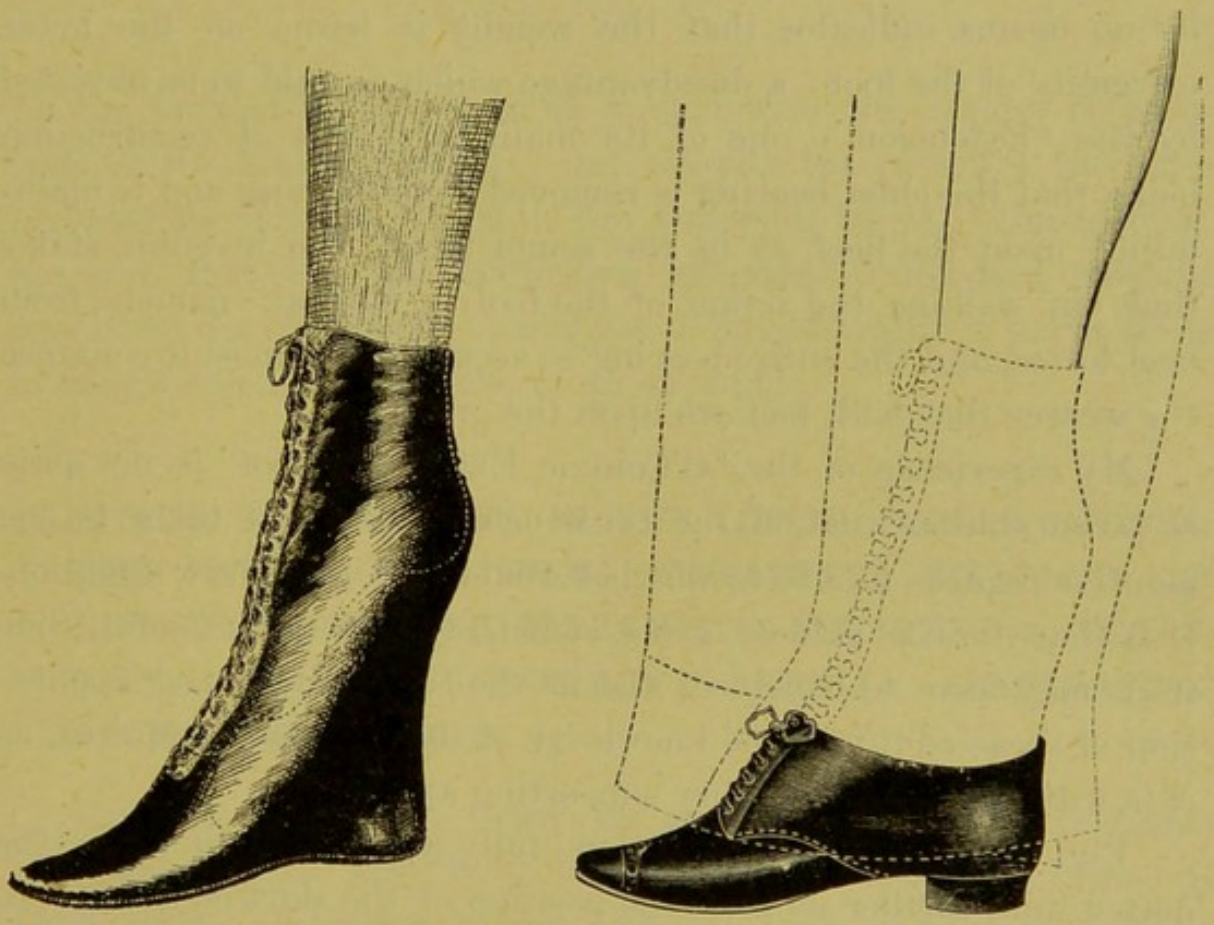


Fig. 45.—A, aluminium heel plate; B, wooden base of 'extension;' C, aluminium instep plate, which keeps pressure of outer shoe off toes; D, the foot in position; E, trousers; F, jointed toe of 'extension;' G, heel of outer shoe; H, leg

One of the latest constructions of this kind is the 'O'Connor Extension' boot. It is used in cases of considerable shortening, such as three or four inches, and it aims at disguising the deformity. It is probably chiefly applicable to cases where there is extensive paralysis and in which we could hardly expect to get a very useful foot by relieving the deformity. I mean that if the calf muscles are contracted and the foot is in a position of equinus and the paralysis extensive, it may be worth while not to divide the tendo Achillis, but to allow the deformity of the foot to make up for the shortening. However, when the muscular action round the joint is not very much interfered with by paralysis, there can be no doubt that the free movement of the ankle joint which is produced by section of the tendo Achillis is of great comfort and benefit to the patient, and under such circumstances fixation of the foot in this equinus position is detrimental to the free locomotion of the patient.

Moreover it is impossible to judge accurately before operation as to the increase of power in the partly paralysed anterior muscles which will result from division of the tendo Achillis. The advantages of restoring freedom to the movements of the ankle are discussed under Tenotomy, and it will there be seen how desirable it is to relieve the contracture even when there appears to be little or no power left in the flexors of the foot.



FIGS. 46 AND 47.—The O'Connor Extension boot, showing the general appearance. In fig. 47 the outlines of trousers and skirt are given

The most important point for consideration under these circumstances is the matter of personal appearance. The O'Connor Extension boot will enable the patient to hide his deformity, but he must be prepared to put up with the inconvenience of the stiffness and the strain upon the foot.

The principle followed in the manufacture of this boot is to give as complete a support as possible to the whole sole of the foot, and especially to the heel, with the object of securing an even bearing. Fig. 45 shows in outline the construction of this apparatus.

Fig. 46 shows the 'Extension' with the foot in position (see dotted line). The toes being allowed to drop lower than the heel by no means indicates that the weight is borne on the lower extremity of the foot—a disadvantage which is said to be obviated by the 'Extension'—one of its main principles of construction being that the chief bearing is removed from the toes and is maintained upon the heel, as in the sound foot. The inventor states that 'in walking the action of the foot is natural—namely, from heel to toe, and the entire bearing so accurate as almost to convince the wearer that both feet are upon the ground.

My experience of the 'O'Connor Extension Boot' is not quite so favourable as that of the constructors of it, and there is one point as regards its use to which I would especially draw attention. It is that the boot seldom gives sufficient support by itself. Side irons may have to be added, and in the construction and application of these additions the knowledge of the surgeon is required, as it is with the use of all other supporting apparatus.

Fig. 47 shows the 'Extension' fully equipped with shoe; the dotted lines further indicate the position of the skirt or trousers in concealing the appliance. It will thus be seen that the foot of the shortened leg will resemble the other very closely.

APPENDIX

As the purpose of this work is to deal with the results of paralysis of the lower extremities and not with the causes, I have not included the following cases in the foregoing pages. Considering, however, that they are interesting examples of modern surgical operations for the relief of paralysis, I have thought it worth while to describe them in the form of an appendix.

FRACTURE OF THE SPINE IN THE LOWER DORSAL REGION, THE PATIENT REMAINING ABSOLUTELY HELPLESS AS REGARDS THE LOWER EXTREMITIES FOR OVER 4½ YEARS. OPERATION AND SUBSEQUENT PARTIAL RESTORATION OF WALKING POWER

Case I.—A. E. W. (aged 22 at the time of the accident) was training in the West Cumberland Hussars on June 1, 1893, when his horse reared and fell back and crushed him. He was also dragged for some distance, one of his legs being retained in the stirrup. He remained paralysed from his waist downwards. I first saw this patient in August 1896, three years and two months after the accident. He was then in the Home for Incurables at Carlisle, and was in a very weak state of health. There was an acute angular projection of the tenth dorsal

vertebra. He had very slight power of flexing the left thigh as he lay in bed, but the lower limbs were absolutely useless to him. There were several bed-sores, which had commenced a few months after the accident and had continued more or less since, and other symptoms of paralysis existed which I will describe later. It was obvious, from the fact of his having lived so long, and of there being some movement in the left leg, that the cord was more pressed upon than crushed, and I suggested that laminectomy, to relieve that pressure, was desirable.

The patient was very anxious to have everything done that could be, but for various reasons he was unable to come to London until January 1898, when he was admitted a patient under my care in the City Orthopædic Hospital, Hatton Garden. His condition was then found to be as follows :—

Condition.—There were old scars from bed-sores, as well as several open sores. Complete anæsthesia and analgesia of the whole of the right inferior extremity, with the exception of the upper third of the front of the thigh, where the patient detected both touches and pricks. Sensibility was not so much affected on the left side, the patient being able to detect touches and pricks above the level of the knee, both in front and behind, and over a limited area below the knee, in front and on the inner side of the leg. Below this level there was complete anæsthesia and analgesia. There was no blunting of sensibility of the trunk, the muscles of both lower limbs were greatly wasted, and there was considerable contracture of the calf muscles, both feet being extended and the heels drawn up. There was also some amount of 'varus,' especially on the left side, and the toes were bent towards the soles of the feet. This contracture of the toes in the flexed position had been more marked on the right side than the left, and most marked in the great toe, but diminished in degree towards the little toe. There was com-

plete inability to move the toes of either foot or the feet at the ankle joints. The right leg could be slightly drawn up in bed, flexion at the hip and knee joints thus resulting, but there was no power of extending the limb at the knee joint, so that the heel could not be raised from the bed. The power of movement which was preserved in this limb was only very slight in degree. There was somewhat greater range of power of movement on the left side, shown by ability to draw up that limb in bed, flexion of the hip and knee resulting. There was slight power of extension at the knee joint, so that the foot and heel could be raised off the bed to some extent.

The patient was in a very emaciated condition; for some months he had been failing in his general health, and was able to take but little nourishment. He was suffering from cystitis.

Reflexes.—The plantars were both absent as well as the knee-jerks, and there was no ankle clonus. There was complete loss of control over both sphincters.

Operation.—On February 5, 1898, I operated, with the assistance of my colleagues, Mr. Jackson Clarke and Mr. Chisholm Williams, Mr. John Poland also being present. I cut down to the spine and exposed the laminæ of the tenth, eleventh, and twelfth dorsal vertebræ. The arches of the eleventh and twelfth were united together by callus and were pressing upon the spinal cord. One pointed fragment penetrated the membranes, and upon this being removed a small opening was left which allowed the escape of cerebro-spinal fluid. The cord seemed to be then quite released from pressure, so I closed the wound. The wound healed up rapidly, and a few days after the operation I applied a splint similar to what I have used successfully in spinal caries. The general condition of the patient began to improve within a fort-

night of the operation. The bed-sores gradually healed up and the functions of the bladder and bowels began to improve, so that on March 30 I was able to report that during the last fortnight he had regained control over the bladder to the extent that, instead of the urine dribbling away constantly, he was able to retain it half an hour at a time, and was perfectly conscious when he wished to pass it, a condition which had not previously existed since the day of the accident, four and a half years previously. As regards the bowels, he was now perfectly conscious as to their action,[1] but the paralysis of the sphincter ani remained. From this time forward the patient improved in every way, until ten months later massage was commenced. After about two months of this treatment, the patient had gained so much control over the limbs that I contemplated getting him on to his feet. Both feet were in a position of extreme equinus, and it became necessary to divide the tendo Achillis on each side and place the feet at right angles with the legs. Although the parts felt inanimate and lifeless, yet the healing process took place perfectly, and upon January 18 light steel supports were applied to the right foot and knee and the left foot and ankle, and with the help of these he commenced his attempts at walking. The process was of course a slow one, but on January 22 he was able to walk across the ward with the assistance of the nurses. By February 1 he was able to walk a few steps by himself with the assistance of two chairs, and on February 15 he managed to extend his walk, without manual assistance, from one ward to another. He was located for the time at Dr. George Stoker's Oxygen Home, where he had been kindly taken in during the rebuilding of the City Orthopædic Hospital. On March 8 he informed me that he had been able to

[1] At the present time, June 1899, the patient does not recognise any improvement as regards the bowels, but the above statement was thought to be correct at the time.

walk into the next ward and back again three times during the day, still helping himself with two chairs. Ordinary sticks did not afford sufficiently firm support for him, so I had two straight sticks constructed with a base to each like a small plate.

On May 5, 1899, the patient was walking about the ward by the help of one of the sticks and a light chair (fig. 48).

Report of the condition of this patient, May 20, 1899.

Left Side. *Hip joint.*—There is fair power of flexion of the hip joint and possibly a very slight power of extension, but the latter is doubtful.

Knee joint.—There is fair power of extension of the left knee joint, so that the leg can be held straight out in the air. There is no power whatever to flex the joint. An appearance of this movement is produced by flexing the hip joint, when the leg at the knee naturally bends, owing to gravity; but if the femur be fixed no flexion at the knee joint can be produced.

Ankle.—No movement whatever at ankle joint; the foot is in a position of moderate 'varus.'

Right Side. *Hip joint.*—There is slight power of flexion of hip joint, but less than on the left side. There seems to be very slight power of extension, but this is doubtful.

Knee joint.—No movement. Joint stiff in position of extension.

Ankle.—No movement.

Anæsthesia.—Total anæsthesia on the right side up to the groin; on left side up to the level of about three inches above the knee joint.

Reflexes.—Knee-jerks and plantar reflexes are absent.

Nutrition.—There is much wasting of both limbs below the knee joints.

By comparing the report of this patient's condition before the operation with that taken on May 20, 1899, it will be seen that, as far as the muscular system is concerned, the improvement depends chiefly or entirely upon greater power of those muscles which were not at first absolutely paralysed. The only movement which the patient performed voluntarily before the operation was lifting the left leg slightly, so that the increase of power in the muscles as above described has been very great. The chief improvement in nerve power has been the partial restoration of the functions of the bladder and the better nutrition shown by the healing of the bed-sores. The improvement in general health is also very considerable, for whereas the patient appeared to be rapidly sinking at the time of his admission to the City Orthopædic Hospital he is now in fairly good health—is cheerful and enjoys life.

Fig. 48.—Portrait of the patient in June 1899

Sequel.—In August 1899 this patient went to the sea-side for a change. The rules of the institution where he was received did not

permit him to take as much rest as he had been accustomed to. The Bath chair which he was permitted to use was furnished with a hard seat, and bed-sores, which had healed long previously, returned in the old places. He begged to be allowed to remain in bed, so that these sores might heal, but this request was not acceded to. He returned to London in an emaciated condition, the bed-sores suppurating freely.

His temperature was high, varying from 100° to 103°.

There was constant irritation in the bladder, although it was washed out frequently. With perfect rest and careful attention he began to recover again, but uræmic poisoning supervened, and while semi-conscious he wounded himself seriously with his razor—cutting deeply in the hypogastric region, but without wounding the bladder, bowels, or large vessels; he also cut across the scrotum.

He succumbed the next day to uræmic poisoning and exhaustion.

If this patient had been operated on shortly after his accident it seems probable that he might have made a very good recovery.

I have elsewhere ('Lancet,' August 19, 1899) urged the value of early operation in nearly all cases of fracture-dislocation of the spine, giving numerous instances of the satisfactory results of such treatment.

I am indebted to my colleague, Mr. Jackson Clarke, for his great care in the treatment of this patient after the operation.

COMPRESSION OF THE SPINAL CORD BY A VASCULAR GROWTH, CURED BY LAMINECTOMY

The object of operation in this case was the relief of interference with certain nerve functions. The operation was successful.[1]

Case II.—Miss M., aged 31, was first seen by me on September 19, 1890. About four years previously she had injured

[1] Reported in *Brit. Med. Journ.*, December 1, 1894.

her spine in lifting a patient. Subsequently pain and weakness developed in the back and also in the lower limbs. Three years before the above date the patient had suffered so much that a felt jacket had been applied. This apparatus, however, gave very little comfort.

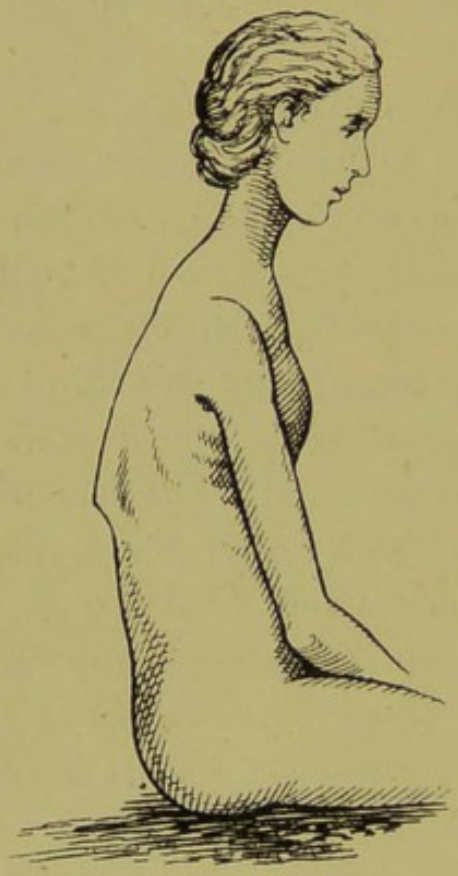


Fig. 49.—Appearance of patient, September 1890

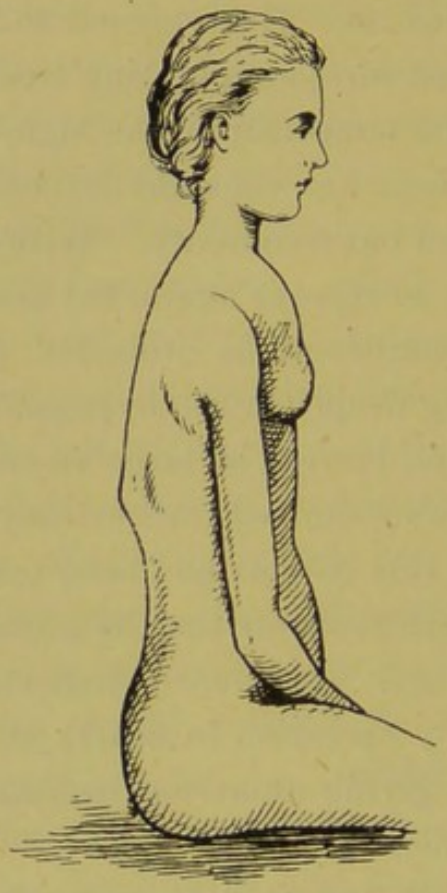


Fig. 50.—Appearance of patient, September 1894, after treatment by apparatus

The case seems to have progressed in a chronic manner, and the walking powers were gradually affected. At the above date there was distinct angular projection centred in the tenth dorsal vertebra, as shown in fig. 49. By means of more efficient mechanical support to the spine than she had previously had, the pain in the back was subdued, and a few months later the patient was decidedly better as regarded general health and the weakness

in the back. The vertebræ then seemed to be consolidated (fig. 50). A feeling of coldness in the lower extremities, and great difficulty in walking, however, remained. A course of massage, rest, and special feeding relieved the symptoms to some extent, but only for a very short period. The difficulty in walking became more pronounced, and in January 1894 I noted that she was unable to lift the legs forward in walking, and she described her sensations as if weights were attached to the legs. The patient had been obliged to use crutches for the last year, having used a stick before this.

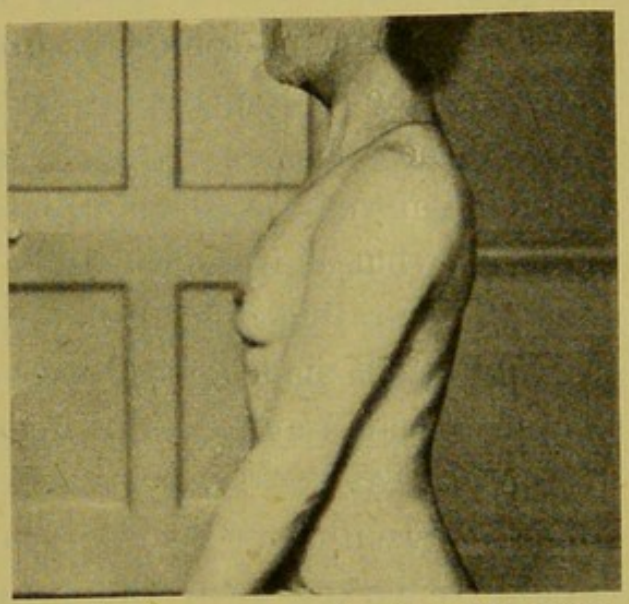


Fig. 51.—Appearance of patient, May 1897. After laminectomy

Pain.—There had been pain of a neuralgic character in the region of the sacrum for several years, gradually increasing in acuteness, with periodical attacks of greater severity. When the patient remained at rest the neuralgic attacks were quiescent, but any attempt at walking brought them on. The patient —standing between two chairs and supporting herself on them— could only lift the knee of each leg upwards about four inches, and backwards to about the same extent. The knee-jerk was natural, and there was no ankle clonus.

Anæsthesia and hyperæsthesia.—There was dulness of sensation in both thighs, with the exception of a line of hyperæsthesia in the course of the internal cutaneous nerve. On the right side this anæsthesia commenced at the groin and extended to within two inches of the knee. On the left side this area extended

upwards to about the eleventh rib. At the back of the thighs the area of dulness did not extend so far downwards. There was hyperæsthesia of the buttocks.

Operation.—On May 24, 1894, with the assistance of Mr. Ernest Lane, I performed laminectomy by removal of the neural arches of the eighth, ninth, and tenth dorsal vertebræ. There was no fat over the dura mater, which was congested, and in the upper part of the opening, in the position beneath the removed arch of the eighth vertebra, was found a spongy material like granulation tissue. This was producing some pressure on the cord and was removed. It covered the dura mater as far as it was exposed transversely, being rather thicker on the right than on the left side. The amount removed was about equal to the contents of an ordinary hazel nut; but as it could only be taken away in small pieces the amount was rather difficult to estimate.

The patient made a rapid recovery from the laminectomy. The wound appeared quite healed upon the third day after the operation, except at the lower part, where a drainage tube had been left in for twenty-four hours. The day following the operation the patient remarked upon the great difference in her sensations, having lost the feeling of coldness in the lower extremities, which she had suffered from for several years. She gradually recovered strength, and with a supporting apparatus to the spine began to walk about three weeks after the operation.

A letter from her, dated November 7, 1894, five months after the operation, describes her condition at that time in comparison with what it had been formerly. She referred to the coldness, which had existed for years, in her lower limbs, as 'deadly coldness.' She had been obliged to have hot bottles at night, summer and winter, and these had only given her relief during their use. She stated: 'Almost directly after the operation I felt

warm again, and this has continued since. My digestion, which had been getting steadily worse, improved wonderfully, and I now eat very fairly and feel no discomfort after meals.' She further stated that the severe headaches with which she had been so constantly troubled had disappeared. Spasmodic jerking of the legs, from which she had suffered very frequently, had also gone. The walking powers had been practically quite regained. She could then walk at least two miles without stick or crutch, and with comfort.

The patient remained in good health and able to get about comfortably for two years. The operation had removed the angular projection (fig. 51). At the end of this time she was so unfortunate as to be knocked down by a cart, and she fell flat on her back. The accident set up an attack of spinal meningitis, and for a time her life was despaired of. She gradually recovered, and has since then been perfectly well as regards her powers of locomotion. I saw her during December 1899, when she seemed to be quite well.

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SPOTTISWOODE AND CO., NEW-STREET SQUARE
LONDON