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PREFACE

In this volume we record our personal experiences of the most recent methods of treating the sequelæ of congenital and acquired forms of paralysis. We have written merely in passing of the older and simpler methods, such as tenotomy and mechanical devices, because they are fully set forth in the standard works on Orthopædic Surgery, and do not need repetition. The newer procedures of muscle-grafting, tendon-transplantation, and arthrodesis have widened the scope of surgical treatment, both of paralysis itself and of its resulting deformities, and promise to effect an entire revolution in this branch of surgery.

We trust that the volume may serve as a

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SECTION I

INFANTILE PARALYSIS OR ACUTE ANTERIOR POLIOMYELITIS

CHAPTER I

INFANTILE PARALYSIS: ITS ETIOLOGY, PATHOLOGY, GENERAL TREATMENT, AND THE PRODUCTION OF DEFORMITY

In this section we propose to limit ourselves to the consideration of infantile paralysis or acute anterior poliomyelitis. It is a disease, occurring with few exceptions, from the second to the fourth years, and those instances where similar symptoms occur in later life are sufficiently rare to merit comment.[1] Of 250 cases we have noted, 57 occurred in the first year, 95 in the second, 53 in the third, 29 in the fourth, 22 in the fifth, 5 in the sixth, 2 in the ninth, 1 in the eleventh, 3 in the

[1] Cf. an important case quoted by Williamson, *Med. Chron.* vol. xii. p. 454. Here the diagnosis was confirmed by post-mortem examination. Other cases are given by Schultze, *Virch. Arch.* 1878, vol. lxxiii.; Friedländer, *Virch. Arch.* 1882, vol. lxxxviii. p. 84.

excitable. Over-exertion, dentition, traumatism, and heat, may all be looked upon as exciting causes, and there does seem to be a connection between a recent attack of scarlet fever, measles, or diphtheria, and an attack of infantile paralysis.

Etiology.—Four important etiological facts are known: the relation which the disease has to age, climate, season, and to the infective fevers.

Gowers[1] states that it is ten times as frequent in the first decade as in all the rest of life. Of 116 cases noted by him, 21 occurred in the first, 21 in the second, 25 in the third, 9 in the fourth, 17 in the fifth, 4 in the sixth, 2 in the seventh, 6 in the eighth, and 4 in the ninth year. The greater incidence of the disease in the summer months in England has been noted, and its prevalence among English children in India is remarkable.

Other etiological factors have been mentioned, such as over-exertion, trauma, and dentition, but there is no proof that these bear any essential relation to the disease.

[1] *Disease of the Spinal Cord*, 1892, p. 352.

Further, it occurs in connection with measles, scarlet fever, smallpox, and typhoid.

The occurrence of the disease after the infective fevers is important as showing that in these cases, at all events, it has probably a toxic origin. Further, its prevalence, especially in certain months, when diarrhœa is also most common, and that form of diarrhœa which is known to be caused by a micro-organism, is suggestive as indicating that there may be a poison absorbed by the alimentary canal; and this is concerned in the production of those morbid conditions of the vessel of the cord, which are in the majority of instances the immediate cause of the disease. Recent opinion favours an infective theory in regard to poliomyelitis. In this connection we will first give instances, based upon our personal observation, which favour that theory. In 1897 one of the authors was asked to see a child of four years who lived at a seaside resort.

CASE 1.—The child was a visitor, and lived during August with a family of four children. The patient, accompanied by the nurse, had been out playing on the sands on September 3rd, a day which was not particularly hot. On the 4th he complained of feeling unwell, was sick, vomited three times during the night, and he had slight diarrhœa. His temperature on the 4th, 5th, and 6th reached 103°, but on the 7th the acute symptoms had disappeared. It was noted, however, that he did not move his left leg, which proved to be paralysed.

CASE 2.—On the 6th a child of three years in the same house became almost similarly affected. She was sick, perspired profusely, and had diarrhœa. Her temperature for three days reached 105°. On the 9th of September the symptoms cleared up, and it was thought the child was well. On the 11th, however, both limbs were paralysed. One other child of the same family, 2½ years of age, had a very bad attack of diarrhœa with vomiting on the 8th. This lasted two days, but did not result in any paresis.

CASES 3 AND 4.—Two children, one of two years of age and the other three years, were brought to us from a certain house, one child affected with monoplegia, the other with paralysis of the muscles governing the ankle. They were both taken ill on the same day with a febricular attack, accompanied by vomiting, and on the fifth day the paralysis was noted. There had been no exposure to excessive heat.

CASE 5.—A boy of eight years was brought to us on account of an uncertain gait on the right side, which had existed some years. It proved to be a partially recovered peroneal paralysis. When the parents were informed of this, they mentioned that six years previously three children had been taken ill with sore throat, headache, and sickness. One, who died of pneumonia later, was completely paralysed for a month, but he recovered the use of the right limb; the second perfectly recovered; the third was the patient referred to, with peroneal palsy.

The Occurrence of the Disease in Epidemics.—One of the strongest proofs that the causal agency in a disease is infective is its occurrence in epidemics; and it is now known that, in many instances, infantile palsy may attack so many children at the same time as to constitute an epidemic. It is in such cases that the disease exhibits exceptional symptoms, which show that the causal agent is capable of producing a widespread disturbance in the nervous system. Brackett[1] of Boston has recently collected records of many of these outbreaks of paralysis. The most full and important account is that of Medin.[2] Whereas ordinarily he saw two or three cases a year, in the six months between June and November 1897 he saw 44, of which no less than 30 occurred in August and September. Of these 44 cases, 27 were typical infantile palsy, 3 showed paralysis of the face, 6 had the symptoms of acute peripheral

[1] *Transactions American Orth. Assoc.* vol. xi. p. 133.

[2] *Verhandlungen des X. Internat. Med. Cong.*, Berlin, 1890, vol. ii. part vi. p. 37.

neuritis, in 7 the cranial nerves were involved in addition to the extremities, and in 1 the symptoms pointed to a cerebral lesion with paralysis of the abducens oculi, the cerebral and neuritic symptoms being the exceptional symptoms in this epidemic form.

In 1885 Medin[1] encountered another epidemic, in which the same striking features were met with. In some of these cases valuable post-mortem examinations were made and the lesion shown to be a vascular one. Leegard,[2] in the small town of Mandal, saw 8 cases between July and September. Cordier (quoted by Marie),[3] in a town with a population of 1500, saw 13 cases of this disease in two months.

The unusual symptoms which may be present are again illustrated by Brackett[4] of Boston, in two of whose cases speech was lost; whilst Taylor[5] of Philadelphia mentions that the sphincters were affected in some. The fact that several children of the same family may

[1] "Epidemic of Infantile Paralysis," *Hygeia*, 1890.
[2] *Münch. Med. Wochenschr.* No. 38, 1898.
[3] *Lyons Medical*, 1888.
[4] *Trans. Amer. Orth. Assoc.* vol. xi. p. 135.
[5] *Boston Med. and Surg. Journal*, cxxix. p. 504.

be affected has been known for a long time. Simon, quoted in Pepper's *System of Medicine*, mentions a family in which three children were attacked within twenty-four hours. An important observation was made by Caverley, who records an extensive epidemic of 140 cases in Vermont, in general resembling infantile palsy, but with the presence in some of cutaneous eruptions, and in others of paralysis of cranial nerves, anæsthesia, and symptoms of multiple neuritis. It is perhaps worth while mentioning that during this epidemic a large number of domestic animals also died with paralysis. The cause of such paralysis in animals has sometimes been found associated with lesions of the alimentary canal; and in a pig which Dr. Warrington has had recently under observation, a form of subacute paralysis of all four limbs developed, and the intestine was found to be loaded with nematodes. Whilst, of course, it is known that such parasites infest the alimentary canal of domestic animals, the observations may be of some value as indicating that toxic products formed in the intestine may cause an affection of the spinal cord. W. Pasteur reported in

1897 [1] the case of a family of seven children, who early in July were attacked in rapid succession within the space of ten days by an acute febrile disorder of three or four days' duration, characterised by headache and general malaise. Within a few days of the onset, paralytic symptoms supervened in three out of the seven, whilst in two more there was some temporary disturbance of nervous equilibrium.

The fever was limited to this household, no other case being found in the district. Influenza was not prevalent; the sanitary conditions were good, and no adult was attacked. Pyrexia and headache, and in some cases backache, were the prominent symptoms. There was no catarrhal manifestation. Sore throat was found only in one case, but there was no diarrhœa, nor vomiting, nor convulsions, nor twitchings. Enlarged glands, rash, or desquamation did not occur.

Dr. Brackett [2] of Boston describes an epidemic in North Adams which occurred in the summer of 1894, a description rendered the more valuable inasmuch as the cases were

[1] *Clinical Society's Transactions*, vol. xxx. p. 143.

[2] *Trans. Amer. Orth. Assoc.* vol. xi. p. 133.

examined at a considerable period after the outbreak. Ten cases are reported, occurring with one exception between the middle of August and September 18th of that year. The cases were distinctive, and some were very severe. In the majority of the cases the invasion was sudden, and the attack was ushered in by fever, headache, vomiting, and occasionally delirium or stupor. These symptoms were followed by paralysis after an interval of from one to twenty-one days. The distribution of the paralysis was not different from the ordinary type, but the muscles of the trunk were often badly affected. There was a loss of speech in two cases, and blindness in one. An interesting feature was that, of 10 cases, 8 presented loss of control of one or both sphincters. As in Medin's patients, the meninges seemed to have been involved, and many of the cases were not of a pure spinal type.

An epidemic was reported as occurring in 1894 in Rutland in America,[1] many of the cases proving fatal. The epidemic persisted mainly during July and August, and included 132 cases which occupied a few miles of

[1] Caverley, *Journal of American Medical Assoc.*, Jan. 4, 1896.

territory along Otter Creek. Fifty-five cases were actually from Rutland, 27 from the village of Proctor, and 50 scattered about the farming districts. There were no demonstrable etiological factors. The summer was hot and dry, the formation limestone, and only in the town of Proctor was the location at the water's edge. The onset was characterised by fever, by symptoms of stupor, hyperæsthesia, and by the development of paralysis more severe than that found in ordinary poliomyelitis. The cerebral nerves were frequently affected; and it is to be noted that in the epidemic cases the disease showed a distinct tendency to spread centrally to the brain, and peripherally to the spinal nerves. Nineteen of the cases were under six years; none occurred in adults. Twelve cases were convulsed; 18 cases were fatal; in 20 muscular rigidity was present. Thus there appear to be two types of infantile paralysis: the purely spinal and usually sporadic, and the cerebro-spinal type, which is often epidemic.

A series was recently reported by Dr. Taylor[1] of Philadelphia, occurring at Cherry-

[1] *Boston Med. and Surg. Journal*, vol. cxxix. p. 504.

field, where that writer happened to be. The series of 7 included two children of the same family. They presented symptoms typical of poliomyelitis limited both as to area and time. Altman[1] of South Australia reports an epidemic of 14 cases occurring between March and April 1895. The severity of symptoms was characteristic of the other epidemics. In 10 cases there was marked initial fever, and the upper extremities were involved.

Pathology.—A review of what is known of the facts in the pathology of the disease shows that much of importance has gradually been discovered. The significance of some of these facts is great; the initial processes underlying the structural alteration in the spinal cord have been carefully studied and found to be due to a primary vascular disturbance, a conclusion at once of the highest importance in the treatment of disease in its earliest stage. Moreover, evidence both clinical and bacteriological has been adduced to show that the vascular disturbance is to be attributed to some toxic agent. We do not purpose, in a

[1] *Australian Med. Gazette*, April 24, 1897, p. 173.

monograph intended to be clinical, to enter into pathological details, nor to criticise the various theories which have been advanced. We will be content merely to indicate the salient points connected with recent observations. It was Cornil[1] who first offered proof that the affection was primary in the cord and that the muscular theory was incorrect, while, later, Charcot[2] pointed out that the cells in the anterior cornua were chiefly attacked. In consequence of the disproportion of the wreckage of the cells to the injuries of the connective tissue, he argued that the cells were primarily affected, and that the inflammation of the connective tissue was a secondary lesion. Roget and Demaschino[3] were the first observers to make detailed pathological examinations of recent cases. In one case the examination was made twenty-six days after the onset of symptoms, and foci of red softening were found throughout the cord with great dilatation of blood-vessels, and a disten-

[1] *Compt. Rend. des Séances et Mémoires de la Soc. de la Biologie*, 1863, series 3, vol. v. p. 187.

[2] *Archives de Physiol. Norm. et Pathol.* 1870, vol. iii. p. 134.

[3] *Compt. Rend. des Séances et Mémoires de la Soc. de la Biologie*, 1871, p. 49.

sion of the perivascular lymphatic sheaths with corpuscles. The ganglion cells were found destroyed, and the myelin of the anterior roots broken up into droplets. They were of opinion that the cell-destruction was secondary to the myelitis.

Goldscheider,[1] in an interesting communication, basing his conclusions on the examination of three cases, while adhering to an inflammatory theory, argued that the lesion was closely connected with the distribution of the central branches of the anterior spinal artery. He found that the lesion in poliomyelitis was not confined to the ventral horns, but it invaded the white matter and the dorsal horns. This represented the area of supply afforded by the central branches of the artery. These branches course mainly in the long axis of the cord, so that if we take the cord at any level, we find it supplied by branches from several central arteries. Goldscheider made the important discovery that, where one such artery escaped attack, the cells in the area it governed also escaped. In this way various groups of cells were affected at

[1] *Zeitshft. f. Klin. Med.* 1897, vol. xxx. p. 175.

Ligature of the aorta in animals rapidly produces paralysis of the hind limbs, and marked changes are found in the cells of the anterior horn; but if the stoppage of the blood-current has not been made for too long a period, the paralysis and alteration in the structure of the ganglion cells will pass away.

Batten[1] ascribes the changes in the cord to thrombosis occurring in the area supplied by the anterior spinal artery. He bases his arguments on the similarity of the pathological appearances in recent infantile palsy to the patches of red softening which follow thrombosis of the small vessels of the brain.

In the light of the epidemic character which is sometimes assumed by poliomyelitis, the search for a specific germ has been carried on assiduously. Schultze performed a lumbar puncture in a case of anterior poliomyelitis, and isolated an organism which had the characteristic growth of the Weichselbaum-Jäger meningococcus. F. Engel has found the staphylococcus albus in the cerebrospinal fluid of an undoubted case of polio-

[1] Batten, private communication to Gossage, quoted in a paper by the latter published in *Amer. Journ. Med. Science*, May 1902.

myelitis, and several observers have found micro-organisms both in infantile paralysis and in ordinary myelitis.

It is probable, from the history of a large number of cases, and from careful clinical observations, that there may be three or more diseases which are grouped as anterior poliomyelitis or infantile paralysis, and Gossage[1] suggests the following classes :—

(1) That class where paralysis comes on suddenly without previous ill-health. (2) That class where the onset of the paralysis is preceded by general symptoms such as fever, vomiting, pain in the back. (3) The epidemic class in which the disease tends to spread to the brain and distal nerves. (4) The adult class. Some neurologists have distinguished a spinal type, and a mixed or cerebro-spinal type of infantile paralysis.

We have always maintained that the complete paralysis which at first occurs so often, and the rapid recovery of the majority of muscular groups, point to pressure upon nerve elements and cells rather than to a destructive inflammation; but to verify these

[1] *Amer. Journ. Med. Science*, May 1902.

points, post-mortem examination and pathological experiments are needed. These should consist of inoculations taken from an early case, and of cultivations for the discovery of a microbe. To throw more light upon the changes noted in the cells of the anterior cornua, further comparisons should be made with the changes observed in the same region in old cases of amputation, in cerebral palsy, and ancient ankylosis of the larger joints. In addition, valuable information may be gained, as in Warrington's[1] experiments, by division of nerve-roots; and by noting the changes in the motor cells at various periods after amputating the limbs of growing animals.

In the absence of an accurate pathology, we may rest assured from clinical deductions alone that there is hyperæmia of the cord, which has the effect of inhibiting temporarily, or actually destroying, certain ganglion cells in the anterior cornua. These cells having trophic as well as motor functions, any injury to them gives rise not only to certain paralysis, but to impeded circulation and

[1] *Transactions of Pathological Laboratories*, Univ. Coll. Liverpool, vol. i. p. 197, 1898-99.

arrest of growth. When we examine at a late period, therefore, we find a shrivelled limb with wasting out of all proportion to that caused by mere desuetude. It feels quite cold to the touch, is shorter than its fellow, and often presents a mottled blue colour. When the affected member is not retained in the normal position during the early stages, it assumes a position of more or less deformity, the etiology of which will be discussed later. For some time this deformity can be overcome with ease, but later this, in many cases, is not practicable, structural shortening having taken place in the healthy or less affected muscles.

Symptoms.—Clinically the course of the disease may be discussed under three headings: (*a*) the onset; (*b*) the paralysis; (*c*) the nature of the deformities.

(*a*) The onset varies considerably, and is very often acute in character. The cases can usually be grouped under one of the following heads:—

(1) A child is taken suddenly ill; the symptoms are those of febricula with pain in head and back, and perhaps diarrhœa. The

temperature varies from 99° to 102°. There are restlessness and perspiration. The paralysis follows in from three to ten days.

(2) A child is irritable and out of sorts, and goes to bed. In the morning paralysis has occurred. Apart from this the child is well.

(3) A child is suddenly seized with vomiting and convulsions, which pass off without recurrence, or they continue. This condition may last for hours or days. When the acute symptoms pass off, paralysis is noted. It may affect any muscle, or any group of muscles, or any number of muscular groups.

The majority of cases may be grouped, as regards onset, under the first class. We so rarely have the opportunity of examining a little patient at the moment of onset, that accurate personal observation is much needed. We have, however, noted a temperature of 103°, which continued for over three days.

To illustrate this classification we give three cases respectively :—

Case 6.—A small boy of three years of age, who had been playing on the sands, complained of wanting to lie down. He was taken home and put to bed. He felt sick, and his temperature rose the same evening to 101·5°. There was some pain complained of over the stomach, which caused the little fellow to cry. On the second day the temperature rose to 102·5°, with occasional attacks of perspiration. There was no feeling of nausea, no headache, but he had a very dry tongue and a pulse of 120. On the third and fourth days the child was better, the temperature 101° and 100°. It was then noted that all the muscles of the left limb were paralysed, and the same had happened to the extensors of the right leg. For eight or ten days the child was examined every morning, and power slowly returned to the left limb; first in the psoas and iliacus, then in the extensors of the toes, then in the quadriceps, while the calf muscles and hamstrings made what was apparently a simultaneous recovery. The left leg, which had been totally paralysed, made an absolute recovery, while no improvement at all occurred in the extensors of the right leg.

Case 7.—A boy of $2\frac{1}{2}$ years of age, who had been playing all day, complained in the evening of pain in the head, and refused food. He was taken to bed; his temperature was only half a degree above normal. He slept well all night, but he perspired freely. In the morning he was quite well in health, but he had lost control of the left limb. During the next three weeks the power returned to all the muscles save the extensors of the toes.

Case 8.—A child of two years of age, residing in a healthy suburb, showed signs of irritability and restlessness. Sickness then came on, and great pain in the head. The temperature was 100°, both that day and the following, and the head still ached. On the third day the temperature was 99°, the head became easier, the vomiting ceased, but he complained considerably of pain at the back of the neck. The temperature dropped, but convulsions occurred about twice a day for a week. On the ninth day the left arm was paralysed, the muscles involved being the deltoid, supra- and infra-spinatus, the biceps and the supinators. The tenth day a sudden paralysis of the left leg occurred, the muscles involved being the rotators of the hip, the extensors and flexors of the knees, with complete loss of power in all muscles below the knee. In fifteen days power had returned to all the muscular groups of the limb excepting to the flexors of the ankle. No power had returned after six months to the muscles of the arm.

With regard to the relative frequency of the muscles attacked it is difficult to draw any inferences of value, for so few make accurate investigations at the moment of onset, and any later observations are valueless as to the total number of muscular groups attacked. It is a simpler matter to analyse the cases which come to us later with their residual paralysis.

In the leg, the peronei are most frequently affected, then the extensors of the toe, then the quadriceps, then the tibiales. The hamstrings and the calf muscles are about equally attacked, and the muscles which most frequently escape are the sartorius and psoas and iliacus.

In the arm the deltoid is the muscle most frequently affected; then the shoulder group, consisting of the deltoid, supra- and infra-spinatus. The biceps and supinators are generally conjointly paralysed. The flexors of the hand are rarely affected excepting in a more general paralysis, and to a lesser extent the same may be said of the extensors. We have frequently noted a paralysis affecting the flexors and extensors of the forearm, while the flexors and extensors of the hand escape.

A Table of the Distribution of the Paralysis

Of 250 cases—160 were girls, 90 were boys.
137 were affected on the left side; 113 were affected on the right side.
In 140 cases the paralysis was confined to one leg.
In 27 cases the paralysis was confined to one arm.
In 28 cases paralysis of both legs was present.
In 10 cases paralysis of both arms was present.
In 9 cases paralysis of both arms and legs was present.
In 20 cases paralysis of one arm and one leg was present.
In 9 cases crossed paralysis existed.
In 4 cases paralysis of muscles of trunk was present.

It will be seen, therefore, that paralysis has been more often noted by us in girls than in boys, and that the disparity is marked. In the poliomyelitis occurring after puberty, the disease is much more frequent in boys than in girls. Indeed, it is quite a rarity to see it in girls. The disease has more frequently affected the left side. Paralysis occurred in one leg in considerably over half the cases.

(*b*) The paralysis comes on in from a few hours to a week or ten days after the onset of the disease. It appears usually suddenly, and in certain cases its intensity is increased by successive attacks of the initial fever, which reaches the maximum generally in a few hours, and rarely lasts longer than two days. For a varying period the paralysis remains stationary. In from six weeks to three months it diminishes in intensity or completely disappears. This improvement is at first most rapid, but gradually becomes less so, until finally it remains stationary. After six months it is rare to find any case, untreated, improve. Atrophy of the affected limb is a marked feature, and is often observable a few weeks after the onset; this, of course, is not due to the desuetude, but to disturbance of trophic cells. The temperature of the affected limb falls. In one case, a girl aged 8 years, the left lower limb was shortened half an inch in three months. If a case has not been treated, the limbs may have assumed a position of more or less deformity. For some time this deformity can be readily overcome by the hands, but later this ceases to be possible, structural shortening having taken place in the healthy or less affected muscle. Ulceration is sometimes an accompaniment of the paralysis, and is due to irritation or the pressure of splints, and its favourite site is the calf. Reflex action is lost in the regions allied to the affected muscles, but it comes back on the return of muscular power. The slightest degree of weakness in the extensors of the knee may be accompanied by diminution or abolition of the reflex. Sensation is most rarely affected, but anæsthesia is met with in many of the epidemic and in some sporadic cases.

(c) *The Character of the Deformities of Poliomyelitis*—(1) those due to trophic changes; (2) those due to mechanical causes following paralysis.

(1) Those due to trophic changes.—These are wasting of muscles, vaso-motor disturbance, coldness of the limb, and shortening. The degree of shortening due to trophic causes bears no certain relationship to the severity of the motor affections, and in some rare cases the paralysed limb may actually be lengthened. Two cases seen in June 1900 bear witness to this fact.

CASE 9. *Lengthening of Affected Limb in Infantile Paralysis.*—A youth of sixteen presented a complete paralysis of the left leg (not including the psoas and iliacus) and calcaneo-valgus due to paresis of the tibialis posticus and calf group. The paralysed limb was $\frac{3}{4}$ of an inch longer than its less affected comrade. The paralysis had lasted fourteen years, and so far as a history could be procured no recovery of muscles could be chronicled.

CASE 10. *Lengthening of Affected Limb in Infantile Paralysis.*—This case was that of a man of thirty who had been for many years under skilled treatment. The left leg was completely paralysed below the knee, and in addition the quadriceps was powerless. The right foot presented a pure equinus, due to paralysis of the extensors or dorsi-flexors. The more completely paralysed limb was an inch the longer.

That the rate of growth is not dependent upon the degree of paralysis can be verified by noting that often in a completely paralysed limb, when growth has ceased, the shortening is not more than one inch or so; while in cases with a very limited palsy you may see as much as five inches shortening. Again, in different people with similarly affected muscles the shortening of the limbs widely differs. True it is that generally a more marked shortening in connection with severe rather than with slight palsy is seen; all we affirm is that this is not necessarily the case. It is interesting to note that the bone near the affected group of muscles is more affected than the more remote ones. For instance, if the leg be paralysed below the knee, the shortening will be most marked in the tibia and fibula. Furthermore, if the groups above the knee are affected more than those below, the femur will show more shortening than the tibia. In order to render prognosis more accurate, it should be remembered that the arrest of growth is proportionate to the growth rate, and that the younger the child affected the greater the shortening.

(2) The class due to mechanical causes following paralysis contains the vast bulk of

the deformities associated with poliomyelitis. They usually do not appear for months or sometimes years after the onset. We believe that the causal factors in the production of deformities are mechanical. They do not immediately follow on paralysis, but evolve gradually. The antagonistic theory is not supported by observation. Unbalanced muscular action is undoubtedly an etiological factor, but the effects of gravity and of body pressure are greater factors; and certainly superincumbent body-weight, especially in the lower extremities, influences both the direction and severity of the deformities.

Diagnosis.—It is not necessary in dealing with paralytic deformities to enter into the question of diagnosis, as the conditions are quite easily recognised. As, however, the prophylaxis is most essential, it is important to detect anterior poliomyelitis quite early. It is almost impossible, unless it should occur during an epidemic, to make a diagnosis of poliomyelitis in the febrile stage. Temperature, pain in the limbs, and cerebral symptoms are all common occurrences in a variety of infantile disorders.

The points upon which a diagnosis may be based are: (*a*) the sudden onset; (*b*) the rapid muscular wasting; (*c*) the electrical reaction of muscles; (*d*) the motor paralysis; (*e*) the loss of tendon reflex; and (*f*) the vaso-motor changes.

We subjoin a table of the distinguishing features of poliomyelitic and cerebral spastic paralysis.

TABLE OF DIFFERENTIAL DIAGNOSIS BETWEEN ANTERIOR POLIOMYELITIS AND CEREBRAL PARALYSIS OF CHILDREN

	Anterior Poliomyelitis.	Cerebral Paralysis (Spastic Paralysis).
Onset.	Convulsions not often present. If so, they are general in character.	Usually present, sudden, severe, often unilateral, and often start locally.
Reflexes.	Generally lost. Myotatic irritability lost.	Normal or increased. Myotatic irritability present.
Reaction.	Loss of faradic irritability. Reaction of degeneration present.	No loss of faradic irritability.
Character of paralysis.	Monoplegia or paraplegia. More rarely hemiplegia. No spasm present.	Generally hemiplegia; sometimes paraplegia or diplegia; most rarely monoplegia. Spasm often present.
Age.	Generally limited to children of from one to three years.	Often congenital; not strictly limited to childhood.
Nutrition.	Marked wasting.	Wasting not so complete.

It is not easy to confuse infantile paralysis with other disorders of childhood, although even skilled observers have at one time or another been deceived. The early stage of hip-joint disease, where the child is apt to drag its limb and complain of pain, has been mistaken for it. Apart from the difference in onset, the flexion-test will at once decide the presence or absence of coxitis. Progressive muscular atrophy, which so rarely afflicts children, but sometimes begins in the leg, betrays no loss of reflexes while any muscular tissue remains. Its onset is never sudden. Pseudo-hypertrophic paralysis, if the early history were known, should always make the differential diagnosis easy. Its exceedingly slow onset, its development keeping pace with the child's growth, the excess of tissue in the muscles in its early stage, is so different in both appearance and progress from acute anterior poliomyelitis as to prevent confusion. Gowers, however, mentions a limited palsy affecting mainly the quadriceps where the patient, in rising, climbed by his knee. The authors have noted two cases of a similar kind. In one, a child of five, the paralysis was limited to a bilateral affection of the quadriceps; the calves were fairly developed, and the child pressed his knees both in rising and in walking. These, however, were the only points of similarity, and there was no difficulty in diagnosis. Transverse myelitis in adults is more likely to be confused with the rare condition of poliomyelitis; but in children, as Duchenne observes, transverse myelitis is practically always poliomyelitis.

In certain rarer cases, especially in older persons, the question of the diagnosis between anterior poliomyelitis and peripheral neuritis of an acute type may arise. The following signs may be considered as indicative of a spinal origin :—

(1) The onset is more rapid. (2) The cranial nerves are very rarely affected. (3) There is no pain and no tenderness on pressure over the muscles or nerve-trunks. (4) The reaction of degeneration is more complete and corresponds more to the actual amount of paralysis. (5) The maximum degree of paralysis is more rapidly attained and the atrophy more pronounced. From diphtheritic paralysis the diagnosis is only difficult when poliomyelitis follows diphtheria independently. Severe atrophy is not present, and electrical reactions are not so commonly altered. With a little

care it is next to impossible, in the paralytic stage of infantile paralysis, to confuse it with any other condition.

Prognosis.—The prognosis of infantile paralysis as to complete recovery of every affected muscle is not good, but there is no case, however apparently unpromising, which cannot be very considerably benefited by one or all of the many surgical procedures open to us. In our opinion a considerable number of cases make complete recoveries before a diagnosis has been made. The evidence for this is to be found—

(1) In the large number of cases where affected groups have recovered completely from the attack, the effects of which are observable in a single group or a single muscle. (2) The cases so often seen where the effects of a transient palsy are noted in school children. (3) The cases where parents state two or three children were afflicted with similar onsets at about the same time, and where only one or two became paralysed. (4) Direct observation of cases during their onset.

(1) It seems only reasonable to suppose that where there is an involvement of cells

sufficient to completely paralyse a limb, and yet within a few days that limb recovers all power except perhaps in the peronei, other cases must occur where the pressure is removed from all the cells, and complete recovery follows. Indeed it is difficult to conceive that this should be otherwise. Frequently the history of these cases reveals a paralysis of both legs, one of which recovers to the stage of practically showing no trace of defective muscle. Then, too, the only evidence the practitioner has is in the paralysis of the group which is probably the residual one, and other groups have recovered before he has had an opportunity of making a diagnosis. If this be so, and evidence thereof is overwhelming, it is most likely that many of these attacks of poliomyelitis have never been recognised by physicians unless paralysis has been noted.

(2) In our surgical clinics we have frequently noted a wasted limb, the result of a transient paralysis where all the movements may be performed. This is more often observed in the upper limb, where if there be an imperfection it is found in the hand. If the patient be asked to open his hand, the fingers

ages were $1\frac{1}{2}$, $2\frac{1}{2}$, and $3\frac{1}{2}$ years. The child of $3\frac{1}{2}$ years, who was 6 when we saw him, had paralysis of the left leg with displacement of the hip, lordosis, and contraction of the knee. The other two children had no sequelæ.

(4) Dr. Sheldon[1] had an opportunity of watching two patients with infantile paralysis, one of whom had both legs completely affected so far as could be ascertained. In three weeks no trace of paralysis remained. In another case, where there was a monoplegia in a child of four, the paralysis cleared and left no defect. One of the authors had the opportunity of noticing two recoveries where no trace of imperfection remained. In one case, in a boy of three years of age, all the muscles below the knee were paralysed; on being seen five weeks later not a trace of paralysis was present. The other case was that of a child aged four years whose left leg and right arm were affected, and with the exception of some hyperextension of the fingers during movement, the recovery twelve months later was complete.

It is difficult to say how far an individual case will recover the lost power, but this may

[1] Personal communication.

be safely said: the recovery under proper treatment exceeds all anticipation. In fact the condition of a child at any given time is no measure of the possible or even probable improvement, and parents have often expressed their thanks to us for a hopeful prognosis when matters looked very much otherwise.

Treatment.—The surgical treatment of infantile paralysis may be conveniently directed towards—

(*a*) Prevention of deformity.

(*b*) Correction of deformity.

The surgeon is often asked "At what time should treatment be commenced?" The answer is, As soon as possible after the attack. If this were generally recognised there would be no fixed deformities requiring tenotomy; for only those surgical procedures which aim at the restoration of muscular power, or at the stability of limbs, or fixation of joints, would be required. The patient should undergo for the first few days such medical treatment as offers a prospect of reducing the severity of the fever, and when that is over the case should remain under surgical care.

The cells in the anterior cornua govern

motion, nutrition, and growth, and in poliomyelitis general principles should be applied to minimise the practical effects of the damaged or destroyed cells. In the earliest stages this is best accomplished by massage and warmth. Until one has had an opportunity of electrically testing the muscular groups, the massage should be general over the affected area. In its application there is nothing occult nor mystic. The mother, nurse, or maid can in a few minutes be taught all that is necessary to be learnt. The hands should be powdered with French chalk and the skin rubbed for two or three minutes, and for about ten minutes the muscles should be roughly grasped and pinched between the thumb and fingers, almost to the point of being painful. This most effectively increases the vascular supply of the muscles and ministers to the nutrition of the limb. With similar ends in view thick flannel should surround the limb; but on no account should a bandage be applied, for this both limits the circulation directly and interferes with muscular nutrition by circular compression. We cannot speak highly of electricity either in the early or later stage of the disease; a combination of voluntary movements on the part of the patient and massage is invariably more effective. We have arrived at this conclusion after an extensive trial of both methods.

So soon as it is possible to separate, electrically or otherwise, the affected from the sound muscles, a more special line of treatment must be adopted. Massage should be mainly directed to strengthening the affected muscles, and the limb must be kept in a position opposed to the deforming tendency. Particular attention should be given to the muscles essential to progression, and exercises of every kind devised to bring under control any muscular tissue not completely paralysed.

There is much more value in these movements than in such extraneous aids as massage and electricity, however useful as an aid massage may be. As soon as the little patient is anxious to walk he should be allowed to do so, care being taken that the limb is so protected that body-weight does not produce, nor increase, deformity.

The Mechanical Treatment of Infantile Paralysis.—The backward condition of the surgical therapeutics of poliomyelitis is due to a serious error, which practitioners make in that they fail to distinguish the loss of power caused by a destruction of motor cells from that due to muscular contracture. This error has largely grown in consequence of the homage paid to it by eminent neurologists both at home and abroad, and thence has originated the pessimistic tone which pervades our literature when the treatment of infantile palsy is discussed. The authors would endeavour to impress upon their readers that by the intelligent recognition of the differences between the disabilities due to mechanical causes and those due to central pathological changes, much of the difficulty of treatment will disappear. By a proper appreciation of the available therapeutic and mechanical agencies, we need rarely, if ever, encounter any paralytic deformity. This is a statement deliberately made, the import of which can be easily realised when we note the rarity of the occasion where we meet paralysis without deformity. The principle we desire to emphasise may be best understood by reference to some groups of muscles. The extensors of the wrists and fingers, for instance, are more frequently and seriously paralysed than are the flexor muscles, and in consequence the deformity known as "dropped wrist" develops. Then two factors come into play: the first is gravity, which places the hand in a semi-flexed position; the second is inefficiently opposed muscular action, which allows the flexors to contract. This contraction is increased for two reasons. In the first place by the continuous effect of gravity, and in the second place by the persistent overstretching of the weakened extensors by the stronger flexors (H. O. Thomas[1]). As no improvement can take place in the extensors, until the strain is entirely taken off them by mechanical or operative means, this principle we regard as cardinal. Numberless instances of such deformity may be seen in all our centres, most of them having gone the round of hospitals and physicians, most of them treated assiduously by galvanic currents, a few with deformities no more severe having been neglected from the first. Some are monoplegic; some are hemiplegic; most are the result of poliomyelitis; a few, not to be con-

[1] Personal communication.

sidered here, are the direct result of cerebral lesions.

It may well be asked concerning such cases if there be a time-limit after which treatment is of no avail, or may cases of old standing be hopefully attacked? There is no time limit, for we have successfully treated cases of over twenty years' standing, and a prognosis may be quickly given in any case which comes before our notice. The element which has to be combated is the secondary change in the contracted stronger group of muscles. For convenience of description this change is termed contracture. The term contraction explains itself; contracture involves a tissue-shortening due to prolonged contraction. To give an example:—

A patient presents himself with dropped wrist (Fig. 1). He has been afflicted for ten years. He is asked what he can do, and from force of habit he takes his normal hand to open the maimed one. The moment he removes this help the hand at once contracts. The

FIG. 1.
To show the appearance in a case of wrist-drop with affection of the fingers.

problem is, Can it be cured, and, if so, how? To all intents and purposes we have before us a case which has probably undergone early treatment by galvanism with no result. He arrives with his deformity intensified, and hopeless of improvement. Such cases rarely come for treatment on their own initiative. If not directly recommended by some recovered friend, the surgeon will seldom be called upon to suggest the possibility of treatment.

The clinical test of the recoverability of such a case is simple. If spasmodic movements occur on a voluntary attempt at opening the fingers, mechanical methods will only partially succeed. If, again, when a patient is asked to extend the fingers he can only do so by simultaneously moving the fingers of the other hand, the case is hopeless. If, however, a patient on being asked to move his fingers responds by the faintest quiver (Fig. 2), the surgeon, still further contracting his hand,

Fig. 2.

To show the method of testing for movement in the extensors. The surgeon's hand pressing gently against the dorsum of the patient's hand notes if there be any slight response in the extensor tendons.

should ask him to repeat the effort. The fingers are at once moved back to the point from which the surgeon started them. (Fig. 3). Such a case, should it have lasted one year or thirty, will almost certainly recover. The reason of the disability is not far to seek. The cells governing the useless extensor muscles have recovered, and when

FIG. 3.

The patient's hand is further flexed, and it is noted that he can now voluntarily move back the fingers to the former position.

the contracted flexors are relaxed by forced flexion of the wrist, the elongated extensors are enabled to make an unopposed effort; for hitherto the extensor muscles have succumbed to the contracture of their opponents, and being overstretched have had no breathing time, and become progressively weaker; but yet they have not remained permanently paralysed.[1]

It is clear, therefore, granted the recovery of the nerve lesion, the presence of contracted

[1] Thomas, *Diseases and Injuries of the Upper Extremities*, p. 57. (H. K. Lewis.)

opponents, and the weakening influence of prolonged extension, that the scientific treatment must be to slowly reverse the conditions. We must endeavour to weaken the strong muscles and to strengthen the weak ones. This can best be done by *lengthening the shortened muscles* and *shortening the long*

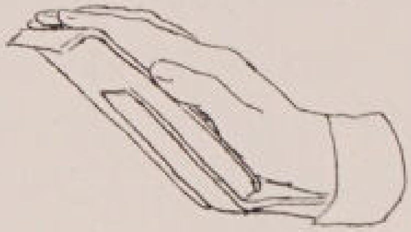


FIG. 4.

A case of wrist-drop—the hand having previously been placed on a straight splint, is now placed in a Thomas' splint for hyperextension of the wrist.

FIG. 5.

The same, with the angle of hyperextension increased.

ones. With this end in view we first place the hand and forearm on a straight malleable iron splint. It is kept in that position for so long as any tension remains, and the splint is bent from time to time until a stage of hyperextension almost to a right angle is attained (Figs. 4 and 5). This position is maintained until what we term the "test of recovery" is applied. The patient is asked (Fig. 6) to try and lift his fingers from the splint. If he can do so recovery is practically assured by such a proof of the restoration of muscular balance. The splint is, however, not taken off at once, but instead of the hand plate reaching to the finger tips it is cut below the knuckles in order to allow of finger movements, while the wrist remains extended. At night for

FIG. 6.

The test of recovery from wrist-drop—the patient is able to lift the hyperextended hand from the splint.

a confirmatory period the fingers are again extended (Fig. 5). During the whole of this treatment no bandages should exert pressure upon muscular tissue, but they should be applied around the tendons as depicted in Fig. 6. As will be noted, every movement of the arm from the splint still further extends the hand. From the first day of the application of the splint, until a considerable period after its removal, the extensor muscles should be roughly beaten with an indiarubber "muscle-beater," which consists of a gutta-percha ball transfixed

Fig. 7.
Muscle-beater.

by a skewer, which is placed in a handle (Fig. 7). This materially adds to the development of the muscles, and is as useful here as it is futile during the elongated state of the muscle.

As to the length of treatment required, a word or two may be helpful. It will be from six to eighteen months, and it depends upon the duration of the affection, the degree of contraction, and the severity of the paresis. We have seen cases, where the affection has lasted twenty-four years, which have recovered in fifteen months, and some rare cases of three to five years old which have taken nearly as long. This disparity is doubtless due to the very partial recovery of nerve lesion in the younger cases. A simple test will enable one to fairly gauge the necessary duration of time. If the surgeon, when he forcibly contracts the wrist, will note the strength of the action of the extensors, he will decide that those which act with greater strength will require the shorter treatment.

This principle is so important, for it really underlies the mechanical treatment of all disabled muscles, that we refer here to instances of other affections, the treatment of which is governed by the same laws, in order to emphasise the importance which we ascribe to them. We will refer to four well-known conditions common to surgery :—

(*a*) Alcoholic paralysis or drunkard's wrist. (*b*) Lead palsy. (*c*) Traumatic dropped foot. (*d*) Mallet finger.

Drunkard's wrist is doubtless due at times to direct pressure upon the musculo-spiral, but we are quite certain that it is often due to direct stretching of the extensors of the fingers. In proof of this we can refer to the notes of several of our cases, where the arm did not rest during sleep upon a hard substance. In three cases it was clearly elicited that the patients lay on a soft bed ; in one, on straw in a barn ; in another case, a surgical friend, having stitched some divided flexor tendons, kept the hand for a fortnight in an acutely-flexed position. As the patient two months later could not voluntarily extend the hand he was sent to us. The wrist at that time could quite easily be moved in all directions, but it required over a fortnight of hyperextension to restore power to the muscles. Frequently, in obstinate cases of drunkard's palsy, and also in lead palsy, hyperextension has brought about a rapid recovery. We will later refer to such cases, and also to recovery in paralysis due to injured nerves, all in confirmation of the *fact that contractures must be overcome before opposing muscles can properly act, and that elongated muscles are earliest restored to power by maintaining them in a slackened posture.*

The treatment of mallet finger is, if needed, a further confirmation. Hyperextend the terminal phalanx for a few weeks and recovery is assured—a result rarely accomplished by a simple straight splint. In dealing with the mechanical treatment of paralysis, its objects may be defined as the prevention of deformity; the correction of deformity; aids to locomotion; and the restoration of muscular equilibrium. With regard to the preventive functions of our mechanical art, we need not here enter into any detail. Our knowledge of the factors which give rise to deformity will enable us to devise means for their prevention. In the earliest stages of the affection the feet and hands should be kept from contraction by movements, or, if needed, by appropriate supports so devised as to keep the wrist and ankle in position, without allowing pressure on muscular tissue. Later, mechanical precautions may be taken against the tendencies of gravity, and still later to prevent any baneful influence of body-pressure on paralysed joints.

For the correction of deformity mechanical aid is essential. Concurrently with its application, tenotomy has frequently to be employed. We shall have occasion later to illustrate the immense leverage action which simply designed implements can induce, showing how certain deformities which do not admit of operative procedure can be made to yield to mechanical suasion. Indications will be given as to when mechanical aid may be so directed as to transform the act of walking from being productive of, to being corrective of, deformity.

As an aid to locomotion, mechanism has an important rôle to fill. Despite such operative triumphs as tendon-transplantation and arthrodesis, we are, except in the rarest cases, quite unable to undertake treatment without the aid of apparatus. In the case of complete paralysis of the lower extremity, including the glutei and the ilio-psoas group, walking can be assured by an apparatus which need travel no higher than the groin; while in so trivial a condition as the flapping of a foot from a recovered peroneal paralysis, the application of a leather strip to the outside of the sole of the boot will correct the tendency. This serves to demonstrate the wide sphere of usefulness the surgeon can control mechanically.

We have already referred to the principle which bears on the use of apparatus as a factor in the restoration of the balance of power between muscular groups (p. 46). It holds good in every joint. The requisites of a good splint are efficiency, simplicity, durability, and cheapness. Nothing has tended more to the discredit of the practice of orthopædics than the lumbersome and complicated machinery with which surgeons have loaded their unfortunate patients. Screws and ratchets which have to be daily revised, loosened or tightened, are too much in evidence even yet. We will, therefore, in illustrating our methods only

amined him and gave him a hopeful opinion. In saying so we were guided by the fact that, on still further flexing his wrist there was a feeble power of extension, which, had it not been present, would have rendered treatment hopeless. That the recovery would be tedious we knew from the weakness of the power of limited extension; also from the amount of force required to extend the fingers and wrist, and from the duration of the disease. A straight splint was placed on the palmar aspect of the wrist, hand, and forearm, and from time to time the hand was hyperextended, while the extensor muscles were well beaten with a muscle-beater twice a day. In fifteen months, the hand then being in a splint with the wrist fixed in a hyperextended position, it was noted that the patient could with more and more ease move his fingers off the splint. The restraint was therefore removed during the day while the hand was exercised, to be reapplied in the intervals, until the restoration of muscular balance. In less than two years his recovery was so admirable that he was enabled to carve wooden organ-pipes—so completely had the restoration of movement returned to the wrist and fingers.

CASE 12. *Dropped Wrist from Infantile Paralysis—Cure.*—Miss B., aged seventeen, consulted us about the same time. For fourteen years, following an attack of poliomyelitis, she had not been able to use her hand, except within a very limited radius, when the wrist was completely flexed. Her wrist and fingers were fully flexed, and in addition there was marked adduction owing to a shortened ulna. For ten years she had given up all hope of recovery, and her parents were almost apologetic in seeking further advice. For some years she had undergone both at home and in Germany various courses of treatment, electric and otherwise, with absolutely no improvement. On examining her we were able to assure her, on similar evidence as in Case 11, that her recovery might be counted upon in less than two years. The prognosis proved quite correct, and, with the exception of some adduction of the hand, deformity was corrected and movements were restored.

CASE 13. *Paralysis of the Deltoid Muscle and Dropped Wrist—Cure.*—F. H., a child of twelve, became monoplegic ten years previously. There was loss of power in the deltoid and a typical dropped wrist. The patient was able to lift the paralysed hand into position by resting the palm against a wall or table, and the structural shortening was not sufficient to prevent a passive hyperextension of the wrist. No mechanical treatment had been adopted, although the patient had always lived with a surgical relative. Electricity had been applied without intermission for three years. On being tested the arm was found at the usual mechanical disadvantage, and treatment was accordingly directed to restoring muscular equilibrium. In ten months a very useful hand resulted, and in three years she was able to write quite nicely, and had begun to play the pianoforte.

CASE 14. *Dropped Wrist from Infantile Paralysis—Recovery.*—T. L., aged twenty-five, had suffered from a right wrist drop since he was two years old. There was always some adduction of the hand. The contraction of the wrist was not extreme, and it could quite easily be hyperextended by the sound arm. There was just the slightest power of extension, merely a movement, without primarily further flexing the wrist. He had been the round of the neurologists, who gave him no prospects of recovery. Placed under mechanically favourable conditions, the functional use and normal range of movement was restored to the hand and wrist. The patient ultimately so far recovered as to be able to play a good game of billiards.

CASE 15. *Severe Paralysis of Upper Extremity—Partial Recovery.*—S. B., a boy of fifteen, was attacked with a paralysis involving the upper arm and scapular muscles, and also all the controllers of the elbow, and to a less degree the extensors of the wrist and fingers. The arm hung by the side limp and useless, fully extended with fingers flexed. Quite casually, while being treated for an ailment, the mother spoke to us of her son, and the trouble, grief, and expense his case had been to them. Endless journeys had been made to surgeons and physicians of repute, but no good had resulted, and finally for two years the little patient had remained in the metropolis in order to undergo gymnastic evolutions under a surgeon's direction. Our treatment was directed to the same end as in the previous case, and in twelve months the boy had so far recovered as to be able to voluntarily keep the wrist in an extended position and move the fingers freely through a normal range. The treatment adopted for the arm will be referred to later, but the boy sufficiently recovered, and at Cambridge he became an excellent swimmer, and he could use his hand for riding and driving.

CASE 16. *Dropped Wrist from Infantile Paralysis—Cure.*—Elsie V., aged five, was brought with dropped wrist accompanied by dropped foot. There was barely any resistance to completely extending the wrist and fingers, although this could not be done voluntarily. Mechanical treatment restored the hand in less than four months.

We have merely chosen six cases in order to supply types of those which are presented to the surgeon, and to enable readers to make a correct prognosis as to time. We have not kept accurate notes of all the cases of paralytic dropped wrist we have treated, but at a low computation we must have seen considerably over a hundred. A very large proportion of these cases had been quite disheartened by failures in treatment, although many had consulted the best of our neurologists.

These facts have urged us to lay the greatest importance on this special form of treatment; and to point out, what we will amplify later, that this principle of placing the weakened muscles under mechanically favourable conditions is the dominant note in treatment throughout the long list of paralytic deformities.

To *summarise* we would say :—

That most cases of paralytic dropped wrist are recoverable. That the severity of contractions and the duration of disease do not contra-indicate a favourable prognosis. That we have easily available clinical data whereby in nearly every case we can prognose as to the result and duration of treatment.

The data as to prognosis are:—

Flex still further the contracted fingers. If they can be made to voluntarily extend towards the point from which they were flexed, recovery can be confidently predicted.

If the force of this limited extension be feeble, recovery will be slow. If strong, *cæteris paribus*, recovery will be quick.

The structural shortening of the flexors is a more serious impediment to recovery than the long duration of the disability.

The paralytic groups to which we will next refer are the following:—

(1) *Complete paralysis of the upper extremity.*—For this extremely rare condition no treatment is suggested. The elbow and forearm lie flail, but we have noted contractions of the hand—a fact which tends to disprove a current German theory, which states that paralytic deformities are primarily induced by voluntary contractions of unparalysed muscles. The arm in this type of paralysis

is fully extended. Contraction at the elbow rarely occurs, because it is always allowed to swing freely. The fingers are generally somewhat contracted, because this is their normal condition when left hanging, as may be confirmed on any subject under an anæsthetic. The weight of the fingers is insufficient to keep them extended.

(2) *Paralysis of the deltoid, supra- and infra- spinatus, biceps, and the supinators.*—(This is the upper arm type of Erb.)

In this condition power may often be restored to the biceps muscle. The wrist should be placed in a simple splint so designed (Fig. 6) as to keep the hand hyperextended. This is to prevent the otherwise inevitable contracture of the flexors. The arm should be kept in a sling or halter at an angle of flexion somewhat less than 90°.

The object of this is to keep the biceps relaxed; it should in addition be pretty constantly kneaded. This offers the only chance of recovery to the biceps. During treatment care should be taken not to allow, even on one occasion, extension of the arm. Once the slightest trace of power can be discovered in the biceps, a successful result may be certainly awaited. Eighteen months or two years of active treatment are at least needed. Should the sling be removed too soon, the biceps will again be stretched, and for a few weeks will not respond to any voluntary effort. This proves the correctness of the Thomas' theory of muscle-shortening. The clinical test of the recovery of the biceps is the power of voluntary movement of the arm from its flexion angle to a point nearer the chin. This can be tested without removing the sling. To develop the power of the biceps should be the surgeon's main aim, and the patient should constantly be urged to lift his hand to his mouth. The test of recovery of the extensors is the power to hold the hand in a hyperextended position when the splint is removed. The arm and hand should be secured at night-time for a considerable period, and restraint even during the day should be very cautiously removed.

If the patient is so fortunate as to recover the use of the hand and biceps no apparatus need be applied to the shoulder, as he swings his arm into useful postures with but practically little inconvenience. Should the biceps not recover it may be necessary to apply a light rectangular splint to keep the elbow flexed, so that the recovered hand may be placed in a position of vantage. If this is irksome, an operation of transplanting part of the triceps into the biceps and part of the pectoralis major into the deltoid, devised and carried out by the authors (p. 261), may be substituted, and gives excellent results.

(3) *Paralysis of the extensors, the supinators escaping.* (Forearm type of Remak.)—This is eminently suited for the treatment on the same lines as for "dropped wrist."

On a New Method of fixing the Elbow-joint at a Permanent Right Angle.—A large number of cases come under our notice, where all the muscles governing the elbow are paralysed, while the muscles of the hand have escaped. Such an arm is very useless to the patient, as the shoulder muscles often participate in the affection. It hangs loosely at the patient's side, and is of no use for feeding purposes, being generally lifted by the opposite arm. To obtain fixation at an angle is a great advantage, and this the authors

cases with the promise of considerable success.

FIG. 10.
The sutures tied.

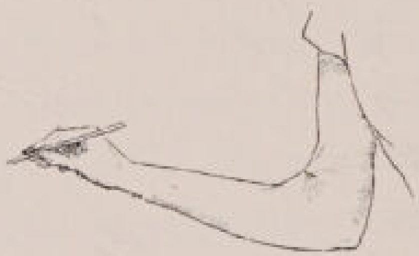


FIG. 11.
To illustrate the result of the operation.

FIG. 12.
To illustrate further result of the operation and the improved utility of the arm.

Sufficient time has not yet elapsed to test whether the skin will yield, but one case operated on two years ago has maintained absolutely the flexion angle at which it was placed. Cases of contraction of the elbow after burns bear out the correctness of our practice, for it will be in the experience of most surgeons that severe contractions sometimes occur without involving large areas of skin at the bend of the elbow. A sling is all that is needed afterwards. This should be continued for some months until contraction is well advanced.

Arthrodesis of the Shoulder-joint.—In paralysis of the shoulder-girdle, affecting all the muscles controlling the humerus and the scapula, operative interference is useless. In those cases, however, where the paralysis is less general, arthrodesis may with advantage be performed. For instance, the paralysis in rare instances may affect the deltoid alone, more often in addition the supra-spinatus, the infra-spinatus, and the teres minor. In other cases scapular movement may be retained, and power in all the muscles of the upper arm may be lost. If the surgeon should decide that the usefulness of the arm will be improved by making its movement dependent upon scapular motion, arthrodesis is indicated. This operation has been strongly advocated by Bothezat,[1] who reports three cases. Bothezat makes an incision from a little inside the acromio-clavicular articulation downwards and in the interval between the

[1] *Revue de Chirurgie*, May 10, June 10, July 10, 1901.

pectoralis major and deltoid. The capsule is incised in the bicipital groove and the coraco-acromial ligament divided. The synovial membrane should be removed and the head of the humerus brought out of the wound, any obstructing muscles and tendons being divided. The cartilage should then be removed from the head of the bone and the glenoid cavity. To reach the latter it may be necessary to transversely divide the capsule. The head is then fixed in internal rotation. Silver sutures are inserted, one between the head of the humerus and the upper border of the glenoid cavity, and the other between the head of the humerus and the acromion. Resection of a portion of the capsule may be practised if it be too lax, as it will help to immobilise the arm. The arm should be kept fixed for seven or eight weeks.

The operation of arthrodesis of the shoulder can be only really useful when the conditions around the elbow are such as to enable the hand to be used about the neck and mouth. We would only recommend arthrodesis where some power remains in the hand or elbow, or in conjunction with the authors' operation for flail elbow.

Lateral Curvature of the Spine from Paralysis and Hemiplegia.—In both infantile paralysis and infantile hemiplegia it is by no means unusual to find weakness, and

FIG. 13.

Scoliosis from infantile paralysis. The left erector spinæ is paralysed.

often complete loss of power, of the erector spinæ and associated muscles on one side. The actual extent of the loss of power varies, but, however slight it be, the balance of the spine is so delicate that the upright line is lost, and first deviation and then rotation set in. The primary curve is always to the affected side, and it rapidly assumes extensive proportions, and alterations in the shape of the chest and outline of the trunk soon make their appearance (Figs. 13 and 14). It is a

FIG. 14.

The same case as in the preceding figure. Lateral view.

very intractable form of curvature when it is once well established. In all instances of paralysis of an arm and a leg on the same side, particular attention should be paid to the spine from the first, and massage and other muscular stimuli be assiduously used daily; and it is noteworthy that, while rapid recovery ensues often in the arm and leg, some residual paralysis remains in the back, and, if untreated, it results in depressing deformity. The point we wish to emphasise is this, that such a deformity may come on some time after the patient is apparently cured, and therefore it calls for special observation and examination. The loss of tension on the part of the erector spinæ and other muscles permits dropping of the pelvis on the affected side, and often extreme tilting, so that there is great apparent lengthening of the lower extremity.

FIG. 15.

Spinal support used for paralytic scoliosis. The main curve is in the dorsal region and to the right.

This is a very serious condition to treat, and it is not satisfactorily remedied by raising the limb on the affected side, because this only induces more tilting, and therefore more lateral curvature of the spine. In the early stages of the affection every effort should be made to limit the deformity by physiological measures, but when once it is well established it is essential for the patient to wear a form of spinal support (Fig. 15); and indeed these cases are among the few instances where we recommend this measure. Despite the support, it will often happen that the spine continues to incline. We have been partially successful in reducing the deformity in some cases by placing the patient on a suspension couch, which is so arranged that the patient is lifted very lightly off the couch by an arrangement of straps supporting the head and passing beneath the axillæ, the body weight acting as an extensile force to the curved spine. In any case the outlook is very unsatisfactory, and it is sometimes necessary to continue the support from the lower extremity right up to the axilla, to counteract the tendency of the trunk to fall towards the paralysed side.

CHAPTER III

INFANTILE PARALYSIS OF THE LOWER EXTREMITIES, AND ITS TREATMENT

TREATMENT—PREVENTIVE, MECHANICAL, AND BY TENOTOMY

FOR convenience of describing the treatment we will classify paralysis of the lower extremity thus :—

(*a*) Paralysis—partial and complete—of the ankle.

(*b*) Paralysis—partial and complete—of the knee.

(*c*) Paralysis—partial and complete—of the hip.

1. *Preventive Treatment.*—Before speaking of those cases in which a deformity has declared itself, we feel it incumbent upon us to reiterate that in a recent case of infantile paralysis every

effort should be made to prevent distortion. As a general rule the flexors are less affected than the extensors, and hence the contraction will occur on the flexor aspect of the joints. The effect of this is twofold. It not only causes the limb to assume an abnormal position, but it also overstretches the already weakened extensor muscles, and so precludes their chance of early recovery. To take examples:—One lower extremity is found to be extensively paralysed, shortly after the onset of anterior poliomyelitis; and if partial recovery only takes place, we know in which direction the probable deformity will follow. Therefore it behoves us to keep each joint in the position of equilibrium midway between flexion and extension, and assiduously to massage and improve the nutrition of those muscles which are more likely to recover slowly. The child should therefore be placed recumbent, and a straight splint, with a foot-piece, fitted to the whole length of the lower extremity, with a weight and pulley attached; or, better still, he may be placed in a Thomas' splint (Figs. 31 and 32). Twice or thrice a day the splint must be removed, and massage and rubbing diligently performed. When it is evident that no more recovery is to be expected in the paralysed muscles the child should be allowed to walk provided with suitable retentive apparatus.

2. *Operative and Mechanical.*—In treating paralysis of the lower extremity tenotomy is so generally called for that it is often a preliminary to mechanical treatment. It is commonly employed in the case of tendons around the ankle-joint, where unassisted mechanical methods become irksome and difficult. We are also obliged to resort to it so as to correct the shortening of the hamstrings, and less often in the treatment of flexion and adduction of the hip. The operation is always a simple one, and no fear need be entertained that union will not take place. In over 10,000 tenotomies performed by the authors only four times union failed, and in each case it was in the extensor proprius pollicis. The tendons around the ankles should be divided subcutaneously. At the hip and knee the incisions should always be open ones. In dividing the hamstrings the classical transverse incision must be avoided, and parallel in-

cisions are better made along the tendons of the semitendinosus and biceps. By lifting the skin and using a hernia director, the deep fascia over the popliteal region can be sufficiently divided. The drawback to the transverse incision is that it indefinitely prolongs treatment, as it gapes the moment an attempt is made to extend the joint. With the longitudinal incisions the limb can be freely manipulated. At the hip the adductors should be approached by an open incision, as it is impossible to divide them effectively from without. The same is true of the sartorius and tensor vaginæ fasciæ.

We shall now speak of

Paralysis at the Ankle

This may be (*a*) *Partial*, and thence may arise the simple forms of talipes, which are :—(1) Talipes Equinus, due to paralysis of the dorsiflexors of the ankle; (2) Talipes Calcaneus, due to paralysis of the calf muscles; (3) Talipes Varus, due to paralysis of the peronei; (4) Talipes Valgus, due to paralysis of the tibiales. The compound forms met with are Equino-varus, Equino-valgus, Calcaneo-valgus, and Calcaneo-varus.

(*b*) *Complete* paralysis of the ankle.—The common form of deformity met with is Talipes Equinus, and the rarer forms are Calcaneo-Valgus and Varus and Flail-like Ankle.

The object in treating any or all of the above deformities is not only to permit the patient to walk, but also in cases of partial paralysis to place the paralysed or over-stretched muscles in the best position to recover their power. The authors do not therefore favour accumulators nor any form of elastic artificial muscles, except under very unusual circumstances. The principle of treatment here—as elsewhere—must be to place joints in positions favourable to the recovery of over-stretched muscles.

Now it is quite evident that a case of simple talipes, or of the compound form, may be efficiently treated in one of two ways: either less scientifically, by dividing and lengthening the tendons of the sound muscles and maintaining the foot in the corrected position by apparatus for an indefinite period; or more scientifically, by distributing around the joint some portion of the power possessed by the sound muscles and running to waste. And in the latter method lies the principle of tendon-grafting.

Talipes Equinus and Equino-varus, due to paralysis of the dorsiflexors of the ankle.—This is a disability which seriously interferes with and impedes the patient, for not only is the ankle extended, but the toes drop and become unduly plantar-flexed, on account of the inability of the extensors to raise the toes, the yielding of the medio-tarsal joint, and the compensatory shortening of the plantar fascia. The patient therefore walks by swinging his knee, and often draws the dorsal aspect of the toes along the ground. If the foot can, as in recent cases, be placed in position manually, no operative interference is called for; but most cases of talipes equinus call for division of the tendo Achillis, and probably this is the simplest and easiest method of treating them.

We must then investigate the condition of the stretched extensors just as we should do in dropped wrist. If the toes extend on plantar-flexing the ankle we can give a cheerful prognosis in proportion as the power of extension is good. Section of the tendo Achillis permits the foot to be placed at right angles and allows of adaptive shortening of the extensor longus digitorum. As the latter muscle recovers, muscular equilibrium is restored. During the day a very effective and simple appliance will permit of walking. Place an iron rod, which reaches from just below the popliteal space, into the back of the heel of the boot, and extends thence through the sole as far as the instep (Fig. 16). The patient will then be able to walk without either flexing or extending the ankle. At night-time a rectangular club-foot shoe (Fig. 17) must be applied. The extensors must be well massaged, and so soon as the patient is able to hold his foot at right angles, he is on the road to complete recovery. As a precautionary measure, before permitting

FIG. 16.

Apparatus for the after-treatment of talipes equinus. In the later stages the bar under the sole is added and the iron is removed.

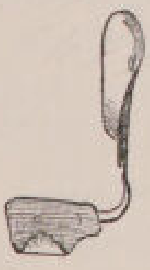


FIG. 17.

A simple form of shoe for the treatment of club-foot.

him to use the ankle-joint freely it will be well first to remove the iron and also the heel from his boot, and place a bar under the sole.

When the talipes equinus is complicated by the contraction of the plantar fascia this should be divided before the tendo Achillis,

Fig. 18.

Right side boot for varus, with inside upright to calf and T-strap.

Fig. 19.

Left side boot for valgus, with upright to calf outside, T-strap and valgus-wedge on inside of sole and heel.

and the sole of the foot thoroughly stretched before section of this tendon is made. If the conjoint forms of equino-valgus or varus are present, the inversion or eversion of the foot must be rectified before the tendo Achillis is severed, and care should be taken that mechanism be applied to the boot so as to invert the foot in the case of valgus (Fig. 19), and to evert it in the case of varus (Fig. 18).

during walking and sleeping. When the con-

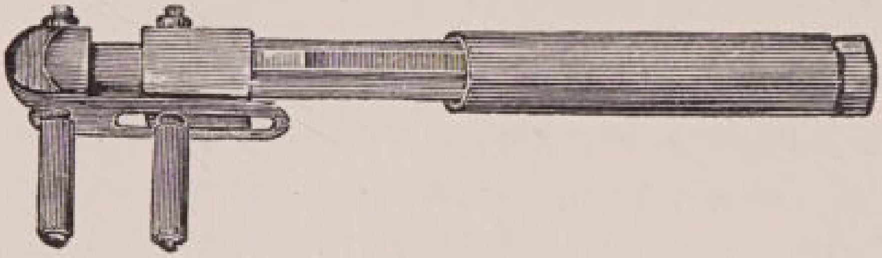


Fig. 20.
Thomas' wrench.

traction in the sole of the foot is obstinate,

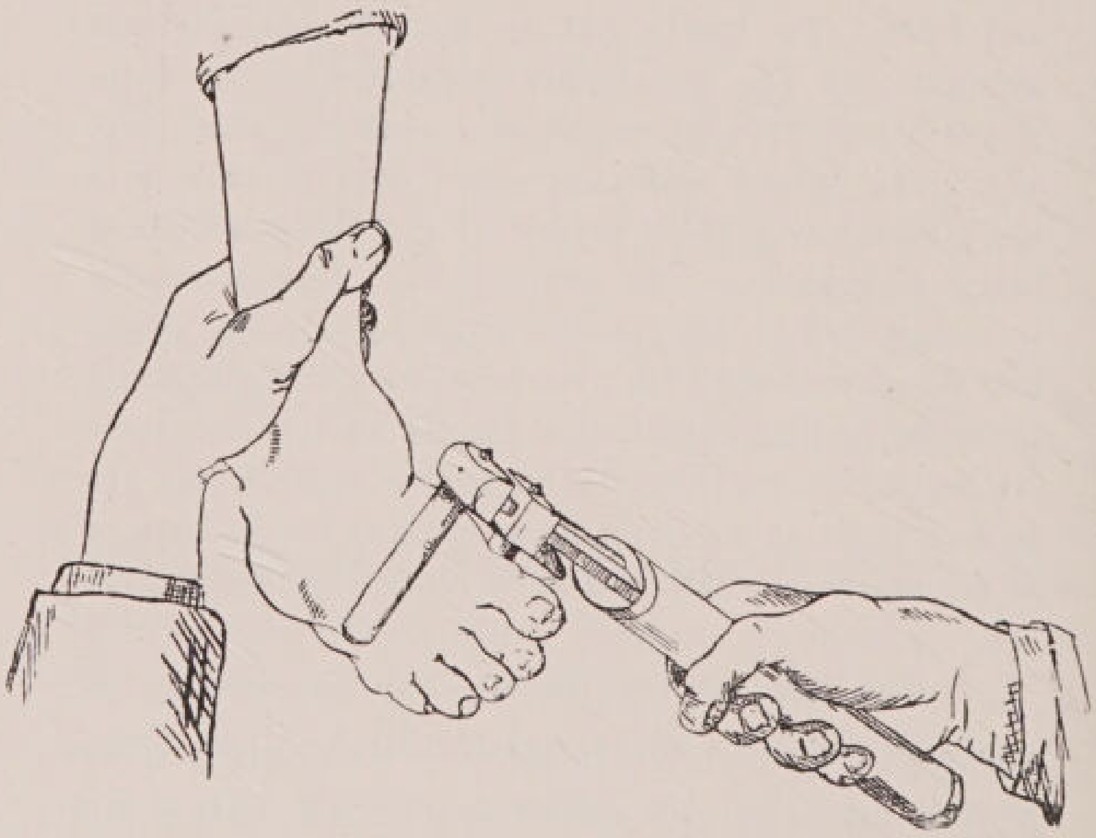


Fig. 21.
Reduction of varus part of the deformity by Thomas' wrench.

free division of the plantar fascia is called for, with repeated wrenching with Thomas' wrench

(Figs. 20, 21, 22, 23), until the normal shape

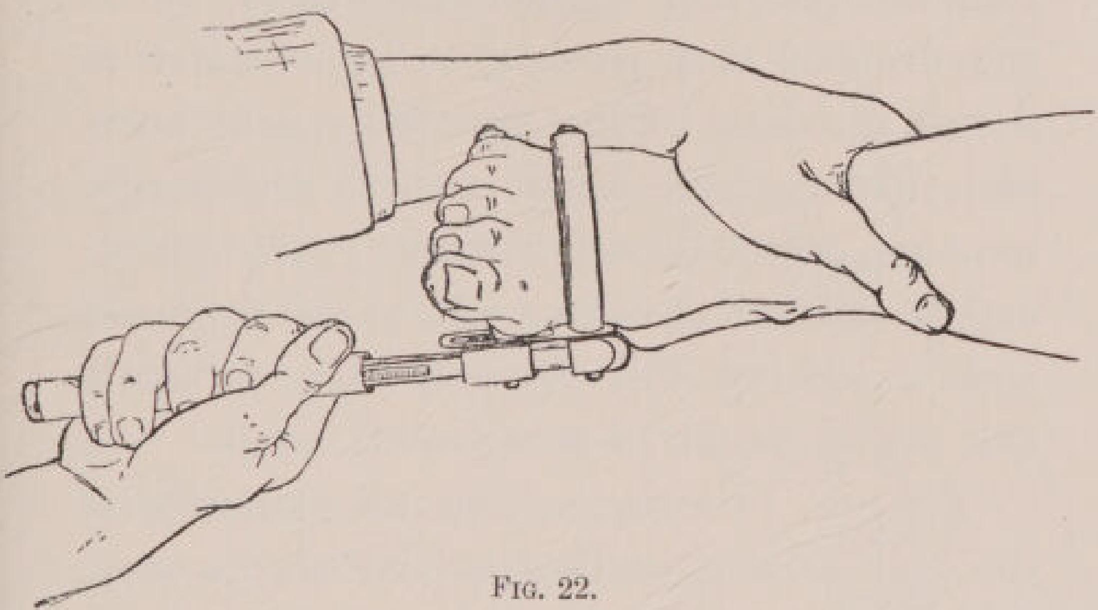


FIG. 22.

Reduction of equinus portion of the deformity by the Thomas' wrench.

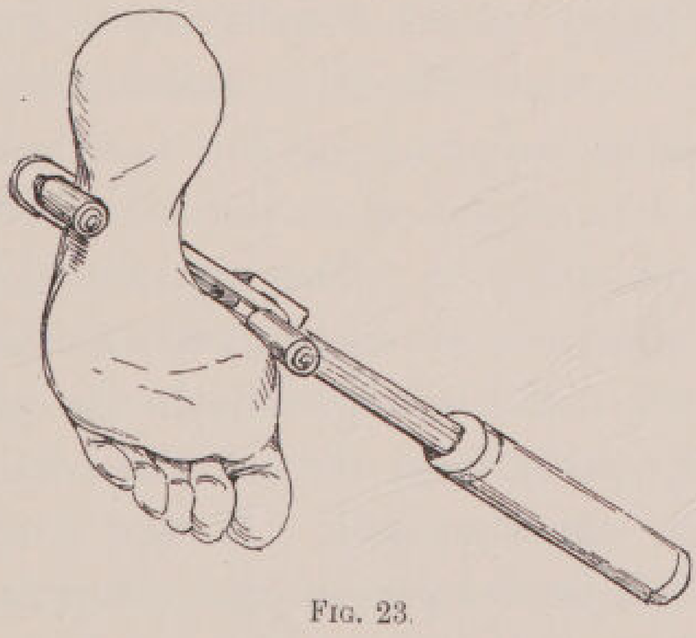


FIG. 23.

Overcoming the adduction deformity at the medio-tarsal joint by the Thomas' wrench.

of the foot is regained. The foot should then be placed in a shoe (Fig. 17) in order to maintain the position. In obstinate cases, where the dropped foot persists, it is necessary to excise the head of the first metatarsal bone, and this we have found a most satisfactory measure, especially as it is often hypertrophied; and no amount of section of the plantar fascia and wrenching will prevent undue pressure and the formation of troublesome corns.

Talipes Calcaneus, due to paralysis of the calf muscles.—This is one of the most difficult forms of paralysis to treat mechanically, and it is quite unsuitable for tenotomy, because section of the dorsiflexors does not in any way overcome the characteristic deformity, namely, the dropping of the heel and the globular-like projection of the os calcis downwards and backwards. This particular deformity can always be avoided by early mechanical treatment, so devised as to enable the patient to tread equally upon the anterior portion of the foot and the heel. If the dropping of the heel be not prevented, a compensatory shortening of the plantar fascia takes place, and needs treatment before the calcaneus portion of the deformity can be removed; and until recently the toe-depressing spring fixed to an iron was the only form of treatment possible. Then various methods of shortening the tendo Achillis were tried, notably that of Mr. Alfred Willett; but in our experience the operation is a failure, because the heel always drops after it. For those patients who will not submit to operation it becomes necessary to resort to mechanism alone, and treatment should consist in fixing the foot in a boot constructed in such a way (Fig. 24) that the ankle cannot be dorsiflexed during walking, and the foot is therefore maintained in extension.

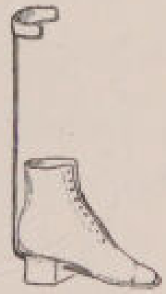


FIG. 24.
Boot with posterior upright and high heel for the treatment of talipes calcaneus.

Of all simple forms of paralysis, talipes calcaneus is that which is best adapted for tendon-transplantation, and admirable results have been obtained by grafting the peroneus longus or part of it into the tendo Achillis on the outer side, and the flexor proprius pollicis or part of it into the inner side. In all those cases in which simple calcaneus is present, it is advisable to remove a wedge-shaped piece from the astragalus (Figs. 25 and 26). The wedge is taken from the outer side, and is so placed that its base is upwards to prevent valgus, and downwards if it is necessary to counteract varus. This we have ourselves practised for the last twelve months with excellent results. We were led to do so

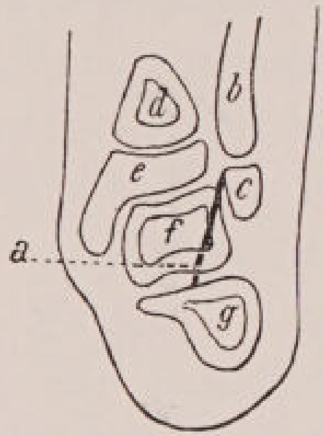


FIG. 25.

Vertical section through the bones about the ankle in a young child to illustrate a method of artificially counteracting a varoid position in talipes and during the operation of arthrodesis by an oblique section *a* through the astragalus *f*, and removal of the part of that bone internal to *a*. *b* is the shaft, and *c* the epiphysis of fibula; *d* is the shaft, and *e* is the epiphysis of tibia; *f* is the astragalus, and *g* is the os calcis. The oblique line is drawn a little too near the lower end of the fibula.

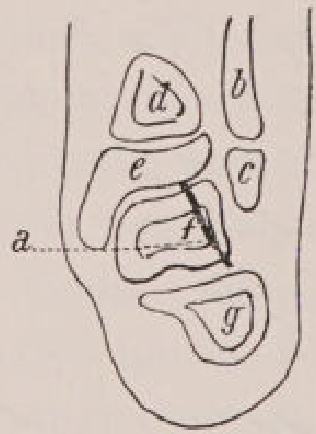


FIG. 26.

The same as in the preceding figure. The oblique section *a* through the astragalus *f* is marked in the opposite direction, so that talipes valgus is permanently corrected.

by finding that after muscle-grafting for simple calcaneus the foot assumed a valgoid position on account of the instability of the calcaneo-astragaloid joint. Removal of a wedge is essential in dealing with calcaneo-valgus.

When the paralysis is severe, a comparatively good result may be secured by combining an arthrodesis of the ankle with shortening of the tendo Achillis. Whitman[1] in an able article discusses the advantages and disadvantages of arthrodesis in this condition. He assumes that the desirability of the arthrodesis depends upon the insecurity of the feet; an insecurity which, while directly caused by the paralysis, is rendered more pronounced by the fact that the weight must be borne on an astragalus perched upon an unstable os calcis. He therefore urges the removal of the astragalus, arthrodesis, tendon-transplantation, and the replacement of the foot. This is accomplished through a curved incision proceeding from below and behind the external malleolus to the head of the astragalus in front. The two peronei tendons are freed, and either divided or displaced backwards, and the removal of the astragalus is comparatively easy, after the interosseous ligament has been divided by forcibly displacing the foot inwards. The cartilage is then removed from the surface of all the adjacent bones, the tendo Achillis is

[1] *American Journal of Medical Sciences*, November 1901.

shortened if it is any longer than the new position of the foot will require, and into it are inserted the proximal ends of the tendons of the peronei. The wound is then closed, and the foot is displaced backward, so that the internal malleolus is brought into contact with the scaphoid, and a plaster bandage is applied to fix the foot in an attitude of slight plantar flexion. Apparatus to prevent deformity has been used in all these cases, although the patients walk without it very well, and it may be that in time it can be discarded.

We have performed this operation on several occasions, but prefer to remove half the astragalus in the transverse direction in the form of a wedge, the base of which in calcaneo-valgus should present on the inner side, and in calcaneo-varus on the outer side; or better, to remove the wedge from the outer side of the astragalus in a vertical direction. In calcaneo-valgus the peronei, and in calvaneo-varus the tibialis posticus, should be transplanted into the tendo Achillis. The arthrodesis should be efficiently done, and the foot kept well in apposition to the leg. In these operations we find great benefit in making an oval incision, either on the outer or inner side of the foot, removing a considerable flap of skin, stitching the edges together, thus holding the foot in an over-corrected position.

Talipes Varus, due to paralysis of the peronei.—It is rare to find this deformity so pronounced as in a case of congenital varus, but even in a mild case there is generally a difficulty in everting the foot, mainly owing to the shortening of the tibialis posticus. In cases of poliomyelitis long past, one often notes in the walk of a patient, who has had a transient palsy of the peronei, that in walking the foot assumes a flapper-like action and the toes are slightly inturned.

FIG. 27.

Rim on outside of sole of boot for the after-treatment of talipes varus. The rim is placed on inside of sole of boot for talipes valgus.

The treatment is mechanical or operative, by tenotomy and tendon-grafting, or it may involve a combination of both. In the practically recovered cases all that is needed, in addition to massage, is a small rim of leather or iron on the outside of the boot (Fig. 27). In more advanced conditions wrenching and an inside iron support, with the rim on the outside of the boot, are needed.

So far as operation is concerned, some prefer to divide the tibialis posticus and anticus, but most surgeons nowadays will perform tendon-transplantation. (See p. 150.) Should the deformity have lasted a long time, and changes in the bones have resulted, a combination of arthrodesis and muscle-grafting will probably be indicated. In all stages of the affection the foot should be kept everted during the night, in order to stretch the tibialis posticus and relax the peronei, and the latter muscles should be daily and rigorously massaged. In walking and sitting, the inside of the foot should be directed to the ground, and exercises with a view to eversion of the foot sedulously practised.

Talipes Valgus is due to paralysis of the tibiales, but is commonly associated with paresis of the calf muscles, and sometimes of the flexors of the ankle, but is not usually confined to the tibial muscles. The patient walks on the inner side of the foot. The deformity is treated mechanically, and is attacked on similar lines to talipes varus.

The boot is crooked and raised on the inner side, and the ankle is bandaged to an iron fixed to the outer side of the boot (Fig. 28).

FIG. 28.

A boot with outside iron and inside wedge for sole for the after-treatment of talipes valgus.

Many cases, however, are better treated by tendon-transplantation (see p. 146), or by arthrodesis, or by a combination of them. The compound deformities, such as equino-valgus and equino-varus, are extremely suitable for transference of tendons, and will be spoken of in the chapter dealing with the subject.

Complete paralysis of the muscles around the ankle-joint calls invariably for arthrodesis, in preference to the complicated mechanical apparatus hitherto in vogue, and the methods of performing arthrodesis are dealt with in Chapter V. of this section.

PARALYSIS OF THE MUSCLES CONTROLLING THE KNEE

The following are the forms met with :—

1. Paralysis of the quadriceps muscle, without contraction.

2. Paralysis of the same muscle, with contraction of the hamstrings.

In these two forms the sartorius frequently escapes, and it is an important point to verify the existence of good power in the muscle, as it can be made of the utmost use as a substitute for the extensor by tendon-grafting. In the forms 1 and 2 the hamstrings frequently escape—indeed, it is a very rare occurrence to find them alone affected.

3. Paralysis of all the muscles of the knee, without contraction.

4. Paralysis of all the muscles, with contraction of the flexors; and where paralysis of the limb is complete, flexion deformity at the knee, external rotation of the tibia, genu valgum or genu recurvatum may be present.

Before the knee can be effectually treated, it is essential to have the ankle under such control that the sole of the foot falls flat upon the ground, for any lateral deviation of it quite prevents a successful mechanical result. Where there is much shortening of the limb, and a complete paresis of the dorsiflexors of the ankle, it may be advisable to make up the deficiency by a boot so constructed as to keep the toes near the ground. But even then the sole of the boot should fall fairly on the ground. When the ankle is secured in a good position, we can direct our attention to the knee; and, provided that the ilio-psoas muscle still retains its integrity, we may assure the patient, however helpless he may be, that progression may be made easy for him.

The principles of treatment of the paralytic condition of the knee are as follows:—

(1) To ascertain the condition of the muscles around the knee, as to their retention of contractile elements. This is best effected by testing with the faradic and galvanic currents.

(2) To rectify any deformity of the knee, such as lateral deviation or flexion.

(3) To stimulate the muscles to renewed contractility if any active tissue remains.

(4) To utilise by muscle-grafting the power left about the knee.

(5) To supply an apparatus, simple and inexpensive, which will bear the body weight during locomotion under the control of the psoas and iliacus muscle. For this purpose no apparatus is so suitable as Thomas's calliper splint (Figs. 29 and 30), provided the ring be

made of the proper shape and at the proper angle. It is much more effective than complicated apparatus requiring pelvic girdles or shoulder straps. No joint should be placed at the knee, so that the quadriceps muscle should

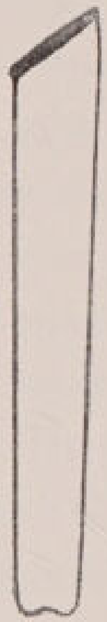


Fig. 29.

Thomas' calliper bed-splint.

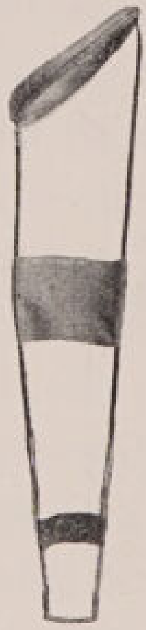


Fig. 30.

Thomas' walking-splint, with attachment for fitting into boot.

not be stretched; but if the paralysis has been remedied by muscle-grafting, a simple joint (Figs. 31 and 32) may with advantage be introduced. The terminals of the calliper should be so placed in the heel of the boot as to give aid in maintaining the rectified position of the foot.

1. To take a simple condition of paralysis at the knee, namely, paralysis of the quadriceps, without contraction.[1] If the sartorius or the

FIG. 31.

Thomas' calliper splint for paralysis about the knee, with joint at knee for use after muscle-grafting.

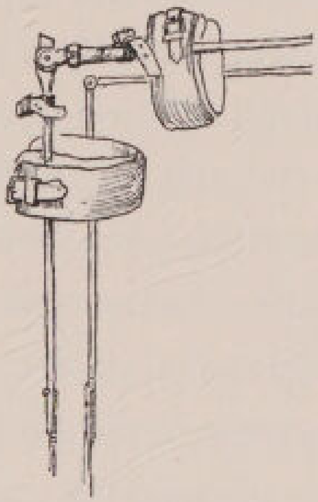


FIG. 32.

The same, to show the ring-catch action at the knee-joint.

hamstring muscles show contractile power, the best course of treatment to propose to the patient is muscle-grafting of the sartorius into the top of the patella; or, if this be not available, to advance a slip from the biceps

[1] We have met with four cases of subluxation of the patella, both inwards and outwards, due to partial paralysis of the quadriceps, and we have treated them successfully by quilting the lax quadriceps transversely for an inch or more; so bracing the patella into position.

on the outer side and from one of the adductors on the inner side, choosing that one which is least wasted and most contractile.

With this form of paralysis we have frequently found genu recurvatum, and the best means of overcoming it is by muscle-grafting, in the way just indicated. If the patient decline operation, then we must resort to the use of a calliper splint, and it sometimes happens that, when the strain is taken off the over-stretched and apparently hopelessly paralysed quadriceps, it shows signs of recovery, and the knee is ultimately braced up. The appearance of genu recurvatum in these cases is an interesting example of the deformity approaching the paralysed side, and is due to the fact that when the leg swings forwards under the action of the ilio-psoas the weight comes down on the heel, and so a firmer base of support is secured for superincumbent body weight. The lax tissues around the joint in consequence allow of hyperextension.

2. When we have to deal with paralysis of the extensors, with contraction, we have at our disposal mechanical extension, tenotomy, muscle-grafting, arthrodesis, and osteotomy.

In order to overcome flexion by mechanical means it will be sufficient to place the limb in a Thomas' bed splint (Fig. 29), and fix it by extension straps; and pressure pads are applied to the thigh and leg. In more obstinate cases an anæsthetic may be given, and an attempt made gradually, but forcibly, to straighten the knee. This should be repeated every week until the flexion has disappeared, the limb during the intervals being kept well stretched on a bed splint. Obstinate flexion, which will not yield to one prolonged pull, finally gives way when persistently attacked by this method of forcible reduction, preceded and followed by extension in a splint. It is better, however, in most cases to perform tenotomy of the hamstrings, and the open incision should always be made, care being taken to incise the skin along the tendons, and not across the popliteal space. This saves much time in treatment, and often a good deal of pain to the patient. Even if the contraction does not immediately yield on division of the tendons, subsequent stretching under an anæsthetic, followed by extension on a bed-splint, effects the purpose.

A slight degree of genu valgum can be successfully combated by making the inner iron of the calliper bowed, and bandaging the limb to the outer bar, or by the use of an upright on the inner side extending to the inner condyle of the femur (Fig. 33).

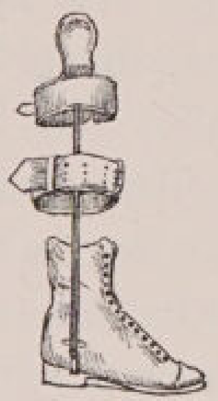


FIG. 33.

Boot with upright for the treatment of slight degrees of paralytic genu valgum.

When the knee has been straightened, and it is evident that power is left in the contracted flexor muscles, the advisability of muscle-grafting should be considered; and if, at the time when the open tenotomies are done, the flexion yields completely, or nearly so, it is quite easy to extend the operation, and advance a portion of the flexors to the top of the patella. Some cases, however, present bony deformities and such obstruction in the joint, that it is necessary to treat them either by arthrodesis or by osteotomy, according to the methods referred to on pages 179 *et seq.*

3. *Paralysis of all the Muscles of the Knee, without Contraction or Flail-like Knee.*

—This is a very serious disability, but, provided the ilio-psoas is intact and the contraction of the hip can be remedied, we can fully assure the patient that means can be devised by which he will be able to walk in security. The simplest method is the calliper splint applied from the boot to above the knee. Arthrodesis has been practised for this condition, but it is not an operation which we altogether recommend, because it is difficult to secure bony ankylosis; and even if we do, the result is a long shaft of bone, which is liable to be snapped by an accident.

4. *Paralysis of all the Muscles, with Contraction of the Flexors.*—This is an interesting condition, the more especially as that great surgeon, Volkmann, asserted that no contraction ever occurred at the knee—no matter how extensive the paralysis. But this is not borne out by facts, nor by our experience. The treatment of this condition is to reduce the contraction, and then fix the joint either by mechanical means or by arthrodesis. In those cases where both knees are affected, the methods of treatment are the same. Crutches help locomotion at first, but should

be discarded for sticks as soon as possible, and many of our patients have walked for miles after efficient treatment.

Paralysis about the Hip

(1) In some cases there is merely a weakness of the extensors and abductors, which promotes undue action of the flexors and adductors, resulting in contracture of the latter muscles.

(2) Paralysis of all the muscles around the hip may exist, with the exception of the psoas and iliacus, and perhaps the sartorius and tensor vaginæ femoris. This condition may be present either with or without contraction on the flexor aspect.

(3) Complete paralysis of all the muscles and a flail-like limb.

(4) Paralytic dislocation of the hip.

The most important point to ascertain in a case of monoplegia or paraplegia is whether the ilio-psoas has escaped or not. Even with complete paralysis below the hip, we can assure our patient that he will be enabled to walk; and in cases of paraplegia, so long as the ilio-psoas remains intact on one side, we are able to achieve the desired result, since he is enabled to bring the other limb forwards by a swinging action of the pelvis.

Practically, almost all patients coming to us with paralysis about the hip-joint show contraction on the flexor side of the joint, and this must first be removed. In very young or only slight cases the recumbent position upon a double Thomas' splint will in a very few weeks reduce the contraction, and the change is brought about by a fall of the spinal column and by rotation of the pelvis. The patient is placed on the splint (Fig. 82) lying on a soft leather pad. The limbs are bandaged to the posterior bars, and slowly the lordosis diminishes until it disappears. Tenotomy and fasciotomy, performed by the open method, of the muscular structures below the anterior superior spine (p. 240), and on the inner side of the thigh, will expedite the reduction. During the application of the splint, precautions must be taken to prevent the formation of sores on the buttocks from pressure. The most effective way is to change the point of pressure every night and morning by drawing the skin which lies on the bar one day to the right, and the next day to the left. By this means, provided there be no dislocation, complete reduction can be obtained. When the patient begins to get about, a calliper splint or a simple appliance with a pelvic band is very useful.

Paralytic Dislocation of the Hip-joint.—This may be either partial or complete. If complete, it is due to the great relaxation of the soft structures, owing to their paralytic condition. If the paralysis be severe and if left untreated, the head of the femur may leave its socket and become dislocated. After a time contraction of the flexors sets in, so that the deformity is perpetuated by the contracture and by the body-weight. The head passes upwards, or upwards and inwards, or upwards and backwards, and marked lordosis is a complication. The condition is a very difficult one to treat; because, if complete reduction is effected, so soon as weight is borne upon the limb, the head slips out. Some pressure may be taken off the limb by mechanical means, but whether resection of the hip is a justifiable proceeding in these cases is a moot point.

In general, we may add that the after treatment of these paralytic lesions should be as-

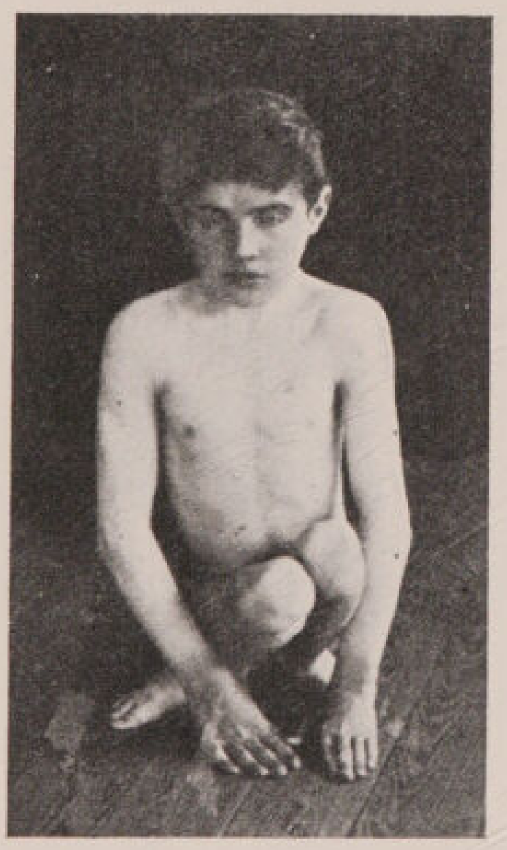


FIG. 34.

Flail-like paralytic deformities. Patient unable to stand since birth.

siduous and thorough, and it must not be abandoned too early, if rapid recurrence of the deformity is to be avoided. This is more especially applicable to the hip, because of the great difficulty in completely reducing flexion there; and we must remember that the conditions which give rise to the deformity will remain, even after reduction is complete. The patient, therefore, should for months sleep in a double frame, and even later still, during

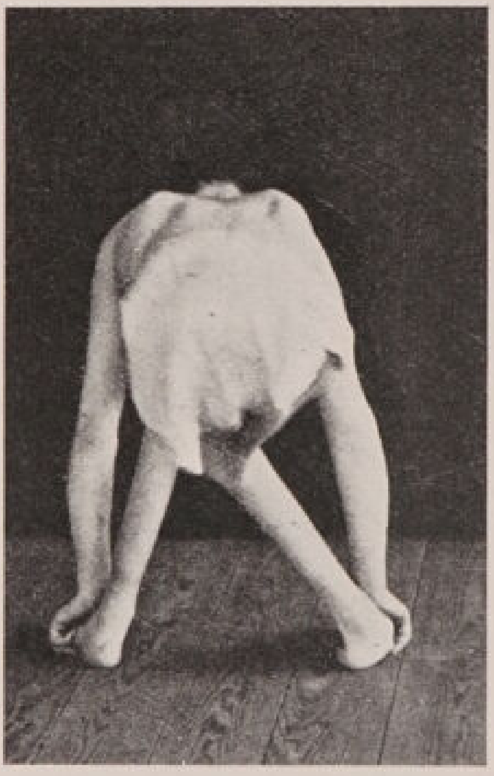


Fig. 35.

Method of progression. Patient lifts his feet with his hands.

the night, the limbs should be tied to the foot of the bed, which should be elevated from 12 to 18 inches.

From what has been said it will be seen that the treatment of cases of paralytic deformities of the feet, knees, and hips is of the most hopeful character possible; and no one is justified in condemning a patient to a crippled life, when such improvements in his condition

FIG. 36.

After arthrodesis of one knee and both ankles, and osteotomy above the knees.

are possible. We have known cases brought to us, in which the child has shuffled on the buttocks with his legs twisted under him like a Chinese idol, and has been condemned to a hopeless existence.

We have found these unfortunate beings

FIG. 37.

Some months later. He now walks with sticks.

with the feet in any position, the knees tightly contracted, the hips flexed and almost immobile, and we have been enabled to gradually unfold all the contractions. And, provided that power is retained in the ilio-psoas even on one side, we have placed them on their feet, and many cases are now walking about for some miles daily (cf. Figs. 34, 35, 36, and 37).

The following instance is given :—

CASE 18.—*Severe Paralysis of the Lower Extremities treated successfully.*—F. S., aged eight years, the son of a doctor in the suburbs of London, had been to see an eminent neurologist, who said that nothing could be done, and one of us was asked to see him, and found the following condition. The child was quite unable to stand. The right leg exhibited some power in the hip and knee, but these were both slightly contracted, and there was contraction of the plantar fascia and right-angled contraction of the tendo Achillis. The left leg was useless for all purposes of locomotion. There were contractions of the flexors of the hip and knee, adduction of the thigh, contracted tendo Achillis and contracted plantar fascia, but the ilio-psoas, the adductors, and the gluteal muscles acted well. All these symptoms came on after an attack of infantile paralysis four years ago. The variously contracted tendons and muscles were divided, massage freely used, light walking apparatus provided, and the child is now able to walk two miles without fatigue.

CHAPTER IV

INFANTILE PARALYSIS OF THE LOWER EXTREMITIES (*Continued*)

Treatment by Tendon-Transplantation

With reference to the operative treatment of infantile paralysis we find that, contrary to general expectation, paralysed limbs are most tolerant of operative interference. Wounds heal well and quickly, and suppuration is less prone to happen than in healthy limbs. Tendons practically never fail to unite after section, and bones join without delay. This, when we consider that the limb has been deprived either partially or entirely of trophic control, is an interesting clinical fact to those largely engaged in the treatment of paralytic deformities.

Tendon - transplantation. — By tendon-transplantation is meant the reinforcement of a paralysed muscle by attaching to its tendon either a part or the whole of the tendon of a healthy muscle. The ways and means of attachment are various, and many modifications of the original operation have been introduced. These will be set out in detail presently. The operation is also known under several other names, such as muscle-grafting, tendon-grafting, transference of muscular power, tendon-implantation.

The operation is particularly adapted for paralytic deformities arising from the following causes :—

(*a*) Those due to Infantile Paralysis or Anterior Poliomyelitis.

(*b*) Those due to Infantile Spastic Paralysis, Infantile Hemiplegia, and Cerebral Diplegia.

(*c*) Those following injuries of nerves, such as the Erb-Duchenne type of palsy, affecting the upper root of the brachial plexus.

(*d*) Those arising from crushing or severance of nerve trunks.

Before we speak of the treatment by tendon-grafting of the deformities succeeding infantile paralysis, there are certain features in connection with the loss of muscular power in this disease which are noteworthy. One great characteristic of this form of paralysis is its selective tendency. It picks out individual fibres of muscles, or a single muscle, or a group of muscles; and sometimes its distribution is so capricious that it affects single muscles in several groups. Another point, which we have verified by extensive clinical experience, is that in any given case it is impossible to foretell the extent to which recovery will take place; and we are constantly pleased by seeing from time to time an apparently hopeless limb resume, under appropriate treatment, most of its functions. If it be permitted to step aside for a moment to indicate the means by which the fullest amount of recovery may be obtained, we may say:—No stretching of the affected muscles should be permitted, either by the uncontrolled pull of their opponents or by the action of gravity; or, to put it in other words, *in order to obtain the maximum amount of recovery in an affected muscle, relax it to its fullest extent and massage it.* The relaxation is obtained by very simple measures, which we have indicated on p. 46; and in the case of the muscles about the wrist and ankle a malleable iron splint, suitably bent, answers the requirements.

Unfortunately it does not often happen to surgeons to have the opportunity of seeing cases of infantile paralysis in the early stages. They are brought to them when deformity has set in, and profound atrophic changes have taken place in muscle fibres; and much of the possible recovery in the remaining unaffected fibres has been discounted by over-stretching for months or years. Such is the class of case with which we have most frequently to deal; but to show the beneficial effects of anticipatory and preventive treatment of deformity we will allude to one case.

CASE 19. *Severe Infantile Paralysis—Prevention of Deformity.*—P. B., aged seven, the daughter of a medical man, was seen by one of us in October 1900. The history of the attack was that on a certain hot day in the preceding August she was out walking in a wood, when she suddenly complained of weakness in her legs, and said she could go no further. She lay and rested for a while, and then seemed to be better and was taken home. The next morning the weakness had passed away. On the following day she went out walking again, and then suddenly fell, and was found to be powerless in both legs, and was carried home. On medical examination both lower extremities and the right arm were helpless. The temperature was found to be 101°, and she was in considerable pain. The temperature fell within twenty-four hours, and the pain passed away in three days. She was seen by one of us six weeks after the attack, and evidence of returning power was noted in the right leg, but the following parts were then paralysed—the extensors of the right wrist, the dorsiflexors of the right foot, and the whole of the left lower extremity. It was also noted that there was weakness of the left side of the back.

Means were taken at once to prevent deformity. Daily massage and the interrupted current were prescribed. The right wrist was placed on a malleable iron splint in a hyperextended position, so as to prevent over-stretching of the weak extensors; and posterior splints with the foot-pieces at right angles were applied to the legs. It was noteworthy that, even in the short time which had elapsed since the onset of the attack, the left leg had failed to keep pace in growth with its fellow, and was three-eighths of an inch shorter. This shortening has not increased during the two years she has been under observation. Recovery has rapidly followed, and the right arm and leg are now perfect. The left leg shows complete return of power in the flexors of the knee, but the extensors are somewhat weak, although still improving. The power of the dorsiflexors is not so great as that of the plantar flexors, so that the foot cannot be dorsiflexed beyond a right angle. There is no deformity anywhere, because the limb has been efficiently controlled.

We quote this case as an example of the preventive treatment of deformity.

In infantile paralysis the limb is always pulled towards the side of the stronger muscles by them, and away from the weaker muscles. The result is twofold. Firstly, there is a loss of balance of power around the joint, and secondly, a certain amount of power is misused or running to waste. The older method of treatment of these cases by tenotomy and lengthening of the tendons of the sound muscles, and subsequent retention of the limb in a good position by means of weighty apparatus, was imperfect, because there was a failure of insight into the factors at work, and a want of grasp of the possibilities presented by the remaining normal structures. It is in this relation that tendon-implantation, tendon-grafting or transference of muscular power, exhibits such an advance on the older methods.

Bibliography.—The operation originated with Nicoladoni in 1882, who, in a case of paralytic talipes calcaneus, attached the peronei to the tendo Achillis with a good result. In 1892 Parish [1] and Drobnik [2] applied

[1] *New York Med. Jour.* 1892. [2] *Zeits. f. Chir.* Band xliii. Sec. 470.

the same method to other forms of club-foot. In 1894 Winkelmann grafted a strip of the tendo Achillis on to the peronei, and he was the first to publish and analyse a series of cases, sixteen in all. Since then Goldthwaite (*Trans. Amer. Orth. Assoc.* vol. viii. p. 20) and other American orthopædic surgeons have done good work on the subject; and Townsend has written on the subject of tendon-transplantation in the treatment of Deformities of the Hand in vol. xiii. of the same *Transactions*, and gives on p. 210 a full bibliography up to 1900. That excellent orthopædic surgeon, Dr. E. H. Bradford of Boston, deals with tendon and muscle transference and arthrodesis for infantile paralysis in the same *Transactions*, vol. xiv. p. 223.

Mr. F. S. Eve[1] has recorded four cases on which he had operated, and we have performed 274 of these operations, some of which are recorded in the *British Medical Journal*, 1899 and 1901, and the *Transactions of the Society for the Study of Disease in Children*, 1902. Messrs. Sinclair White and Montgomery have also reported cases. In the

[1] *B. M. J.* October 15, 1898.

Münch. Med. Woch. April 25, 1899, Vulpius gives his experience of sixty cases, and in the same periodical, in April 1900, Fritz Lange contributes an interesting article on the subject with excellent illustrations. Ernst Künik[1] reviews the subject and discusses details of four different methods of tendon-transplantation. Karl Bruns[2] has employed the same method to prevent contraction after excision and erasion of the knee. Mainzer[3] writes on the subject of indirect transplantation. Instead of joining the proximal end of the active to the peripheral end of the paralysed tendon, when the ends are at a considerable distance apart, he transfers the proximal end of the sound muscle to a neighbouring tendon, then divides the latter below the site of junction, and transfers the conjoined parts into the distal end of that tendon which he wishes to reinforce. Lange,[4] owing to the distance between the sound and the paralysed tendon, makes artificial tendons of

[1] *Münch. Med. Woch.* May 27, 1902.

[2] *Centralb. f. Chirurg.* February 9, 1901.

[3] *Münch. Med. Woch.* May 27, 1902.

[4] *Ibid.* January 7, 1902; and *Med. Review*, vol. v. No. 3, pp. 143-145.

silk, following the example of Glück,[1] who in 1892 had used bundles of silkworm gut to bridge over the gap after division of tendons in injuries. And, be it noted, Kümmell[2] in

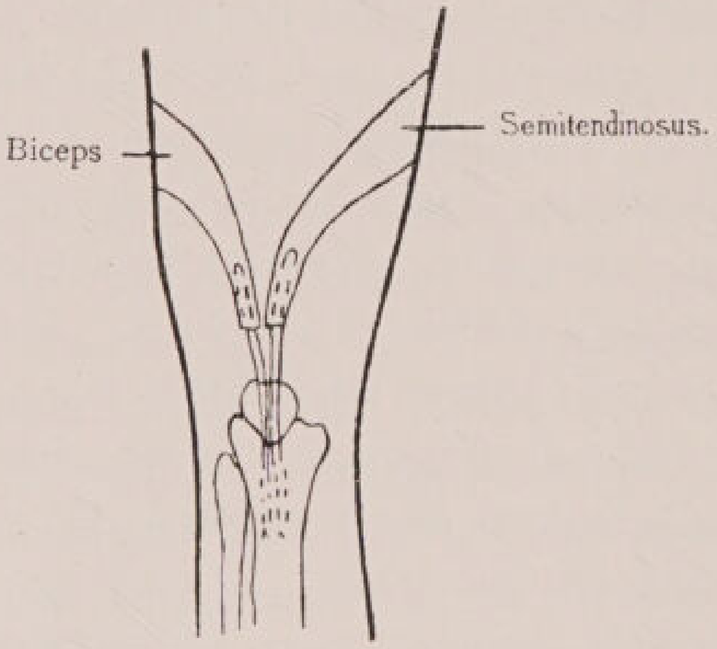


FIG. 38.

To illustrate Lange's method of artificially elongating the transplanted hamstring tendons by silk sutures, so as to effect a junction with the tubercle of the tibia. (After Lange.)

1896 had found that in a case so treated the strand of silkworm gut had become converted into fibrous tissue.

Lange[3] reports fifty-six cases of tendon-transplantation, in which he has prolonged the reinforcing tendons to any required length by silk cords. He has employed this method

[1] *Practitioner*, vol. lxix. p. 360. [2] *Ibid.* [3] *Ibid.*

in a case of paralysis of the quadriceps femoris (Fig. 38). Previous attempts to correct had been made by suturing the sartorius to the quadriceps tendon, but he preferred to bring forward the semitendinosus and biceps under the skin, after freeing them from their insertions. The combined ends are then situated so far above the patella that it is impossible to suture them directly into the tibia. A serviceable silk tendon is produced, however, by the passage of a number of strong silk threads through the tendinous ends of the transplanted muscles above, and the periosteum of the tubercle of the tibia below, giving eventually excellent power of extension. Lange originally employed silk tendons only, when the shortness of the muscles rendered them necessary; he now uses them also in cases in which the tendon to be transplanted appears thin and liable to necrosis if subjected to much tension. Lange has employed silken tendons in fifty-six cases of tendon-transplantation, in all of which healing by first intention was obtained. In only two was the result unsatisfactory, and these cases, according to him, prove the following points :—

"Even long strands of silk may be left as substitutes for tendons without the production of suppuration. Several of the artificial tendons were 8 inches long. The functional results were excellent. Patients in whom the semitendinosus and biceps were made to replace the quadriceps femoris often obtained almost normal powers of extension. The silken tendons are very durable. When the splint is removed from the limb, two or three months after the operation, the artificial tendon is of its original thickness. When, however, the transplanted muscles begin to act and render the silk constantly taut, the cord steadily increases in thickness. Thus in one case, six months after the operation, the artificial tendon was a quarter of an inch in diameter. In another case, twelve months after the operation, the thickness of the artificial tendon was three-eighths of an inch; and in a third case, two years after the operation, the tendon was of the thickness of the little finger. It is probable that the increase in size is due to the formation of fibrous tissue round the silk. In the case of a girl in whom a silk tendon, made $2\frac{1}{2}$ years before for paralysis of the quadriceps muscle, proved too long, an incision was made below the patella in order to shorten the tendon. It was easily found in the subcutaneous connective tissue, and was surrounded by a loose and movable layer of connective tissue. There was no true tendon sheath. The tendon had the appearance of a bluish-white, tough, fibrous cord of the size of a large lead-pencil. Below, it was continuous with the periosteum over the tibia. The condensed surrounding tissue was 2 to 3 millimetres in thickness, and enclosed the silk cords, which appeared to be as sound as ever. Microscopic examination of an excised piece of condensed tissue around the sheath showed that in the deeper, and therefore older, layers next the silk the structure was identical with that of a normal tendon. In the superficial layers the structure was also tendinous, but with the addition of scattered vessels and fat cells. The silk employed is that known as No. 12, and before use it is boiled for ten minutes in a 1 in 1000 solution of perchloride of mercury."

Lange also claims that silken cords are less liable to form adhesions than divided and transplanted tendons. Jochner[1] had succeeded previously to Lange's operations in bridging a gap of $2\frac{1}{2}$ inches in the extensor communis digitorum by using silk.

The *rationale* of the operation of tendon-transplantation is, firstly, to utilise what is ill-directed voluntary movement; and secondly, to restore the balance of power so far as possible in the affected part. But it is evident that the joint can never be a fully strong one, since the amount of power at the disposal of the surgeon has been diminished by disease. Yet it must be conceded that a well-balanced joint is better than an ill-balanced and weak one. And further, one of the greatest benefits of all is that much of the necessity of resorting to the instrument-maker has disappeared. There are, of course, anatomical and surgical limitations to the transference of tendons from one side of a joint to another, although most of the difficulties can be overcome by the indirect method alluded to above, or by the use of silk to elongate the tendon when carried into a new position. It also requires care to regulate to a nicety the

[1] *Practitioner*, vol. lxix. p. 360.

amount of power transferred, and occasionally it happens that some time after the operation an apparently functionless muscle, when it is no longer unduly stretched by over-action of its opponents, will partially recover and disturb the balance which has been obtained.

Cerebration after Tendon-grafting.—In discussing the subject with neurologists and physicians in general we are at once met with the question: What about the brain? What happens to it? For our own part, and speaking from experience, that is a factor which need not, from a surgical point of view, be considered. The brain sends out an impulse which is carried to the muscle, and the nature of the resulting movement depends upon the origin and insertion of that muscle; in the case of the limb the insertion being near or at the part to be moved. And what is really wanted in these cases is to ensure a useful insertion. To take a homely illustration:—A train has for years run from Euston to Manchester, until one day it is diverted at Crewe, the junction for the Liverpool section, at the will of the signalman, and duly arrives at that city. The fact that it had always been accustomed to travel along the rail to Manchester in no wise prevents it arriving at Liverpool when it is so directed. So it is with the nerve-impulses and the action of the muscle after the tendon of insertion has been transferred.

But we may add a few further reflections. Are we to regard nerve-impulses as of a specific nature—that is, extension impulses or flexion impulses; or are we to regard them merely as forms of force sent down to a muscle, and the direction of the force produced as being in no way special to the nature of the nerve-impulse? We incline to the latter alternative, and we take it that what happens in the brain in these cases is not any subtle change from a flexor nerve-impulse to an extensor nerve-impulse, after transplanting a flexor and making an extensor of it, but a change of perception on the part of the sensory centres so far as the position of the limb is concerned; that is, the patients must *learn* that when a certain muscle is contracted, the limb is not in a state of flexion as heretofore, but in one of extension, or of supination instead of pronation. And the learning process is always facilitated after the operation by asking the patient to perform the corresponding movement on the opposite side of the body. So that we always train our children, after transference of a pronator into a supinator, *e.g.* on the left side, and teach them to acquire the supinating movement in that arm by moving the right arm simultaneously in the required direction. When the splints are taken off, patients do not as a rule make mistakes with the new muscle nor with the muscle in the new position, but are embarrassed and hesitating in the use of it.

Various Methods of Tendon-transplantation.—These are very numerous and are being constantly added to by the ingenuity of surgeons, but they are readily understood by reference to the accompanying diagrams (Fig. 39), which show the scheme of tendon-transplantation according to Vulpius. The following methods are recognised :—

1. Both the weak and the reinforcing tendons are completely divided, and the proximal end of the reinforcing tendon is united to the distal end of the weak.
2. The reinforcing tendon is totally divided,

and a slip is partially detached from the distal end of the paralytic tendon, the proximal end of the reinforcing tendon being united to it.

3. Both tendons are divided, and the proximal

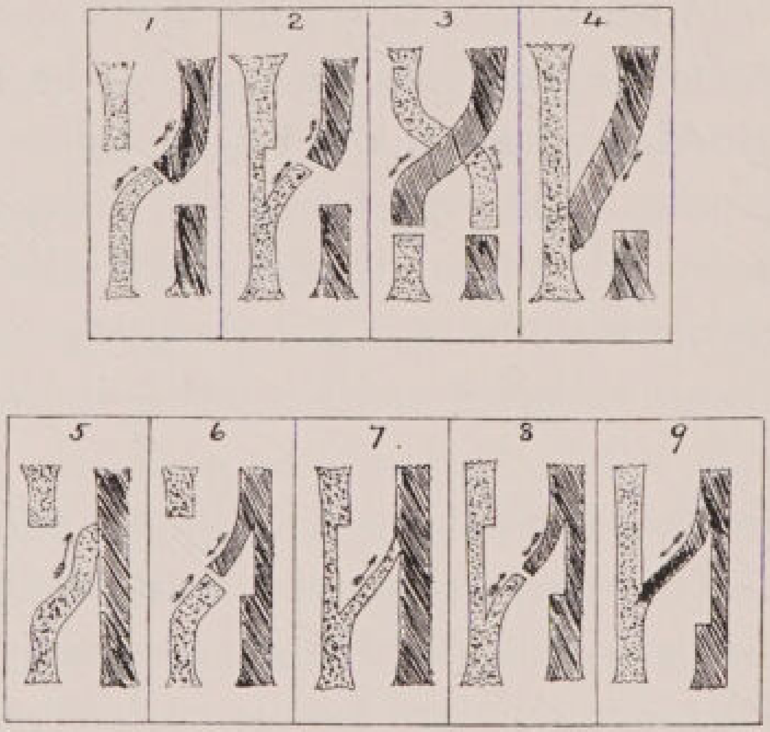


Fig. 39.

Scheme (after Vulpius) to show nine methods of tendon-grafting. The paralysed tendon is in light shading, and the reinforcing tendon is in dark shading.

end of the reinforcing tendon is united to the distal end of the paralytic tendon, and the proximal end of the paralytic tendon to the distal end of the reinforcing tendon, thus effecting a double transfer, crosswise.

This method is very useful in cases where a muscle is not entirely paralysed, and it is not desired, while reinforcing it, to entirely throw out of gear the remaining healthy fibres in the weakened muscle.

4. The paralysed tendon is left undivided. The reinforcing tendon is completely severed, and its proximal end is grafted into the paralytic tendon, the distal end of the reinforcing tendon being left free.
5. The paralytic tendon is divided, and its distal end pulled on tightly and inserted into the reinforcing tendon.
6. A slip is partially detached from the reinforcing tendon; the paralytic tendon is completely divided, and the reinforcing slip is joined to the distal part of the paralytic tendon.
7. A slip is partially detached from the paralytic tendon, and inserted into the reinforcing tendon.
8. Slips are partially detached from both tendons, and the slips are sutured together.
9. A slip is partially detached from the rein-

forcing tendon, and inserted into the paralytic tendon.

Of these, the most useful are No. 4, No. 6, and No. 9.

To these methods should be added :—

10. The indirect method, where a comparatively useless tendon[1] is employed to bridge over the gap between the reinforcing and the paralytic tendon.
11. The method of periosteal implantation, which promises to be of great value in certain conditions. These conditions are recognised readily at the operation. The tendon of an extensively paralysed muscle is often very lax, and when pulled upon stretches unduly, so that, even after being reinforced, it will become slack, and place at naught the power of the reinforcing muscle and tendon. Very paralytic tendons are recognised by their thinness and dull opaque colour, as if they had become fatty, and

[1] We have also found this indirect method valuable in transferring the biceps to the patella. The tendon of the biceps is often too short to be brought across the required distance. If the ilio-tibial band be separated at its lower part, the severed biceps tendon can be attached to it, and the conjoined band so formed carried on to the patella.

by their readiness to stretch. When such are found, periosteal implantation of the reinforcing tendon is indicated.

12. The method of making artificial tendons, and prolonging the reinforcing tendon as practised by Lange, a description of which is given on p. 115.

13. In some cases it is possible to make a separate muscle and tendon; as, for example, in the case of the gastrocnemius. If a long incision be made at the back of the leg, as far up as the junction of the two heads of that muscle, the muscle can be split longitudinally, and a portion of the tendon of the split muscle re-attached in another spot, so forming a new muscle and tendon, which can be used to correct either valgus or varus (Figs. 52, 53, 54).

We may now proceed to describe some of our cases where tendon-grafting was indicated and employed, and we give details of cases under the various headings.

Paralytic Talipes Calcaneus can be treated by transferring one of the peronei (Fig. 40), on the outer side, and part or the whole of the flexor longus digitorum, into the tendo Achillis (Fig. 41), or, better still, into the periosteum of

FIG. 40.

Tendon-grafting for relief of paralytic talipes calcaneus by insertion of peroneus longus tendon *a* into the tendo Achillis at *b*. At *c* is seen the distal end of the peroneus longus.

FIG. 41.

Operation for the relief of paralytic talipes calcaneus. The flexor longus digitorum *a* is inserted into the tendo Achillis. At *b* is seen the distal part of the flexor longus digitorum.

the os calcis. Opportunity may be taken at the same time to shorten the tendo Achillis, and remove a wedge from the astragalus in the way indicated on p. 84, and we add notes of a case so treated.

CASE 20. *Tendon-grafting and Removal of a Wedge from the Ankle-joint for Paralytic Talipes Calcaneus.*—Maurice P., aged 3½ years, was admitted for surgical treatment on October 11, 1902, on account of inability to use his leg properly. Two years ago the child screamed out in the middle of the night, and his mother found him with his right leg drawn up. He was taken to see a doctor, but it could not be ascertained what treatment was adopted. He was, however, not allowed to walk for three months. It was then noticed that one leg was very much thinner than the other, and when he walked without his boot, he did so mainly on the heel. He was then seen by a friend and colleague, Dr. Purves Stewart.

On examination it was found that there was marked atrophy of the muscles at the back of the leg, and the foot was in a position of talipes equinus, but all the movements were present except that of plantar flexion at the ankle.

On October 7 the muscles were tested electrically, and it was found that, both by galvanism and Faradism, reaction was entirely absent in the calf muscles, but all the other muscles were normal.

On October 20 two incisions were made—one on either side of the tendo Achillis, and portions of the peroneus longus and flexor longus pollicis tendons were grafted into the tendo Achillis. A wedge-shaped piece from the astragalus was removed from its outer aspect in order to prevent eversion (Fig. 26). The wounds healed kindly, and the child can now lift the heel off the ground, and the foot points well forwards.

Paralytic Talipes Calcaneo-valgus can be successfully treated by an insertion of the

FIG. 42.

To illustrate Case 21. A case of talipes calcaneo-valgus following faulty operation for talipes equinus. The right foot with the patient lying down.

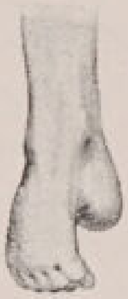


FIG. 43.

The same foot as in Fig. 42, the leg hanging over the edge of a table.

peroneus longus into the inner side of the tendo Achillis (Fig. 40), and in most instances

FIG. 44.

The feet three months after section of the plantar fasciæ, wrenching, and implantation of the peroneus longus tendon into the periosteum of the os calcis.

arthrodesis of the ankle may advantageously be combined. We give, briefly, details of some of the cases we have treated.

CASE 21. *Talipes Calcaneo-valgus, after Operation for Talipes Equinus. Periosteal Implantation of Peroneus Longus into the Os Calcis.*—R. B., aged eight years, was seen on May 9, 1898.

When the feet were allowed to hang, they presented the appearances of a Chinese lady's feet. The insteps

FIG. 45.
The same feet seven months after operation.

were extremely convex, the toes curved over, the soles of the feet were hollow, and the heels were dropped, globular, and elongated. At the back of each ankle was an elongated scar, where attempts had evidently been made to shorten the tendo Achillis after the faulty operation for equinus. The case did not present a promising appearance, and some time was consumed in unfolding the soles of the feet. In July 1898 a longitudinal incision of about four inches in length was made at the back of each ankle, the peroneus longus tendon found in each case and divided just below the external malleolus, and inserted into the posterior aspect of the os calcis. It was very difficult to identify the remains of the tendo Achillis; they were thin and membranous, having the appearance of fasciæ rather than of tendons. The wounds healed kindly, and the child was discharged from the hospital in October 1898, being able to raise herself on her toes, although some pes cavus still existed, and the feet were not of good shape. The calcaneus was markedly diminished, and has remained so. But considerable difficulty has occurred with regard to the persistent tendency to recurrence of the cavus. The conditions before and after treatment are seen in Figs. 42, 43, 44, 45.

CASE 22. *Paralytic Talipes Calcaneo-valgus treated by grafting the Peroneus Longus into the Tendo Achillis.*—A. S., aged six years, was seen on June 23, 1898. It was noted that the peronei acted well, but the calf muscles failed to raise the heel at all. On July 1 the peronei were grafted into the tendo Achillis behind the external malleolus. On August 10 it was noted that there was good power of voluntary extension of the foot, and when it was made, the peronei were felt to become tense. There was no valgus, and the foot was in excellent position. He could lift the heel off the ground, and raise himself on his toes. For a time he wore a light steel apparatus, so as to prevent any valgus deformity, but the splint has since been discarded, and the improvement is maintained.

CASE 23. *Paralytic Talipes Calcaneo-valgus treated in the same way as the preceding Case.*—W. C., aged three years, a male, came to us for surgical treatment on September 19, 1899, suffering from infantile paralysis of the left leg. When about a year old, and after he had walked, he had a fit. It was noted on admission that the muscles of the left leg were generally wasted, and the plantar-flexors and the invertors were paralysed, while the dorsiflexors and evertors retained a moderate degree of strength. The right foot was not much affected, but the sole of the foot was somewhat more hollow than is natural, and the balls of the toes were dropped. On October 28, 1899, the left peroneus longus was grafted into the tendo Achillis after the method figured on pp. 163, 164, Figs. 70 and 71, and the patient was discharged from the hospital on February 22, 1900. He was able to raise himself on his toes, but some talipes valgus persisted, which is controlled by a valgus pad and T-strap, and this is his present condition.

FIG. 46.

To illustrate Case 24. Showing a condition of paralytic talipes calcaneo-valgus before treatment in a girl aged eight years. The foot and leg are hanging over the edge of a table.

FIG. 47.

The same foot before treatment as in Fig. 46, and resting on the ground. The globular heel and excessive concavity of the sole of the foot are seen.

CASE 24. *Paralytic Talipes Calcaneo-valgus treated by Tendon-grafting of the Peroneus Longus and Tibialis Posticus into the Tendo Achillis.*—I. F., aged eight years, suffered from paralytic talipes calcaneo-valgus of the left foot, which had come on after a paralytic attack

FIG. 48.

To illustrate the appearance of the foot in Case 24 nine months after the operation of grafting the peroneus longus and flexor longus pollicis into the tendo Achillis. The shape of the foot is good, and it will be noted that the heel can be lifted well off the ground.

when she was two years of age. She had had no treatment for the condition until she came under our care. When the limb was passively raised from the ground, the front part of the foot hung helpless, pointed and everted, the sole was deeply concave, the heel was prominent, and had the typical globular appearance of these cases, and the plantar fascia was contracted. The

healed kindly, and the leg is now being galvanised. There is a good amount of power in raising the heel off the ground, and the foot is maintained fairly well to the front.

CASE 26. *Talipes Calcaneo-valgus of the Right Foot treated by grafting the Peroneus Longus into the Tendo Achillis and the Extensor Communis Digitorum into the Tibialis Anticus.*—M. H., aged six years, came under treatment on January 22, 1902. She was kindly sent by Dr. J. F. Goodhart.

The history of the illness was that the right leg was noticed to be paralysed after a bad attack of whooping-cough. The family history was good, and on neither side has there been any history of paralysis. For some years she had been under the late Mr. Brodhurst's care, and was subsequently seen by Dr. Goodhart. She has had the battery applied, and persistent massage for the last four years. The present condition is as follows:—

The right limb is seven-eighths of an inch shorter than the left, and is smaller and weaker. When she walks the heel is invariably placed first on the ground, and the outer border of the foot is raised and the inner border is depressed. The condition of the extensor muscles of the knee is quite good, while the calf muscles are partly paralysed, and the invertors of the foot completely, but there is good power in the peronei and the extensor communis digitorum.

It was decided to transplant the peroneus longus into the tendo Achillis, so as to overcome the calcaneus; and at the same time it was thought advisable to transplant the outer two tendons of the extensor communis digitorum into the tibialis anticus, thus using the excessive everting power of the former to raise the inner border of the foot. The operation was done on February 4, 1902. Two incisions were made, one 3½ inches in length above the heel, between the outer border of the tendo Achillis and the peroneus longus. The latter tendon was divided just above the ankle-joint, and its proximal part was drawn beneath the tendo Achillis, and passed through an aperture made in it at its narrowest part, and fixed down with silk sutures. A second incision was made across the front of the ankle-joint from the tibialis anticus tendon to the outermost one of the extensor communis digitorum. The two outer tendons of the latter muscle were then divided, drawn across the front of the ankle-joint, and fixed partly into the tibialis anticus, and partly into the periosteum of the scaphoid. The foot was put up into the equino-varus position.

The wound healed rapidly, and the foot was kept up in the equino-varus position for six weeks. She was then ordered a light walking apparatus with a raised sole on the inner side of the boot. On June 19 it was noticed that she could invert the foot well and raise the inner border, and was able to stand on tiptoe. It was also seen that the arch of the instep had increased. Since the operation she has had persistent massage of all the muscles of the leg, particularly of the peronei and the extensor communis digitorum, and the leg has increased in size. She now walks with the foot well to the front, and the operation is satisfactory.

CASE 27. *Infantile Paralysis: Talipes Calcaneo-valgus, treated by Insertion of Peroneus Longus into Tendo Achillis.*—Vivian H., aged nine years, was admitted into hospital on April 22, 1902. The only history obtainable was that the deformity was noticed four years ago, and came on without any recognised cause.

The left lower limb was seen to be wasted; there was paralysis of the calf muscles and tibiales. The flexors and extensors of the toes and the peronei were active. The heel was dropped, the fore-part of the foot was depressed, and the sole was cavoid. On April 24 a section of the plantar fascia was made, and on May 14 the peroneus longus was grafted into the tendo Achillis. The child has been seen on several occasions since, and he walks very well, and is able to stand on tiptoe.

FIG. 49.

Tendon-transplantation for the relief of paralytic talipes calcaneo-varus. At *a* the proximal part of the flexor longus digitorum is grafted into the tendo Achillis; at *b* the distal part of the flexor longus digitorum is united with the flexor longus pollicis tendon.

Talipes Calcaneo-varus may be treated by inserting the flexor longus digitorum into the outer side of the tendo Achillis, and uniting the distal part of the cut flexor longus digitorum with the pollicis (Fig. 49).

CASE 28. *Calcaneo-varus treated by Tendon-grafting.*—W. H., aged three, came to us with some degree of calcaneus and of varus, the latter being mainly due to contraction of the plantar fascia. This was readily removed, and the calcaneus remained to be dealt with. The peroneus longus and flexor longus pollicis were

FIG. 50.

To illustrate Case 28. Paralytic calcaneo-varus before tendon-transplantation.

FIG. 51.

The same foot after treatment by insertion of the peroneus longus and flexor longus pollicis into the tendo Achillis.

grafted into the tendo Achillis, and the result is good. Figs. 50 and 51 illustrate the condition before and after treatment.

CASE 29. *Tendon-grafting for Paralytic Calcaneo-varus.*—W. S., aged five years, was sent to one of us by Mr. Anglin Whitelocke of Oxford, on July 9, 1902, suffering from paralytic equino-varus. He was a fine well-developed boy for his age, and was quite healthy until 3½ years old, and then he is said to have taken an internal chill, and one morning he staggered, and by the evening the right leg was quite stiff. He complained of much pain, and in two or three days the legs were powerless. He has been treated by massage, and a fair measure of recovery has taken place in the right leg, and a partial improvement in the left. On examination the right foot showed contraction of the plantar fascia, and shortening of the tendo Achillis, so that there was some loss of dorsiflexion, owing to weakness of the dorsiflexors. The left leg was smaller and weaker than the right, and three-eighths of an inch short. There were excessive inversion of the foot, and loss of power in raising the heel; in fact the condition was one of paralytic calcaneo-varus.

On October 8 a tendon-grafting was performed on the left foot, the proximal portion of the flexor longus digitorum being inserted into the tèndo Achillis just opposite the ankle-joint, and the distal part of the former muscle was stretched and stitched into the flexor longus pollicis. The tendo Achillis on the right side was well stretched, the plantar fascia divided, and the foot put up into plaster. The final result in this case promises to be excellent.

Talipes Equino-valgus is treated by splitting from below upwards the tendo Achillis and the gastrocnemius as far as the junction of the two heads of the latter, and then inserting the inner portion of muscle and tendon either into the tibialis posticus; or, better still, bringing it well forwards and fixing it to the under aspect of the scaphoid bone. This relieves the valgus portion of the deformity. The equinus portion is readily rectified by section of the remaining half of the tendo Achillis (Figs. 52, 53, 54).

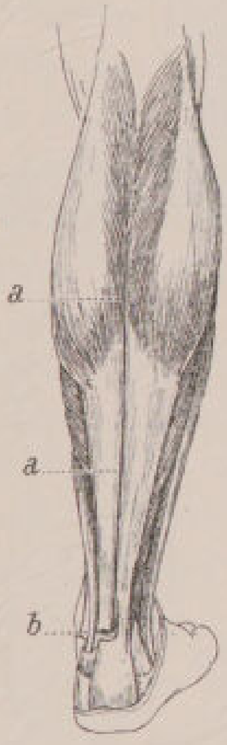


Fig. 52.

Operation for the relief of paralytic talipes equino-valgus. Splitting off at *a a* of the inner part of the gastrocnemius and tendo Achillis, and section at *b* of inner half of the latter.

Fig. 53.

The second stage of the operation. The inner half of the gastrocnemius and tendo Achillis *a* is brought forward and united either to the tibialis posticus *b* or to the periosteum of the scaphoid.

Fig. 54.

Final stage of the operation for the relief of paralytic talipes equino-valgus. The outer half of the tendo Achillis is divided at *a* to relieve the equinus.

Case 30. *Equino-valgus treated by Tendon-grafting.*—C. L., aged $6\frac{1}{2}$ years, was seen by us, suffering from infantile paralysis of the left foot, which was in a position of equino-valgus. The tibialis anticus and posticus were paralysed, while the extensor proprius pollicis and inner portion of the extensor communis digitorum were affected to a less degree, but the outer portion of the latter seemed to act well, and so, too, did the peronei. The tendo Achillis was somewhat tight, and the angle of dorsiflexion was just under 90°. The sole of the foot was more concave

FIG. 56.

FIG. 55.

A case of paralytic equino-valgus before treatment.

FIG. 57.

Figs. 56 and 57 show inside and outside views of the foot after vertical section of the tendo Achillis, union of the inner half with the tibialis posticus, and section of the remainder of the tendo Achillis and of the peronei.

than usual. On October 12, some weeks after section of the plantar fascia, an incision, 5 inches long, was made along the inner and posterior aspect of the leg, and the tendo Achillis was split along its whole length; the inner half was severed below the ankle, and brought round and stitched to the tibialis posticus. The remainder of the tendo Achillis was divided, as well as the peronei. All went well, and when the boy left the hospital in January 1899 his foot was in capital position, but since then a slight relapse has taken place, and there is some valgus present. It is a matter for regret that a portion of the peronei tendons was not exsected; and it would probably have been better to carry round the peroneus longus tendon into the flexor communis digitorum, as well as inserting the inner half of the tendo Achillis into the tibialis posticus. The conditions before, immediately after the operation, and three years later, are seen in Figs. 55, 56, 57.

CASE 31. *Equino-valgus treated by Tendon-grafting.*—B. F., aged nine years, was admitted to hospital with a condition of equino-valgus of both feet, which was undoubtedly of paralytic origin, the muscles of the left leg being particularly wasted. No history was obtainable of the onset of the paralytic condition, but all the symptoms were those of infantile paralysis. Both feet were dropped, owing to partial loss of power in the extensors of the feet, and the valgoid position in the left foot appeared to be due to paralysis of the tibialis posticus and flexor longus pollicis muscles. On February 1 each tendo Achillis was divided and the plantar fasciæ, and on March 22 the outer two tendons and outer part of the left extensor communis digitorum were implanted in the tibialis anticus. The child walked well with the aid of apparatus, but the left foot has shown some tendency to relapse into the valgoid position. (See Figs. 58 and 59.)

FIG. 58.

To illustrate Case 31. Paralytic equino-valgus in a girl aged nine years. Before tendon-transplantation.

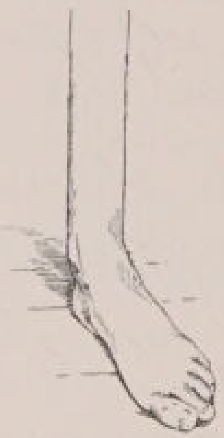


FIG. 59.

The same foot after treatment by section of the plantar fascia and tendo Achillis, and transplantation of the outer part of the extensor communis digitorum into the tibialis anticus.

CASE 32. *Paralytic Talipes Equino-valgus treated by splitting the Tendo Achillis and Gastrocnemius and Grafting.*—Gertrude C., aged 7½ years, was seen on January 6, 1902.

At the age of four years she was attacked by pain in the head, followed by paralysis of the left lower limb.

On admission it was found that the flexors and extensors of the toes were weak; the gastrocnemius and the peronei were active, but also weak; but in all other respects the paralysis below the knee was complete. She was unable to dorsiflex her foot or invert it. The foot was wasted and cold, and the leg was half an inch short.

The electrical reactions were as follows:—To faradism

—the peronei react briskly; the extensor communis digitorum doubtfully; the gastrocnemius and flexor longus digitorum well; the tibialis posticus badly, and the anticus not at all. To Galvanism—the peronei and gastrocnemius gave K.C.C. greater than A.C.C.; the tibialis anticus, the extensor communis digitorum, and the tibialis posticus, did not react. These tests were kindly made by Dr. Purves Stewart.

On January 16 the peroneus longus tendon was divided just above the external malleolus, and its proximal part brought obliquely across the front of the ankle through a tunnel made by a director in the subfascial tissue, and inserted into the tibialis anticus tendon. The tendo Achillis was then exposed by an incision for nearly 8 inches in length parallel with its inner border. Its inner half, with the muscle belly attached, was defined, and a new muscle and tendon made by severing it from the remainder of the tendon below, and the new muscle so made was inserted into the tibialis posticus. The remainder of the tendon of the tendo Achillis was then divided.

The wound was soundly healed in ten days, and the foot was put up in a right-angled position and in inversion. On February 7 electrical tests were again applied, and the peroneus longus and gastrocnemius reacted briskly to faradism, their transplanted tendons being strongly pulled upon. On March 6 it was noted that the results were excellent, and the child was discharged wearing a light walking apparatus. She has been seen several times since, and the walking apparatus has been dispensed with, there being no tendency to relapse.

CASE 33. *Tendon-grafting for Paralytic Equino-valgus.*

Part of extensor proprius pollicis inserted into tibialis anticus (Fig. 60), *and periosteal implantation of extensor communis digitorum.*—Gerald N., aged four years, was sent to us by Dr. Ferrier on May 16, 1902, suffering from talipes equino-valgus.

The history was that when a year old it was noticed that he did not properly move the right leg, and since then he has been under the care of several medical men.

FIG. 60.

Replacement by tendon-grafting of the paralysed tibialis anticus *a* by the extensor proprius pollicis *b*. The reinforcing tendon is shaded darkly. At *c* is the extensor communis digitorum.

On examination it was found that the right leg was three-eighths of an inch short, and that he had completely lost power in the tibialis anticus. The tendo Achillis and the plantar fascia were also contracted. Tendon-grafting was advised, and the following operation was carried out on June 17, 1902:—An incision was made, 3 inches in length, with its centre about $2\frac{1}{2}$ inches above the ankle-joint, and in a line with the tendons of the tibialis anticus and the extensor proprius pollicis. A portion of the extensor pollicis tendon was then partially detached, and the free end of the piece inserted into the tibialis anticus tendon. A second incision was made obliquely across the dorsum of the foot, and the outermost tendons of the extensor communis digitorum were severed and brought inwards, and attached to the periosteum of the internal cuneiform bone, the foot being fully inverted while this was done. The tendo Achillis and plantar fascia were divided at the same time. The foot was put up at the right angle and somewhat inverted, this position being maintained in a Scarpa's shoe for six weeks. When the wound had healed massage was applied to the grafted muscles. The result proved eminently satisfactory. In walking he uses toe and heel well, and he has extremely good power of voluntary inversion.

CASE 34. *Tendon-grafting and Removal of Wedge from the Ankle-joint for Paralytic Talipes Calcaneo-valgus.*—Jack S., aged four years, was kindly sent to one of us by Dr. Goodhart, on July 9, 1902, for a condition of paralytic talipes calcaneo-valgus of the right foot. The history was that he had had an attack of infantile paralysis at the age of one year, and the whole of the right side, including the back, had been affected. All the parts recovered except the right leg.

The history in this case was interesting, having some bearing upon the climatic conditions under which infantile paralysis appears. It has been stated that more cases occur in hot countries than in temperate ones; but this child was born in England, and it was said that he was ill of a "low fever" at Scarborough when he was twelve months old, and that then the paralysis came on. At the age of sixteen months he went to India and stayed there until he was 2½ years of age, and since then he has been at home. The child's condition was that of a fine healthy boy, and his only defect was in his right leg. There was great loss of power in the calf muscles and weakness of the tibialis anticus and posticus. The peronei and extensor communis digitorum were strong and overbalanced their opponents. There was also contraction of the plantar fascia. On July 12 the following operation was done :—

The peroneus longus and half the extensor communis digitorum were grafted into the tendo Achillis, and a new departure in treatment was adopted in order to prevent return of the eversion of the foot, which is so often a blemish in the after results of these cases. From the same incision used for the tendon-grafting the ankle-joint was opened on its postero-external aspect, and a wedge-shaped piece of bone and cartilage was removed from the external articular surface of the astragalus, the base of the wedge being upwards. The result of this was to throw the foot somewhat into inversion.

The usual after treatment was adopted, and on October 20 it was noted that the result was excellent. The boy can stand on his right foot on tiptoe, and he has extremely good power of inversion. The globular appearance of the heel, so characteristic of calcaneus, has disappeared.

Talipes Valgus is treated by transplanting the proximal part of the peroneus brevis into the tibialis anticus above the ankle-joint (Fig. 61), and if necessary tenotomising or exsecting a portion of the peroneus longus. We have found it necessary to remove a wedge from the outer side of the astragalus, the base of the wedge being upwards (Fig. 26). Or the wedge may be removed horizontally, its base being inwards (Fig. 72). And we were led to do this by observing that owing to the alteration of the shape of the joint surfaces, and their

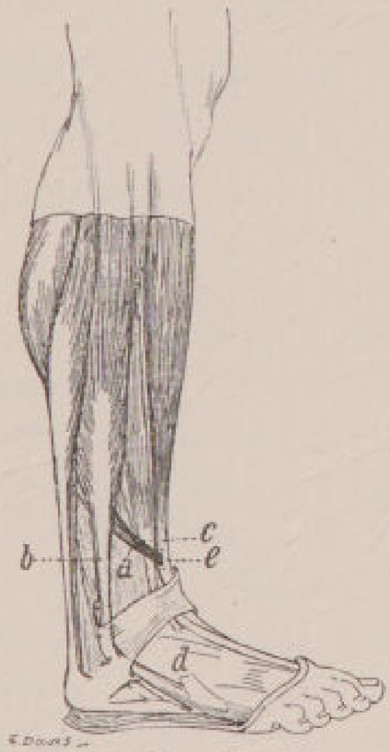


FIG. 61.

Tendon-transplantation for the relief of paralytic talipes valgus. The peroneus brevis *a* is divided and inserted into the tibialis anticus *c* at *e*. At *d* is seen the distal end of the peroneus brevis, and *b* marks the peroneus longus.

FIG. 62.

Transference of the outer tendon of the extensor communis digitorum and the tendon of the peroneus tertius into the inner border of the foot for paralytic talipes valgus. The insertion *a* of the transferred tendons is shown rather too far forward on the inner side of the foot.

adaptation by long use to the valgoid position, there was a strong tendency, despite the muscle-grafting, for the foot to return to its old and bad position. A moment's reflection convinced us that these two factors at work, viz. paralysed muscles and altered joint surfaces, must be attacked simultaneously. In slighter cases it is sufficient to graft the outer tendons of the extensor communis digitorum into the tibialis anticus, or into the periosteum on the inner side of the foot (Fig. 62), and we append notes of a case where this was done.

CASE 35. *Talipes Valgus treated by grafting part of the Extensor Communis Digitorum into the Tibialis Anticus.*— F. L., aged four, came under our care for surgical treatment on February 20, 1900. The history was that a year before admission, when he woke up one morning, it was found that he could not walk, although he had gone to bed quite well the night before. There was much wasting of the left leg, and the knee jerk on the left side was not obtainable. The foot was everted, and there was good power in the peronei and the extensor communis digitorum. When the foot was brought to the middle line, he was able to invert it slightly by the action of the tibialis posticus, although the tibialis anticus appeared to be paralysed. The limb was half an inch short. On February 22 a transverse incision was made across the front of the ankle-joint, the extensor communis tendon found and split longitudinally, and its outer half having been divided, the proximal portion of this section was grafted on to the tibialis anticus. It was not deemed advisable to graft the peronei on to the tendo Achillis, as the amount of calcaneus was not great. The effect of the operation was that he could raise the inner border of the foot and much of the valgus was overcome. When seen on July 18, 1902, the result was very good

FIG. 64.

FIG. 63.

Case of paralytic talipes valgus.

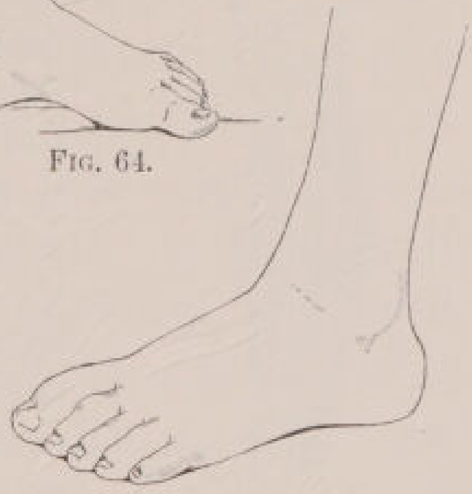


FIG. 65.

Inside and outside views of the same foot after treatment by muscle-grafting of part of the extensor communis digitorum into the tibialis anticus.

indeed, and fully justified the operation. The calcaneus had disappeared as the result of persistent massage and faradism of the calf muscles (see Figs. 63, 64, 65).

CASE 36. *Infantile Paralysis with Talipes Valgus: Treated by inserting one half of the Tendo Achillis into the Tibialis Posticus, and the outer half of the Extensor Communis Digitorum into the Tibialis Anticus* (Fig. 66).—Jack C., aged eight years, kindly sent to us by Dr. F. Hichens of Redruth.

At the age of two years he had an attack of sickness in the night with rise of temperature, and in the morning it was found that his left leg was weak.

On examination it was noted that the foot was in a position of talipes valgus, and the left leg was half an inch shorter than the right. The tibialis anticus and posticus were completely paralysed and the foot was everted. The remaining calf muscles and dorsiflexors and the peronei were intact, and gave the normal reactions. It was decided to graft a strip from the inner part of the tendo Achillis into the tibialis posticus, and the outer half of the extensor communis digitorum into the tibialis anticus, and to divide the peronei. These steps were accordingly taken.

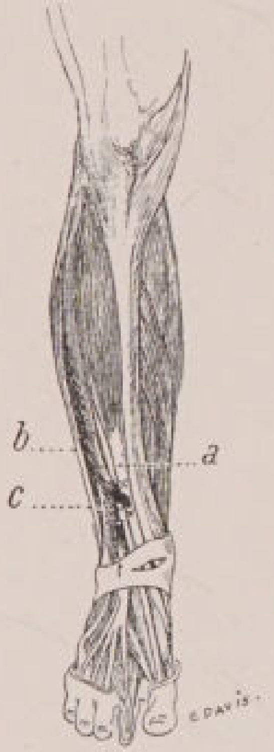


FIG. 66.

Replacement by tendon-grafting of paralysed tibialis anticus *a*, by a slip from the extensor communis digitorum *b*. The slip, which is shaded dark, is united to the tibialis anticus at *c*. This operation is designed for the relief of paralytic talipes valgus due to paralysis of the tibialis anticus.

The parts soon healed, and he left, wearing a light apparatus, with strict injunctions to employ massage and all measures for the improvement of the circulation and nutrition. Without the apparatus he can now walk with the inner border of the foot raised and the toes pointing forwards.

Talipes Varus may be treated by transplanting the tibialis anticus or extensor proprius pollicis into the peroneus brevis above the ankle, and the removal of a wedge from the outer side of the articular surface of the astragalus, the base of the wedge being downwards (Fig. 25), or the wedge may be removed horizontally, the base being outwards (Fig. 73).

Talipes Equino-varus.—This form of paralytic club-foot gives great scope to the ingenuity of the surgeon. We have followed the plan of splitting the tendo Achillis throughout its entire length and the gastrocnemius as well, so making a new muscle. Then by dividing the peroneus longus and brevis, and attaching to their distal ends the outer half of the tendo Achillis with the corresponding half of the gastrocnemius, we have succeeded in replacing the paralysed bellies of the peronei by the healthy outer half of the gastrocnemius. The result is eminently successful, and we append two cases, one in which the operation was carried out in its entirety and was successful, and one in which only a slip from the tendo Achillis was used; but there the result was not so successful because the operation was not sufficiently thorough.

CASE 37. *Paralytic Equino-varus treated by using the outer half of Gastrocnemius and Tendo Achillis to reinforce* *the Peronei.*—C. C., aged $2\frac{1}{2}$ years, was admitted into hospital for treatment on July 6, 1898. He appears to have had an attack of infantile paralysis at the age of nine months. He was a healthy-looking boy, but the right leg was partially paralysed; this was especially so in the extensors of the toes. The foot was pointed and inverted, resting on the external malleolus. On July 22 a longitudinal incision, about 3 to 4 inches in length, was made at the posterior and outer aspect of the leg, and the tendo Achillis and peroneus longus tendon exposed. The tendo Achillis was then split longitudinally for its whole length, and the gastrocnemius as far as the junction of its two heads. The outer part of the tendo Achillis was then severed transversely about an inch and a half above the ankle, and so, too, was the peroneus longus. The proximal part of the tendo Achillis and the distal part of the peroneus longus were then firmly quilted together; the remaining inner portion of the tendo Achillis was then severed, so as to correct the equinus. For six weeks after the healing of the wound, massage and faradism were applied, and it was evident that the everting movement of the foot had been regained. The present condition is that the boy is able to walk about comfortably without any instrumental assistance, the only drawback being that the leg is one inch shorter than its fellow.

CASE 38. *Paralytic Equino-varus treated by grafting a strip from the outer side of the Tendo Achillis into the Peronei.*—A. R. was seen suffering from paralytic talipes equino-varus of the left foot, with paralysis of the peronei, and partial paralysis of the dorsiflexors of the foot. The same procedure was adopted as in the previous case, but the tendo Achillis was only split for a short distance, the gastrocnemius not being divided longitudinally. The outer portion of the tendo Achillis was inserted into both the peroneus longus and brevis, while the inner part was divided transversely. The result is not so good as in the previous case, owing doubtless to the fact that the outer strip of the tendo

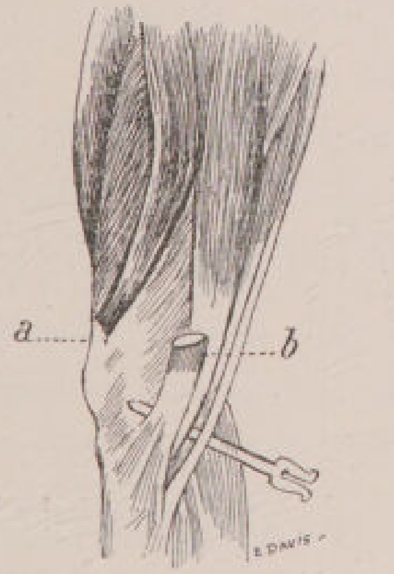


FIG. 67.

Lateral view of inner hamstrings to show transplantation of the sartorius into the patella at *a*. The distal part of the divided sartorius is seen at *b*.

FIG. 68.

Transference of the proximal part of the sartorius into the patella to reinforce the extensor quadriceps. At *a* is the distal part of the sartorius; at *b* is its proximal end.

Achillis was not detached sufficiently from the main body of the tendon. In these cases it is essential to sever the outer from the inner belly of the gastrocnemius, and so provide an entirely separate muscle.

We have dealt fully with the treatment of talipes by tendon-grafting, but it finds a much wider use. It not infrequently happens that the extensor cruris is paralysed, while the sartorius or the hamstrings or the adductors escape. We have divided the sartorius just above its insertion and transferred it to the top of the patella on two occasions, with the result of enabling the patient to maintain the knee rigid in standing and to advance the foot in walking (Figs. 67 and 68). In other cases where the sartorius is defective we have brought a portion of the semimembranosus from the innerside of the joint, and a portion of the biceps from the outer

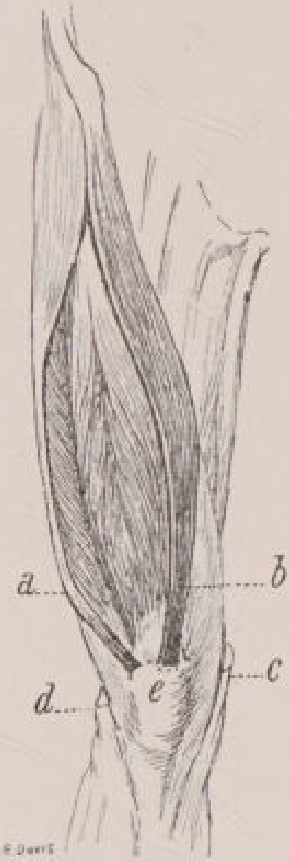


Fig. 69.

Operation of muscle-transference for the relief of paralysed extensor cruris by reinforcement of paralysed muscle from the inner and outer hamstrings. At *a* a slip is brought forward from the biceps; at *b* the proximal part of the sartorius is brought forwards and the muscular slips *a* and *b* are inserted into the patella at *e*. At *d* is seen the distal part of the biceps, and at *e* is the distal part of the sartorius.

CASE 40. *Infantile Paralysis of the Left Thigh and Leg: Transplantation of Sartorius.*—Donald G., aged five years, was admitted into hospital on February 24, 1902.

He was quite well until three years ago, and then became restless and feverish one night, and was powerless when he tried to rise the next day. There were no convulsions. The left leg alone was affected, and the arms were quite free. He was quite helpless for four months and could not sit up. Afterwards he crawled on his hands and knees, with the left leg dragging behind. He began to walk with a support two and a half years ago. Over a year ago he was for a fortnight off his feet, but soon regained his usual power. The child is a healthy-looking, intelligent boy. On examination of the left leg it was found to be seven-eighths of an inch shorter than the right, but the whole leg could be extended feebly. The flexion was much more powerful. When he walked the left leg dragged, the foot was much turned out, and he rested on the inner edge.

The electrical reactions were as follows:—The extensors of the left thigh show the reaction of degeneration, but the sartorius reacts strongly.

On March 4 the patient was anæsthetised, and a flap of skin and subcutaneous tissue was turned back at the front of the lower third of the thigh. The sartorius was dissected out and cut away from its attachment to the tibia, and fixed to the quadriceps tendon above the patella. It was found that the fibres of the muscles on the outer side of the femur were too wasted to be of any service if transplanted; so the wound was stitched up and dressed, and the leg put on a back splint with a foot-piece. On April 26 it was noted that there was distinct voluntary contraction of the transplanted sartorius, and the ligamentum patellæ was tightened. The child could also stand and maintain the knee extended, and could oppose some force when the surgeon attempted to flex the leg.

CASE 41. *Transplantation of Sartorius and part of Biceps Cruris into Patella.*—J. S., aged thirteen, was admitted for severe infantile paralysis affecting the extensor muscles of the right leg. She had been troubled since the age of two years with weakness of that limb, and dragged it considerably in walking. The electrical reactions showed that the extensor was hopelessly degenerated, but the sartorius and the biceps retained considerable power.

A semilunar incision was accordingly made with its concavity upwards and its centre over the top of the patella, and a flap turned upwards. The sartorius was isolated, divided, and stitched just above the inner edge of the patella. A strip from the biceps was also isolated and attached just above the outer edge of the patella. The wound did well, and the patient left the hospital, having regained the power of walking in the affected extremity.

CASE 42. *Very severe Infantile Paralysis affecting the Lower Extremities, treated by Tenotomy and Muscle-grafting.*—Miss W., aged thirty-two, came under our care in October 1900. She had been a cripple since childhood, and was compelled to walk with a pair of crutches. The condition was as follows:—

The right lower extremity had retained a good deal of power, but the foot was in a position of talipes equino-varus, with contracted and distorted toes.

The plantar fascia was accordingly operated upon, and later the tendo Achillis.

The left lower extremity was very helpless indeed. There was considerable weakness of the flexors of the hip, but the ilio-psoas was intact. The knee was in a condition of very marked hyper-extension and almost flail-like. The quadriceps extensor was entirely paralysed, but the sartorius responded to electrical stimuli. The muscles below the knee were fair, but there was some contraction of the tendo Achillis. The vaso-motor disturbance in both lower extremities was extremely severe, and the feet were usually blue and cold, and subject to chilblains.

The condition of the right foot having been improved as above stated, it was decided to graft the sartorius on the left side into the top of the patella. This was accomplished through an incision made for 3 inches along the course of the muscle and just above the patella, and then a second incision was made transversely across the top of the patella. The sartorius was easily found, and it was of a good colour and ruddy. The muscle was divided at a point corresponding to the upper edge of the patella, a channel was made for it in the subcutaneous tissue, and it was reinserted into the periosteum of the patella.

The wounds healed very kindly and everything went well, the patient gradually obtaining the power of holding the knee rigid and in a right line on standing, of raising the heel off the ground in walking, and the sartorius could be seen to contract and pull upon the patella when stimulated electrically. She has now discarded her crutches and walks with the aid of a stick, and later on will be able to dispense with this, although light instruments are still retained for the purposes of preventing relapse.

Paralytic conditions of the hand and arm lend themselves well to tendon-transplantation, and much good may be effected by grafting the flexor carpi radialis and ulnaris to the dorsal surface of the carpus. We shall allude presently to a case in which transplantation of the triceps into the biceps was wonderfully effective.

Preliminary Points in Tendon-transplantation.—Before it is decided to perform the operation the case must be carefully studied and a definite plan of procedure formulated. The electrical reactions of the muscles should be previously ascertained, and an attempt made to estimate the strength of those which it is intended to transplant. In the case of the foot all secondary conditions,—such, for instance, as contraction of the plantar fascia, giving rise to pes cavus,—should be remedied. For mechanical reasons it is advisable to select the reinforcing tendon from a muscle whose line of action is as nearly as possible parallel with that of the muscle to be reinforced. For instance, in a case of paralytic valgus it may be better to graft a strip from the tendo Achillis into the tibialis posticus rather than to bring the tendon of the peroneus longus across the front of the ankle and insert it into the tibialis anticus. It is also important to remember that muscles, which before the operation appear to be hopelessly paralysed, exhibit after the operation signs of returning strength. The operation is rarely called for when one muscle only is paralysed, nor should it be done when nearly all the muscles round the joint are implicated. The latter cases are suitable only for arthrodesis, and indeed there is a fear that an indiscriminate use of this method of transplantation may lead to unsatisfactory results in some cases, and so bring the operation into undeserved discredit. A great point is the careful choice of cases.

In selecting a healthy muscle for reinforcing a paralysed one it is advisable that the one selected should belong to the same group, if possible, as the paralysed one, the reason being that it is nearest, and restoration of voluntary function is more quickly and perfectly secured. Then, too, the reinforcing tendon should be carried as directly as possible to the paralysed muscle, and not bent round at an angle, a manœuvre which has the effect of considerably lessening the transfer of power. For instance, if the peroneus brevis were used to reinforce the extensor communis digitorum, the former should be attached to the latter above the ankle, and not below and in front of the external malleolus. When an opponent of a paralysed muscle is selected, it gives emphasis to this principle, namely, that by selecting one of the opponents of a paralysed muscle we not only reinforce that weak muscle, but we lessen the antagonism which exists between the two groups. And by transferring, for example, the insertion of the peroneus longus in a case of paralytic talipes valgus from the outer to the inner border of the foot, we effect an equality between the forces acting upon the two borders. Finally, it is unnecessary in these latter days to insist upon the absolute necessity of perfect asepsis, insomuch as the success or failure of the operation depends upon healing by primary union.

Technique of the Operation.—After the limb has been rendered completely aseptic, and, if obscuring hæmorrhage be feared, an Esmarch's bandage has been applied, a suitable incision is made of such a length and in such a position as to give free access to the tendons to be operated upon. In many cases a single incision will suffice, but it sometimes happens that, to avoid a single large incision, two smaller ones are made, as, for instance, when the peroneus longus is transferred to the inner border of the foot. In this case one incision is made over the front of the fibula, and a second over the scaphoid bone. By burrowing through the subcutaneous tissues of the dorsum of the foot with a director, a channel is made for the passage of the peroneus longus tendon to the scaphoid. It is curious to remark that no adhesion of the tendon, transplanted under these circumstances, to the subcutaneous tissue takes place, doubtless owing to the endothelium on its surface; whence we learn the necessity of very carefully handling the tendons.

If difficulty exist in ascertaining whether the muscle is paralysed or not, the following description of the appearances may be of some assistance. The healthy muscle is always deep red, firm and elastic. The paralysed muscle is reddish yellow, and often shows signs of fatty degeneration, and is lax. And it is well to have at hand the constant current battery, with electrodes capable of sterilisation, and to stimulate the various muscles as they are laid bare.

It will be better to illustrate the operative procedure by a simple example, such, for instance, as the implantation of the peroneus longus into the tendo Achillis. The two tendons are exposed by an incision of about 4 inches in length made above the external malleolus and between them. Their sheaths being quickly and deftly opened, a longitudinal aperture is made through the tendo Achillis at its thickest part. The peroneus longus tendon is then severed just above the external malleolus, taking care that there is sufficient length to be passed through the tendo Achillis, and to allow the end of the reinforcing tendon to be pleated down on to the tendo Achillis (see Figs. 70 and 71); or lateral attachment may

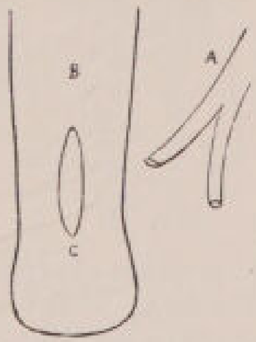


FIG. 70.

To illustrate a simple method of tendon-grafting, namely, the peroneus longus into the tendo Achillis. A, split end of the central portion of the tendon of peroneus longus; B, tendo Achillis; C, aperture in tendo Achillis.

be effected by suture. The latter is not so satisfactory. The foot should now be placed in the position which it is desired subsequently to obtain—that is, somewhat in equinus. A silk ligature having been threaded through the proximal end of the peroneus longus tendon, it is drawn through the Achillis from the front to the back and then pleated down on the posterior aspect. A very important question arises as to the tension of the reinforcing tendon at the time of stitching. Over-extension is to be avoided, because experience has shown that the muscle loses its contractile power subsequently. We are accustomed to pull upon the proximal end of the tendon to ascertain the elasticity of the muscle. The tension of the reinforcing muscle and tendon should be gauged thus:—It should be pulled upon so far and for so long as it shows signs of complete resiliency and no further; at least such

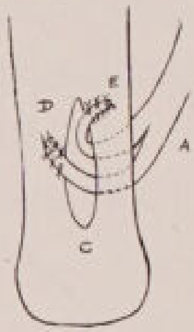


FIG. 71.

The peroneus longus tendon drawn through and fixed on to the posterior surface of tendo Achillis. The ends of the peroneus longus tendon are sewn to the posterior surface of the tendo Achillls at D and E, after having been drawn through the tendo Achillis at C.

is our experience. In effect, "stretch well and stitch well." As to the material for stitching one tendon into another, some have

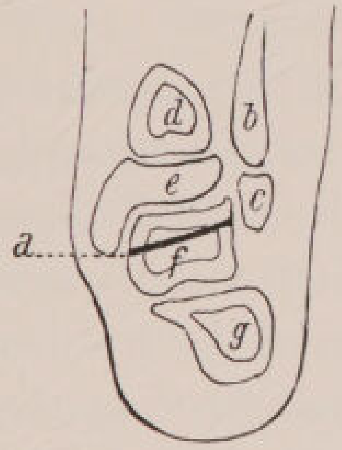


Fig. 72.

Vertical section through the ankle-joint. To illustrate the method of permanently overcoming talipes valgus in arthrodesis at the ankle by an oblique section through the astragalus *f* at *a*, and removal of the portion of that bone above the line of section *a*. *b* is shaft of fibula; *c* is its epiphysis; *d* is the shaft of the tibia; *e* is its epiphysis; and *g* is the os calcis.

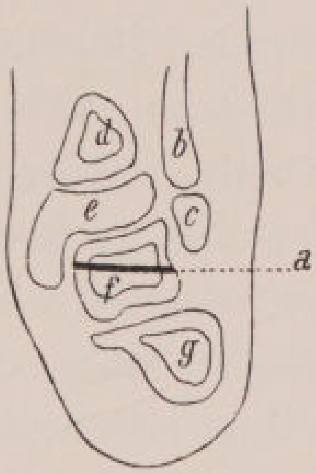


Fig. 73.

Vertical section through the ankle-joint. To illustrate the method of overcoming varus in arthrodesis at the ankle by an oblique section at *a* of the astragalus *f*, the portion of that bone above the black line being removed. *b* is shaft, and *c* is epiphysis of fibula; *d* is the shaft, and *e* is the epiphysis of the tibia; *f* is the astragalus, and *g* is the os calcis.

used catgut and others kangaroo-tendon. We have preferred strands of fine Chinese silk prepared as follows:—The silk is boiled for half an hour, and is then placed for a week in a solution of 1 in 1000 potassio-mercuric iodide in spirit. With these precautions we have never on any occasion had the slightest trouble with the silk in the way of its attempting to work out. The Esmarch's bandage is now taken off, all hæmorrhage arrested, and the wound closed.

On page 177 we deal with the questions of combining arthrodesis with tendon-transplantation, and we have found the method of great value, especially in permanently and quickly correcting lateral deviations of the foot, such as valgus or varus, for in these cases we have ascertained that some alteration in the joint surfaces must be effected at the operation to make it a permanent success. It is necessary to remove a wedge-shaped piece from the astragalus either vertically or horizontally (Figs. 25, 26, 72, 73).

After Treatment.—The foot or limb is fixed in the fully corrected position, and therefore in such a way that there is no tension whatever on the reinforcing muscle. It is left thus for six weeks to ensure good union of tendon. It is curious to note that in many cases the muscles, the tendons of which have been used for transplantation, show the reaction of degeneration immediately after the operation, and the normal reaction does not return for six to eight weeks.

It may appear that in some cases, immediately on removing the splint or plaster of Paris, over-correction has been made, and the reinforcing tendon is so tight as to seem to demand tenotomy. If it has not been overstretched at the time of operation, no interference is called for, as with free movements of the part the muscle readily adapts itself to the length required. And this leads on to the question, Can all retentive apparatus be dispensed with at once? It is better not to do so, because there is a strong tendency for the reinforcing muscle to become overstretched and weak on account of the extra work it has to do. It is therefore well to employ a light retentive apparatus to assist in keeping the part in its new position. But at the same time the ordinary physiological measures should not be neglected. Daily massage of the reinforcing muscle or muscles should be assiduously practised, and the application of the interrupted current appears to be of value. When it is evident that the muscle is undergoing hypertrophy, then the supporting apparatus should be dispensed with; and it is remarkable how exceedingly great is the overgrowth of such transplanted muscles when properly tended and coaxed for several months after the operation.

We are convinced, then, that muscle-grafting has the greatest possibilities in the future, now that we have grasped the main details of the procedure. It is applicable in most parts of the body, and we have been of late endeavouring to stimulate our ophthalmic friends to try it in cases of strabismus. And a step has been made in this direction by our friend Mr. Sydney Stephenson,[1] who has devised an operation for convergent strabismus. He lengthens the tendon of the internal rectus by making a long oblique incision with scissors, commencing at the lower border of scleral insertion, and terminating at the upper border of the muscle some distance from its tendinous attachment to the eyeball, and then slides the lower half of the tendon over the upper half, the two ends being united by sutures. Another method which he describes is to cut through the tendon from below upwards for

[1] *Transactions of the Ophthalmological Society*, vol. xxii. p. 276.

half its width, then to pass the knife backwards at right angles to the first incision for a varying distance, and then to sever the tendon completely by directing the knife to the upper border. The two ends so made are united and the tendon lengthened.

The leap from muscle-grafting to nerve-grafting, which is a very natural one, has been taken; and we are indebted to Messrs. C. A. and H. A. Ballance and Purves Stewart[1] for an account of their efforts towards the cure of facial paralysis by uniting the distal part of the facial nerve with the spinal accessory. Their operations were fairly successful. And it is a principle and procedure capable of wide application.

[1] Remarks "On the Operative Treatment of Chronic Facial Palsy of Peripheral Origin," *Brit. Med. Journal*, May 2, 1903, pp. 1009-1013.

CHAPTER V

INFANTILE PARALYSIS OF THE LOWER EXTREMITIES (*Continued*)

Treatment by Arthrodesis, Osteotomy, Cuneiform Exsection

Arthrodesis.—A problem which surgeons must solve is the best method of treating flail-joints when met with amongst the poor. It is impossible to keep them supplied year in and year out with expensive apparatus; and to be able to dispense with splints within a reasonable period is to have made a considerable advance in such cases. It was with this aim in view that one of the authors revived, with some modifications, arthrodesis, an operation practised in certain cases by Albert of Vienna in 1878. Twenty-six cases were reported in the *Provincial Medical Journal* of December 1894, in which the operation was performed without mishap. The authors have now performed arthrodesis considerably over a hundred times with no mortality, with superficial suppuration in but two cases, and suppuration in the joint in one case.

By arthrodesis we mean the denuding the joint completely or in part of all its cartilages. The operation is best commenced by a free incision which enables the operator to see accurately what he is doing.

The operator aims at either (*a*) partial ankylosis, or (*b*) complete ankylosis. It is not easy to predict accurately which will occur.

Partial ankylosis is desired usually at the ankle. Indeed, without the removal of much bone it is not easy to bring about a complete ankylosis here. Ten or fifteen degrees of movement are advantageous for walking purposes. If we desire a partial ankylosis we merely remove a thin layer of cartilage by gouging it away, taking care that the whole area of cartilage is traversed. If the ankle be wholly paralysed, ankylosis should be as complete as possible. If arthrodesis is employed as an aid to tendon-transplantation, the ankylosis is best if partial.

Complete ankylosis is generally desirable in the knee, as partial fixation, with no controlling muscles, inevitably means painful stretching of the fibrous bands. It is necessary, except in very young children, to completely peel the joint of its cartilage, even attacking the patella.

It is somewhat difficult to decide to what extent arthrodesis interferes with the growth of a limb. Certainly it should retard it theoretically; but practically, from our observation the loss of growth is certainly slight, and does not markedly increase the shortening, which is inseparable from the paralysis. It is well not to take any more cartilage away than will suffice to stiffen the joint, and for this reason we would dissuade surgeons from operating upon the very young, except in the case of the ankle-joint. Ap Morgan Vance believes the operation should be confined to children under ten, and reports that in two cases over this age upon whom he operated both died from fat embolism. We have operated on more than a hundred cases during ten years with no fatality, thirteen of the patients being over twenty years. We think, therefore, that Dr.

Vance's cases do not accurately represent the risks.

The indications for the operation of arthrodesis may be briefly given as follows :—

(*a*) Complete paralysis of all the muscles resulting in flail-limb.

(*b*) Complete paralysis of muscles about a joint resulting in flail-joint.

(*c*) Partially paralysed joint resulting in fixed deformity.

(*d*) Paralysis of certain groups of muscles, where the mobile joint is deformed the moment pressure is put upon it.

(*e*) As an aid to muscle-transplantation, where it is necessary to guard against over-stretching of newly grafted tendons, or when these tendons are neither sufficiently numerous nor strong enough to control the joint.

The disadvantages of the operation are :—

(*a*) Some probable shortening of the limb.
(*b*) The limitation of extension or flexion.
(*c*) The need of a splint in certain cases.

We have already referred to the shortening of the limb, and stated that it is not a factor sufficiently serious to lay stress upon. In reference to the loss of extension and flexion we must admit that there are circumstances where such a loss may be keenly felt. This is scarcely applicable to the ankle, but markedly so to the knee-joint. Many people with complete paraplegia or monoplegia, who have ample means to obtain and renew their supports, will feel acutely the disadvantage of not being able to bend the knee when sitting. In public places the stiff straight limb has obvious drawbacks. To a working lad, however, it is a great boon to be independent of supports, with their expense and worries, and this independence is not at all compensated by the power of flexion. Such cases must be treated in accordance with their desires, bearing in mind that a patient may quite well know what will suit him best. The argument, however, never obtrudes in the case of the ankle, where, in the rare cases of complete fixation, a tolerable degree of movement is carried on at the mid-tarsal joint.

Where we have to deal with a complete monoplegia, with or without deformity of the knee and ankle, arthrodesis of both is a justifiable operation, and may be safely carried out at any age up to twenty-five years. We have operated upon a woman of thirty-five years of age with excellent result, and her deformity was one of extreme paralytic flexion of the knee with equino-valgus of the ankle. Arthrodesis of both knee and ankle was performed, and the patient made an uninterrupted recovery. In another case where arthrodesis of the ankle was performed for a flail ankle in a woman of thirty-two years of age, the ankle was too painful to bear weight twelve months after the operation, although the wound had very rapidly healed by first intention. This condition of pain after arthrodesis in adults is comparatively common, but it usually disappears in a few weeks or months. We have not found it necessary to operate upon the hip-joint in order to stiffen it. It would be difficult to carry it to a successful issue; and, generally speaking, preter-mobility at the hip is not so serious a disadvantage. We are better pleased with the results at the ankle than at the knee, more especially if the ankle alone be affected. With voluntary or with controlled movement at the knee and a stiffened ankle the result is often most excellent.

We sometimes perform arthrodesis for deformed joints where the paralysis only attacks certain muscles governing them. This is peculiarly applicable to the ankle and sometimes to the knee. We may meet with equino - varus with an extremely weakened tibialis posticus and completely paralysed peronei. Such a case often presents a blue cold foot, and sometimes an ulcerated calf. An arthrodesis is performed, so as to readily allow of reduction of the deformity. Similar measures may be adopted in many other paralytic deformities of the foot. And in the case of the knee we sometimes meet with an ill - nourished limb and a flexed knee with external rotation of the tibia. For such a case, which would not tolerate, without excoriation, any attempt at mechanical rectification, arthrodesis is the best remedy. In an adult it must be sufficiently extensive to justify the term "wedge-exsection." Any attempt here at transplantation would be futile, as the tendons needed for the graft are themselves derived from muscles subject to a partial palsy.

Some joints in paralytic subjects are liable to deformity the moment the superincumbent body-weight acts. In such cases, where some power remains in all the muscles around the joints, but not enough to prevent, for example, the foot from lateral collapse the moment the body-weight is placed on it, an arthrodesis proves of value. We have operated upon many such cases with good results. As an aid to tendon-transplantation at the ankle the operation has in our hands been very successful.

In equino-valgus is this especially the case. Given an ankle with very slackened structures, paralysis of the tibiales, and preternatural mobility, arthrodesis may prove most desirable to limit movement at the ankle to a few degrees, and appropriate tendons are introduced into the tibialis anticus and posticus or into the periosteum in order to restore the movement of inversion. An operation on similar lines may be needed in the case of equino-varus. In talipes calcaneus, with some little power in the gastrocnemius, we have found arthrodesis of great value. The results are more satisfactory than in Willett's opera-

calcaneo-valgus, the inner portion of the foot should be raised, and an iron support fixed between the heel and the knee on the outer side. In calcaneo- or equino-varus, the padding should be fixed on the outside, and the support on the inside. These supports can be discarded so soon as the surgeon finds that there is limited but free movement in the ankle, which is sharply and firmly checked in front and behind.

Arthrodesis should never be done to overcome the knock-knee and tibial rotation so often associated with severe poliomyelitis. It is better to perform a femoral osteotomy to correct the lateral deviation (see p. 184).

The Operation of Arthrodesis. (*a*) *At the Knee.*—The limb having been carefully prepared and a tourniquet applied, an incision is made across the front of the joint traversing half its circumference, and curved so as to pass below the lower end of the patella. The flap is turned up and the divided vessels ligatured. The semilunar cartilages are next removed, and with a sharp short-bladed knife or gouge the cartilage should be peeled off the underlying layer of bone, so as to leave a raw surface over the whole of their extent. The crucial ligaments may or may not be left. All hæmorrhage having been arrested, the structures are then carefully reunited by deep and superficial sutures, no drainage tube being employed, and the wound is covered with double cyanide gauze and perchloride wool-wadding.

(*b*) *At the Ankle.*—The operation may be planned at the ankle-joint in one of four ways, according to the circumstances of the case :—

(1) By a transverse incision across the front of the joint.

(2) By a perpendicular incision along the mid-line in front of the joint.

(3) By an antero-external incision just external to the tendons of the extensor communis digitorum.

(4) By a posterior incision over the tendo Achillis.

In cases of old standing, where the foot is deformed and assumes the equino-varus position, and where all the anterior muscles are paralysed, the transverse incision across the front of the joint is preferable. The division of tendons is then of no consequence, and an excellent view is obtained of the joint. If there be any compunction in dividing the tendons they can quite easily be drawn aside, with the exception perhaps of the peroneus tertius. All the structures, however, may be safely divided by an incision across the front of the ankle down to the astragalus. The joint is then deprived of its cartilage, and (if firm ankylosis be desired) even of some of its bone. The vessels are tied, the foot is placed in normal relation to the leg, and a few sutures close the wound. In other cases, where some power still remains in the extensors of the toes, a linear vertical incision may be preferred. This need only be three inches in length, and a better view will be obtained of the joint by making a lateral incision into the capsule. The subsequent proceedings are the same as those after other incisions. These frontal incisions are indicated where some degree of equinus obtains, and where the astragalus is displaced forwards. It is often necessary to divide the tendo Achillis in order to bring the foot into good position.

The posterior incision is useful in talipes calcaneus where the joint can be easily reached from behind. The incision is made close to the centre of the tendo Achillis, which is drawn to one side or divided, while the incision is carried down to the bone. The capsule is opened and the gouging completed. If there be any power in the gastrocnemius, the tendo Achillis must be shortened through the same incision.

Before having recourse either to arthrodesis or to tendon-transplantation, care should be taken to completely overcome by mechanical means any deformity of the foot or leg. If this be not done, considerable traction may be needed immediately after operation—a process to be avoided when possible.

We have before remarked that, in spite of the trophic nature of the lesions, wounds heal rapidly and soundly, and without being able to give specific proof we are convinced that there is less tendency to suppuration of wounds in paralytic than in normal cases. Our osteotomies in paralytic limbs have been very numerous, and not only has there been no instance of an ununited fracture, but the bond of union has been firm in quite the average time. In ulcers of the calf, which we have excised and covered with a flap of adjoining skin, failures have been uncommon. With regard to our statement regarding suppuration, it is difficult in these aseptic days to come to conclusions from statistics, but we have operated upon over 100 cases with only one case of suppuration in the joint, although two or three stitch abscesses have been met with. These operations are often performed by us on patients who come to have the skin sterilised in the morning and go out of hospital in the evening, having been operated upon in the afternoon, while the subsequent dressings are carried on in the out-patient department. We have come to look at operations on these paralysed joints with much more favour than on those for removal of loose bodies from the knee-joint, or ablation of semilunar cartilages, or wiring of the patella, which, in spite of seemingly scrupulous precautions, will sometimes give us anxiety. Wiring a patella, though an operation absolutely simple in itself, is one which no experienced surgeon, however scrupulous his technique, approaches without a considerable sense of responsibility.

There is little or no pain attending the healing process after arthrodesis. A Thomas' bed-splint for the knee should be used while the patient is in bed, and this should be changed to a "calliper" when walking commences. For the ankle nothing is better than a "posterior" splint (Fig. 74). If both knee and ankle are operated upon, a combination of splints is indicated. We have never practised the fixation by arthrodesis of the hip, wrist, or elbow. Indeed, the hip and wrist never present the need. Pretermobility at the hip is never a drawback, and a dropped wrist can be made more useful by other methods. The elbow, however, is an exception, and in certain cases a great advantage accrues from fixing it at a right angle, or at an acute angle. We have described on p. 62 an operation for fixing the elbow more advantageous than ankylosing the bones.

FIG. 74.
Posterior splint for use after arthrodesis.

Osteotomy.—We have had frequent recourse to osteotomy in the treatment of the deformities of poliomyelitis. This has been most frequently performed for paralytic genu valgum, sometimes for contractions at the hip. If employed for genu valgum it should be limited to those cases where there is merely a lateral deviation and no flexion deformity. The bone may be divided either by a chisel or saw, and a calliper splint should be worn after the operation for some months. We have found that a simple modification of Adams' saw is most useful to us. We have it made with a knob which projects below the saw, and once in the groove of bone it does not escape, nor does it pierce tissues with its extremity.

The utility of osteotomy about the hip is not so evident. Most cases of flexion deformity can be overcome by mechanical means. Some need division of muscles and fascia, and no surgeon should attempt to undertake the treatment of paralytic hip flexion without due knowledge of its mechanical features. For instance, in a number of cases of extreme flexion at the hip, where enormous lordosis results on extension, a femoral osteotomy of itself is of no use, as all the obstruction is in the soft structures, and the surgeon will experience keen disappointment when he finds the limb afterwards flexed as ever. An osteotomy of the hip should never be done before the mechanical treatment, fasciotomy, and myotomy have had every chance, and it will then be a matter of surprise what a limited field there is for osteotomy. It should be limited to those rare cases where—

(*a*) The obstruction to extension is felt to be bony.

(*b*) The limbs are rotated inwards and adducted, and where the adduction cannot be corrected even after the obliteration of flexion.

(*c*) The dislocation is so extreme that abduction is practically prevented.

Cuneiform Exsection.—This is rarely needed at the ankle, but often at the knee. In the knee we have performed the operation twenty-four times. In no instance was the patient under eleven years of age. In one case the patient was forty-three. The operation is directed towards reducing the deformities of flexion and backward displacement at the knee. The same incision as that for arthrodesis suffices, and a V-shaped piece of bone from the femur should be removed. Care must be taken not to remove too large a piece of bone, as convalescence is thereby rendered tedious. The cases so operated upon have done very well, although in one case union did not occur; and in another, owing to the removal of too large a wedge in a patient aged thirty-four, over fifteen months elapsed before union was complete.

Resection of the ankle we have only practised twice, and in each case the patient was twenty-three years of age, with marked equinus and an astragalus dislocated forward. The tendo Achillis must also be divided to allow the foot to be placed in the best position for walking.

We append notes of some of our cases of severe paralysis of both lower extremities treated by a combination of tenotomy, tendon-grafting, arthrodesis, physiological and mechanical measures.

CASE 43. *Paralysis of both Lower Extremities treated by Arthrodesis.*—M. O'D., aged sixteen years, was seen suffering from paralysis of the lower extremities. The

quadriceps extensors were healthy, as were also the ilio-psoas muscles. The result of the paralysis was pes cavus, with hyperextension of the first phalanges, and flexion at the first interphalangeal joints.

The right plantar fascia was first divided, and afterwards the left, and on January 26, 1899, arthrodesis of the left ankle was performed, and the result was good.

CASE 45. *Severe Infantile Paralysis treated by Arthrodesis of both Ankles.*—E. A. B., aged eight years and nine months, was placed under our care for treatment on December 31, 1896. The paralysis was very severe, and the resulting deformity considerable. The spine showed a very severe S-shaped scoliosis from the cervical to the sacral region, the amount of rotation at the mid-spinal region being enormous, and the transverse processes and heads of the ribs being more prominent than the spines. On January 13, 1898, the biceps was divided in both limbs, and subsequently arthrodesis of the right and left ankle was performed. The patient was discharged from the hospital on August 17, 1898, wearing tin shoes, and was afterwards supplied with a simple walking apparatus, and now goes about with comparative ease. (Cf. Fig. 75.)

FIG. 75.

To illustrate Case 45. Severe infantile paralysis of both lower extremities, arthrodesis of both ankles performed through the anterior incision.

CASE 46. *Paralytic Talipes Valgus treated by Arthrodesis.*—G. H., aged ten years, was admitted into the hospital on October 15, 1897, suffering from paralytic talipes arcuatus of the right foot and valgus of the left. There was no contraction of the knees, and very little of the right tendo Achillis. In the right limb the general nutrition, colour, blood supply and muscular power were good. The plantar fascia and short muscles of the great toe were much contracted, leading to marked arcuatus and adduction of the front of the foot. The condition of the left limb was as follows:—The blood supply was poor; there was paralysis of the anterior leg muscles and tibiales, leading to paralytic valgus and talipes equinus, with dropping of the front of the foot. There was no deformity present in this limb which could not be passively reduced.

Arthrodesis of the left ankle was performed by the anterior incision, and six weeks afterwards there was good, sound, fibrous ankylosis. The patient was discharged from the hospital on September 29, 1898.

CASE 47. *Infantile Paralysis treated by Arthrodesis of the Ankle.*—A. S., aged thirteen years, was admitted with severe infantile paralysis of the left leg and foot. She is stated to have begun to walk at the usual age, but when she was rather more than two years old she had a fit, and next morning the left leg was found to have lost power. Since then she has been unable to walk without the aid of crutches. On admission, the left leg, below the knee, was seen to be extensively wasted, and the muscles entirely paralysed. The left foot hung flail-like. There was also considerable loss of power in the muscles of the left thigh, and the knee-joint was loose, and could be hyperextended with ease. The flail-like condition of the ankle was treated by arthrodesis. An anterior incision was made from the tip of the external to the tip of the internal malleolus across the front of the joint, each tendon was isolated, and ligatures threaded through, one above and one below the site of intended division of the tendon. The tendons were then divided between the ligatures, and the ankle-joint opened. All the articular cartilage of the joint was then carefully removed, and the bones stippled with the gouge. The tendons were then reunited, and the wound closed. Firm and close ankylosis resulted.

In order to illustrate the manner in which the various methods of treating paralytic deformities may be employed, we append notes of two severe cases.

CASE 48. *Infantile Paralysis of Left Lower Extremity: Contraction of Hip, Knee, and Ankle, and Talipes Equinus: treated by Tenotomy and Arthrodesis.*—Cyril C., aged eight years, came under observation on May 6, 1902.

The history is that he fell when twelve months old, and became paralysed in the left leg.

The hip was flexed and somewhat adducted, and the extensors of the knee were weakened. The muscles of the leg were paralysed, with the exception of some slight power remaining in the gastrocnemius.

Section of the ilio-tibial band, sartorius and tensor vaginae femoris, and of the biceps cruris, was done at once, and a weight-extension applied. On June 11 an arthrodesis of the ankle was performed by a postero-external incision.

By June 18 the wound was healed, and the limb placed in plaster of Paris. He was discharged from the hospital at the end of July wearing a light walking apparatus, and he is now able to walk well and securely.

CASE 49. *Tendon-grafting and Arthrodesis for a severe case of Infantile Paralysis of both Legs.*—Miss P., aged twenty-one years, was brought to one of us by Dr. W. A. Phillips, of Mayfair, in February 1902.

The history of her case was that when two years of age she was put into a damp baby-carriage, and paralysis of both legs came on immediately afterwards. She had various kinds of treatment, but nothing proved satisfactory. She came as an apparently hopeless cripple, walking on crutches, and swinging her legs forward as she moved. There was extreme lordosis, and great flexibility of the lumbar spine. Some portion of the body-weight could be borne upon the left leg, sufficient to enable her to steady herself for a moment to advance the crutches when in motion, but she was totally unable to walk unaided, and her condition was deplorable.

On examination it was found that in the right lower limb there was almost entire loss of extension-power at the knee, and the joint itself was hyperextended at an angle of 45 degrees. The knee was valgoid in addition. The hamstrings acted, but they were stretched and weakened. The muscles of the leg and foot were wasted and entirely paralysed, and the ankle-joint was flail-like. The toes were much cramped and distorted, and the tissues of the foot were swollen and œdematous. The left lower limb was somewhat better than

SECTION II

INFANTILE SPASTIC PARALYSIS, OR CEREBRAL PARALYSIS OF CHILDREN

SECTION II

INFANTILE SPASTIC PARALYSIS, OR CEREBRAL PARALYSIS OF CHILDHOOD

VARIETIES — ETIOLOGY — PATHOLOGY — MORBID ANATOMY — SYMPTOMS — TREATMENT OF UPPER AND LOWER EXTREMITIES: MECHANICAL, OPERATIVE, AND EDUCATIONAL

DURING the past few years our hospital wards have supplied us with many instances of this disease, and the subject is one of great interest to us, mainly owing to the fact that, so far as serious treatment is concerned, the field has been practically untouched. There is something so uninviting and hopeless-looking about a severe case, that a man must possess, in addition to a theory of attack, no small fund of enthusiasm before he decides on treatment.

In 1853 the late Dr. Little drew attention to this group of nerve disorders, and the affection has received the name of "Little's Disease." But later work has shown that there are various clinical types of the affection. In that which is called cerebral diplegia it is found that, while rigidity and paralysis are associated, the rigidity is the more striking feature; while in the hemiplegic form paralysis preponderates, and rigidity is secondary to it. Again, in the hemiplegic form the arm is more affected than the leg, but this is not so with the diplegic forms.

Certain typical varieties of the disease are also seen. Thus bilateral spastic hemiplegia is met with, and it is difficult to distinguish these cases from the severe forms of cerebral diplegia, in which there is much general rigidity. It is said that in the bilateral spastic hemiplegic form convulsions are more common, and the disease is generally due to congenital affections. Pathologically, however, there is a clear distinction. In the bilateral spastic form the lesions in the cerebral hemisphere are deeply situated, while in the cerebral diplegic form superficial lesions are found. A rarer variety is that known by the name of congenital chorea, bilateral athetosis, and choreic diplegia. The athetotic movements are frequently seen in the face and tongue; and in severe cases the muscles of the trunk and limbs are involved also. In this variety convulsions are not well marked, and the mental condition of the patient is good.

For the purposes of description, the cases may be grouped into those of (1) Infantile Hemiplegia, (2) Cerebral Diplegia, and (3) Spastic Paralysis. Of 839 cases, which have been collected from various sources, where the character of the deformity is stated, 510 were hemiplegic, 30 monoplegic, 142 paraplegic, 157 diplegic. This disproportion between the hemiplegic and other groups does not accord with our experience. We have seen more of the diplegic type.

With this preliminary notice of the affection and its clinical varieties, we proceed to give a description of cerebral paralysis of childhood in general, bearing in mind, however, that many variations from the main types will be met with from time to time. In the first place we propose to discuss the etiological questions; and numerous causes have been mentioned. The late Dr. Little ascribed his cases to premature and difficult birth, and to asphyxia neonatorum. If a large number of cases are collected, it will be found that in about two-thirds of them some definite condition either in the mother or in the child can be traced. On the maternal side the following diseases have been found to be associated:—Syphilis, general specific fevers, eclampsia, convulsions, injury, repeated pregnancies; and there can be no doubt that infantile spastic paralysis more often affects the younger children of a large family than the elder ones. In our experience the affection is rarely met with in the elder children. On the fœtal side the most common prevailing conditions are—premature birth, injuries to the head produced by forceps and by prolonged and by precipitate labour, leading to laceration of the vessels of the brain. In some cases the affection has been distinctly hereditary, and consanguinity of the parents has been noticed.

Several pathological causes supervening after birth have been traced as antedating the affection. Such are — acute infectious disorders, associated with rapid wasting, epilepsy and acute encephalitis. But it is open to doubt if these affections are the sole factors at work, and there is good reason to believe that they are only precipitating causes, acting upon an abnormal congenital condition of the cerebral centres. We have not all the space we require to enlarge upon definite examples, but certain facts may be noted. Thus, evidence of meningeal hæmorrhages has been found in cases where there has been injury to the fœtal head *in utero*. It is also interesting to note how often premature birth is associated with cases of infantile spastic paralysis, and more particularly in connection with the paraplegic form. It is well known that the crossed pyramidal tract, at the seventh month of fœtal life, has only reached the medulla, and if an arrest of development of the pyramidal tract occurs in a child born prematurely at the seventh month, then general rigidity should follow. At the eighth month the tract has pushed its way down the spinal cord as far as the dorsal region, and if an arrest of its development occur at that stage, then paraplegic rigidity of the lower extremities should ensue. Fascinating as this hypothesis of non-descent of the pyramidal tract may be, yet, unfortunately, the affection in question occurs not alone in prematurely born children; and often it comes on, not in the first year of life, but in the second or third; and, therefore, it may be surmised that premature birth is not the cause of the spastic condition, but that the same morbid process which gives rise to the nerve affection is also the cause of premature birth. With regard to difficult and prolonged labours, there can be no doubt that they are important factors in producing meningeal hæmorrhage and rupture of the surface veins, and the same may be said of asphyxia neonatorum. It is not necessary for us to discuss the various post-natal factors, but cases have been described in which the affection of the limbs immediately followed acute specific disorders.

From our point of view—that of surgical treatment—it is clearly essential that a complete recognition of the symptoms should be made; and from a therapeutic point of view we would insist that attention should be paid to the extent of the affection, the amount of rigidity, the presence or absence of convulsions, and the mental condition; for we take it that no surgeon would deem it advisable to operate upon a hopeless idiot, nor would he wish to bring discredit upon surgery by attempting to improve, with the aid of the knife, cases of general rigidity. When convulsions occur only from time to time, an improvement may be obtained by surgery, and lessening of the number of convulsions with better general health follows.

We must, therefore, recognise that there is a very wide divergence in the degrees of the affection, and we shall endeavour later to indicate more specifically the particular class, or classes, of cases we believe to be susceptible of surgical treatment, some being diplegic and some hemiplegic, and some examples of Little's disease or spastic paralysis. From general rigidity of some, or all, of the limbs, with hopeless loss of useful motion, to a slight contraction of the calf muscles, all grades are seen; but in the less severe cases there is always a distinct natural tendency to improvement, more especially in the paraplegic variety affecting the lower extremities. And our contention is that this natural tendency should be taken advantage of, and aided by all possible means; for we have found that the improvement which occurs has been, in properly selected cases, much greater than we could have possibly hoped for; and an apparently hopeless condition has been changed into one of moderate usefulness in life.

Symptoms.—The cardinal symptoms of the affection are: Muscular rigidity, which becomes more marked if the limb be moved either passively or by the child, and disappears under an anæsthetic; paresis, ill-directed and perverse movements, contractures, increase of the deep reflexes, mental deficiency and inequality of growth of the limbs.

In the severest cases of all, often the cerebrally diplegic, which are frequently fatal, the rigidity is of such a degree that the patient lies in bed like a log; or in other cases it is impossible for the patient to sit down, because he is unable to flex the thighs and legs; in yet others the movements of the hands and arms are good, or one arm alone may be affected, while the patient can walk only with difficulty, on account of the abnormal condition of one or both lower extremities. The mode of walking is quite typical. He progresses on his toes, with the heels somewhat raised, the knees flexed and pressed together, the thighs rotated inwards, and the body thrown forwards. An exaggerated degree of this style of progression is known as the "scissor walk." The amount of power retained in the affected limbs is, however, astonishing, and it is often out of all proportion to the rigidity.

The upper extremity, when affected, usually assumes the following attitude:—It is flexed at the elbow, the forearm is fixedly pronated, the wrist is fully flexed, the thumb is adducted and contracted into the palm, and the fingers are also fully flexed; the limb is wasted, shorter than its fellow, and sometimes colder. The movements are slight and clumsy, and athetosis may be present. In less degrees of the disease, one limb only may be affected, or even one segment of it. Thus, for instance, talipes equinus of a moderate degree may exist, or the patient may be unable to completely dorsiflex his foot, owing to contracture of the calf muscles. This last-named condition constitutes what is known as right-angled contraction of the tendo Achillis.

It is extremely important, from the point of view of treatment, to note the mental condition of the patient. Excluding those who may be called idiotic, we have in our practice found the following conditions, and we may put them under the following headings:—The Placid Type and the Irritable Type; and both these types are often associated with an extremely good memory for abstract matters, such as figures and dates.

The Placid Type is a child of a very happy disposition, not easily ruffled, frequently smiling, and not subject to gusts of temper; whereas the Irritable Type is an example of perpetual motion. Not only will the mother tell you that he has an unbearable temper, and throws himself upon the ground in storms of passion, but also that he is so mischievous that nothing is safe from him. Some of these children are mentally perverted and show a tendency to cruelties of various kinds and incendiarism. It is, however, worthy of remark that we have found that when the physical disabilities are relieved, the unnatural disposition of these mischievous children improves and alters remarkably. Speech is frequently delayed in these subjects, or complete aphasia exists. But in the milder degrees we have often found that they begin to articulate words at the fourth or fifth year, and then speech gradually improves. Much may be effected for them by careful training. In from 30 to 50 per cent of the cases strabismus of the convergent variety is present, and some difficulty of swallowing is noticeable. Convulsions are commonly associated with the severer forms of the disease, being present in rather more than half the cases, and their occurrence should be carefully noted, as we do not think it advisable to operate unless the convulsions have ceased for three or four years. The muscles themselves are frequently wasted and have a distinctly hard and resistent feeling. The reflexes are always exaggerated, but considerable difficulty is experienced in obtaining the deep ones, owing to the rigid condition of the limbs.

Of chief interest to the orthopædic surgeon are the following facts:—(*a*) the upper limb is more severely affected than the lower; (*b*) the lesion of the upper limb is more permanent; (*c*) the power of dorsiflexion of the hand and simultaneous extension of the fingers is lost; (*d*) the movements are performed without precision, spasmodically and slowly; (*e*) the power of abduction of the thumb is often lost. The disabilities of the lower limb are generally (*a*) Contraction of the knee; (*b*) Extension of the foot; (*c*) Internal rotation of the femur, with adduction; (*d*) Rigidity.

The cerebral diplegic group is by far the most serious, as we have to deal here with both arms and legs. Clinically we may divide this group into—(*a*) Cases with and without severe mental complication; (*b*) Complete and partial disability of the hands; (*c*) Complete and partial disability of the limbs; (*d*) Cases complicated with athetotic movements. When the spasm is confined to the legs the name of Little's disease has been used.

Such then is a brief description of the affection, and the next point of interest to us is its course.

Course of the disease.—In the very severe forms of cerebral diplegia the disease is either rapidly or slowly fatal, more especially if there be excessive general rigidity. If there be only paraplegic rigidity, or slight general rigidity, the condition is non-progressive, or it may tend to improve. The amount of unaided improvement is by no means great, and normal function is never acquired. We have observed more or less complete improvement in the upper limbs, with persistence of spastic rigidity in the lower extremities. No improvement can be looked for, if athetosis is well marked. From the point of view of duration of life, it may be said that cases afflicted with hemiplegia and paraplegia live longer than those in which three or four of the extremities are affected (cerebrally diplegic), and in fact few of the latter ever attain adult life.

Pathologically the conditions found in hemiplegia, paraplegia, and diplegia are of a like kind. The symptoms are due to retardation of growth of the limbs, resulting from embolism, thrombosis, intracerebral hæmorrhage and meningeal hæmorrhage, and secondary sclerotic changes occurring in the spinal cord. In the brain porencephalus or a cystic condition is found, and the cysts may be either on the surface or extend deeply into it. The cysts appear to be the result of extensive scarring in a growing brain. As to the localisation of the cerebral affection it may be said that the more scattered over the trunk and limbs the rigidities and paralyses are, the more probable is it that the surfaces of the hemispheres have been affected, while paraplegia or spastic hemiplegia is due to deep lesions of the hemispheres. Should the porencephalus or sclerosis be unilateral, hemiplegia results; and if the scar be bilateral, diplegia or spastic paralysis follows. Sachs and Petersen have analysed seventy-three autopsies, and found the following conditions:—Atrophy, sclerosis and cysts, 40; Hæmorrhage, 20; Embolism, 7; Thrombosis, 5; Tubercle, 1. Osler, in an examination of ninety brains, found a vascular lesion in sixteen, seven being due to hæmorrhage and nine to embolism.

Treatment.—We desire, after this review of the affection in its various grades, to dwell with emphasis upon the fact that a very fair proportion of these cases are capable of much improvement by operation, by mechanism, and by careful training. The treatment of spastic paralysis has been too long in the province of medicine for much real progress to be made. Indeed, from medicine in this affection we have nothing to expect except indirect results, and we have only to read the textbooks on "Neurology" to realise the note of pessimism which is sounded. Sir William Gowers, in his second edition of *Diseases of the Nervous System*, says: "The tendo Achillis is sometimes divided for contraction of the calf muscles in infantile spastic paralysis, but the operation is useless and ought never to be performed." In his recent third edition, however, he revokes this expression of opinion, and assents to a tenotomy of the tendo Achillis in these cases, but no further suggestions are made as to treatment. The same opinion as that held by Sir William Gowers has been pronounced by other distinguished men, so that one can see how surgery has been silenced in the matter. We would argue, from conviction and from practical experience, that a large proportion of children suffering from severe spastic paralysis may be transformed into useful members of the community, improved both in body and mind by surgical efforts, and enabled to walk with comparatively little deformity, generally requiring merely the aid to be derived from one or two sticks.

We are fully aware that surgical interference has been deprecated by physicians, but we feel that the results we have been able to obtain have been such as to afford us the strongest encouragement to proceed with remedial measures. It is not wise to leave the improvement to nature alone, but to give every assistance in our power to the restoration of the limbs to their proper position and function.

Before proceeding to details, we wish firstly to indicate which classes of cases are susceptible of improvement, and which are not; and then we shall speak of the principle which is involved in operation.

The Classes of Cases which are and are not adapted to Treatment.—A suitable subject for treatment is a child or young adult of fair intellectual development who has had no fits for the last three or four years. Such an one may be brought to us in the following condition:—He is unable to walk with ease or comfort owing to the distortion of the legs. The feet are found to be in a condition of talipes equinus or equino-varus; the knees are flexed, owing to the tightly contracted hamstrings, and they knock together on account of the adduction of the thighs. The thighs are flexed and inverted, and the tensor vaginæ femoris and sartorius and ilio-tibial bands are rigidly contracted. And be it noted that in our opinion these contractures are not primary matters, but secondary, and arising from the position assumed by the limbs, on account of the natural over-power of the flexors. Such contractures are, therefore, capable of removal.

The classes of cases which are entirely unsuitable for treatment are the idiotic, the microcephalic and the violently irritable type of diplegic subject to fits, active athetotic movements and convulsions, who has no control over his excretions. Another class of case which gives much anxiety and trouble is that where the affection of the hands is of such a kind as to promise but slight hope of their assistance to the limbs during walking; that is to say, if the paralysis is complete, or spasm of the hand and arm never relaxes, treatment in our experience is of little avail. If the fingers of the affected hand are only moved in conjunction with the fingers of the opposite side the results will in all probability be discouraging. If, however, it can be ascertained that the patient is able to do more with the hand now than a little while ago, the success of the treatment is probable. Similarly, where any degree of voluntary relaxation exists, apart from an associated movement on the opposite side, treatment is the more urgently called for. It is important to recognise the length of treatment required. Active treatment may be required for two years, and it is therefore unwise to undertake a case in the hospital for two months, and then send it to a miserable home where neglect will be the inevitable sequence. We must secure the co-operation of intelligent parents, anxious to do all they can for their child, and willing to face all the trouble involved in careful training.

The *principles* upon which we operate are these:—It is quite certain that a paretic muscle, constantly overstretched, and therefore in constant action, will never tend by itself to spontaneous recovery, but rather to continued weakness and degeneration. To take a simple example. If the calf muscles are contracted, and the foot is therefore dropped, the extensors on the anterior aspect of the leg undergo continuous and progressive degeneration. Now if an overstretched and partially paralysed muscle be placed in a state of rest it rapidly recovers.

In this case, by dividing the tendo Achillis and bringing the foot to the right angle, the extensors on the anterior aspect of the leg are no longer overstretched, but are placed in a state of rest, and therefore of recovery; that is to say, breathing time is given to the affected muscles to pull themselves together.

There is also a further principle involved. We take it that, as excessive deep reflexes are characteristic of this disease, the important point is, if possible, to limit this excitement; and it may be conceded that the tension of a tendon is, reflexly through the spinal cord, directly responsible for the tension of its muscle; that is to say, there are nerve endings in the tendons which, when excited, send stimuli to the spinal cord, and these are reflected to the muscles. Now, if the tendon of such a highly contracted muscle is divided, the stimulus abates, the vicious reflex circle is broken, and the muscle ceases to be the seat of tonic contraction; so that by division of the tendo Achillis in such a case we have effected the following results:—We have relieved the pointed condition of the foot, and the constant pull on the paretic extensors, and have therefore given them rest and time for recovery. Suitable measures and appropriate exercises will subsequently hasten this recovery in a manner which would have been totally impossible if the tension had not been taken off the muscles. Again, by division of the tendo Achillis, the reflex excitability of the calf muscles has been largely abolished; and not only so, but we believe that the removal of this excessive reflex excitability of the spinal cord permits of that quiescence of the nerve centres so essential to the welfare of these children. It may be argued that all this is hypothetical, and that the good results are merely mechanical, and entirely due to the lengthening of the tendo Achillis obtained in this manner. Whether it be so or not we are not prepared to discuss in its entirety, but we have indisputable evidence of improvement in the limb and the general bodily and mental progress of the patient. Lorenz attributes the good effect of tenotomy to the shortening of the bellies of the tenotomised muscles, so that their range of action is diminished.

However, the practical deduction from these observations is that no opportunity should be lost of performing a tenotomy when a spastic tendon is to be felt.

Treatment.—The *treatment* of infantile spastic paralysis practically falls into two divisions—the operative and the post-operative; the post-operative being mechanical and persistent training of the patient to utilise to the best advantage his limbs, when the deformities have been rectified and the contractures removed. It is well to speak first of the upper extremities, and then of the lower extremities.

Treatment of the Upper Extremities.—When the condition is one of infantile hemiplegia the arm is more affected than the leg. In cerebral diplegia, when the four limbs are attacked, spasm is more marked than in hemiplegia. As a rule the treatment of the hand and arm in infantile hemiplegia is not so promising as in a diplegic case; but the clinical signs, the presence of unrelaxing spasm, or the existence of voluntary relaxation of the spasm, or of voluntary movement, which we havé enumerated on pp. 213, 214, will furnish us with conditions which will prognose success or failure. The most pronounced deformities of the hand and arm in these cases are pronation and flexion of the wrist; so that treatment should consist in rendering the forearm supine and hyperextending the wrist. For this purpose gradual extension of the wrist may be brought about by the use of a malleable iron splint, in which the angle is increased from time to time, but very gradually (Fig. 4). The most difficult part of the treatment is to secure supination; but if the forearm be merely semi-pronated, it may be deemed advisable to disregard this portion of the deformity and devote one's attention entirely to the hands. It is not easy to give a reason for the improvement which ensues; but it may be taken as an axiom that prolonged fixation of spastic muscles in a position opposed to their contraction gradually lessens the severity of the spasm. It would appear as if the muscles at last became tired of trying to pull. If the case be a mild one, the treatment should extend over twelve months, and the extension of the wrist should be kept up without intermission. The test for relaxation must be the return of the power of voluntary movement, however slow it may be. It will be noted that generally, at this stage, the patient, in endeavouring to extend his wrist, will first of all close his fingers, and will only open them on completion of extension. The process is reversed when the wrist is flexed. In order to meet this difficulty, the splint employed to extend both wrist and fingers is modified so as to extend the wrist alone, and to allow freedom to the fingers.

If, in a given case, success is doubtful by this method, or if the progress of the case be unduly slow, we most strongly advocate operation on the forearm and hand; and such operation will consist in tenotomy, tendon transplantation, and lengthening of tendons. We are responsible for the introduction of two forms of operation to meet the spasmodic and deformed condition of the hand and forearm. One of us (A. H. T.) devised an operation for transforming the excessive action of the pronator radii teres into a supinating power, and the other (R. J.) devised a method of reducing the carpal flexion, and converting the carpal flexors into carpal extensors. These operations, combined if necessary with section or elongation of the flexors of the fingers, give admirable results, and pave the way for diminution of the angle of flexion at the elbow, lessening of the pronator spasm, increase of the supinating power, reduction of the carpal flexion, and addition to the extensor power at the wrist. In the typical position, which the hand and forearm assume, it will be noted that it is the muscles which arise from the internal epicondyle which are involved, and these muscles are both pronators and flexors. It therefore follows that any operation designed to lessen the pronator spasm will necessarily diminish the flexor spasm, both at elbow and wrist, and this can be effected by the operations which we have designed.

The Operation of Converting the Pronator Radii Teres into a Supinator.—This operation [1] is carried out as follows :—The position

[1] *Brit. Med. Jour.*, Sept. 7, 1901.

of the pronator radii teres should be identified, and this is an important point, because it is by

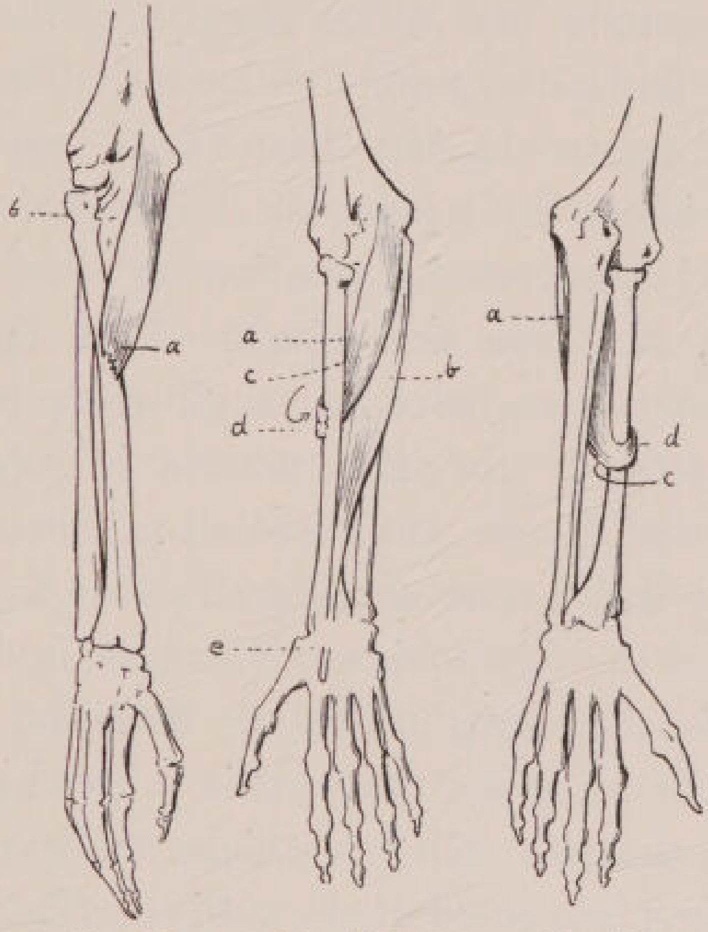


Fig. 76. Fig. 77. Fig. 78.

To illustrate the method of transforming the pronator radii teres into a supinator.

a = pronator radii teres, in Fig. 76 passing in its natural course to its insertion on the radius.

In Fig. 77 the tendon has been detached and has been passed *behind* the radius to its outer side.

c is the opening in the interosseous membrane through which the tendon is passed, and it is reinserted at *d*.

At *e* the flexor carpi radialis has been divided.

Fig. 78 is a posterior view of Fig. 77, but in Fig. 78 the pronator radii teres is drawn too low down on the radius.

no means constant, and is situated at a varying position in the length of the forearm. It can be readily recognised on attempting to forcibly supinate the forearm, when the muscular belly stands out quite clearly, just as it passes under the supinator longus. The hand and forearm having been duly prepared, an incision, $2\frac{1}{2}$ inches to 3 inches long, is made just over the position of the radial artery, and near the middle of the forearm. The inner margin of the supinator longus is then defined, and this muscle is separated from the flexor carpi radialis. The radial vessels and nerve are identified and drawn well to the inner side. The pronator radii teres is then sought for, the direction of its fibres affording a guide. It is a broad muscle with a short flat tendon, which rapidly merges into the periosteum of the radius. The upper and lower borders of the muscle are well cleared, and the tendon, with a goodly piece of periosteum, is detached from the radius, and a stout silk suture passed through it. The next point is to make a way for it through the interosseous membrane, and on the inner side of the radius. This is effected by passing an aneurism needle quite close to the radius through the membrane and around the bone.

By rather vigorously working the aneurism needle in a vertical direction a space of an inch or of an inch and a half is cleared for the tendon to be brought round to the back of the bone. By threading one end of the silk in the pronator tendon on to the aneurism needle, the tendon can be more easily drawn through to the outer side and back of the radius, and the aneurism needle is then dispensed with. The next step is to refix the tendon on the outer side of the radius. This is accomplished in the following way :—A hole is drilled through the radius from front to back; one end of the silk ligature which has been passed through the tendon is threaded on a straight needle, and the needle and silk passed from before backwards through the hole in the radius and through the tendon lying at the back of it, care being taken that the pronator muscle is pulled on vigorously. The ends of the silk ligature are then knotted, and the tendon is bound down in its new position. Attempts should be made to reinsert the tendon on the spot from which it was detached, but if, on account of its shortness, this be not possible, a rough surface, previously made on the bone at the site of the new insertion, assists fixation. When the tendon is re-inserted, the forearm is in a position of

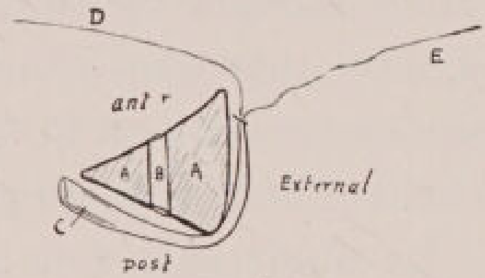
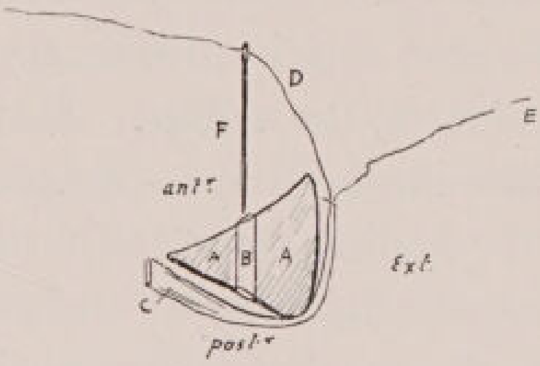


Fig. 79.



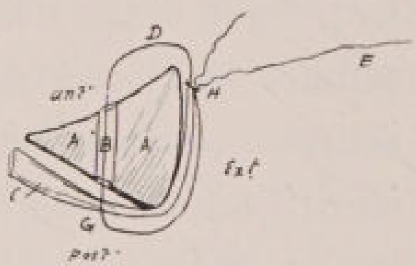


Fig. 80. Fig. 81.

Figs. 79, 80, and 81 show the method of reinserting the tendon of the pronator radii teres to the outer side of the radius after it has been detached and passed through the interosseous membrane.

A A, Section of radius; *B*, hole drilled through radius from before backwards; *C*, tendon of pronator radii teres; *D* and *E*, ends of silk attached to tendon.

In Fig. 80 a needle *F* is seen threaded on one end of the silk, and the needle is in position to be passed through the hole *B* in the radius, and therefore through the tendon *C*.

In Fig. 81 the thread *D* has been passed through the radius and the tendon *C* at *G*, and is knotted at *H*.

supination. (The method of re-insertion of the tendon will be best understood by reference to the accompanying figures, 79-81.)

In the earlier operations we were content to divide the flexor carpi radialis, but the transplantation of the flexor carpi radialis and flexor carpi ulnaris to the back of the wrist is a distinct advance. This operation is done as follows:—An incision is made over the tendon of the flexor carpi ulnaris just above the annular ligament, and another is made over the flexor carpi radialis. Both tendons are divided low down, and taken—(*a*) the flexor carpi ulnaris to be inserted into the extensor ulnaris, and (*b*) the radial flexor into the radial extensor.

The improvement effected by these operations is most marked, and we append notes of some of our cases.

CASE 50. *Spastic Paralysis; Operation on Right Arm; Transformation of Pronator Radii Teres into a Supinator, and Section of Flexor Carpi Radialis.*—J. R., aged four years, was brought to us in 1899, being the subject of infantile hemiplegia on the right side. His birth was a difficult one, and he had to be revived by artificial respiration. We operated upon the forearm, transplanting the tendon of the pronator radii teres and making it act as a supinator, and dividing all the flexor tendons at the wrist by a transverse incision. The hand and forearm were placed in the flexed and pronated position for three weeks, and then were gradually brought into the desired position, so that at the end of six weeks the result promised well. Then followed a period of massage and education of the limb, and at the end of one year he was able to use the hand well for feeding himself, and he could pick up and grasp small objects.

CASE 51. *Infantile Hemiplegia, Right Side; Transformation of Pronator Radii Teres into a Supinator; Section of Flexors of the Wrist.*—William M., aged nineteen, a feebly-developed adolescent with defective speech, but of fair brain-power, was brought to one of us in 1899.

The right upper extremity was in the usual position of flexion of elbow, wrist and fingers, and marked pronation, seen in these cases. The hand was also adducted by the spasmodic contraction of the flexor carpi ulnaris. He was able, however, to use the limb for a few purposes. He had been massaged for several years without any improvement.

The flexor carpi ulnaris was first divided, and the adduction of the hand overcome. Three months later the pronator radii teres tendon was taken round the back of the radius, and implanted on its outer side. The flexor tendons were divided at the wrist, and the forearm was put up in the supinated position, but with the wrist flexed, so as not to entail stretching the band of union between the divided flexor tendons.

The result, so far as the movement of the hand and fingers were concerned, was distinctly good, but the supination power was slow in returning. He can use the hand in playing golf and for many useful purposes.

CASE 52. *Spastic Paralysis treated by Tendon-grafting.*—Thomas Pettit, aged seven years, was admitted to hospital under our care on May 25, 1901, suffering from spastic paralysis of the left arm and leg. The forearm and hand were in the typical position of these cases, and the foot was in a position of equinus. On June 1 the patient was anæsthetised, and an incision was made on the front of the left forearm about 3 inches long, and just inside the anterior edge of the radius. The radial vessels and nerves were exposed and hooked aside, and the insertion of the pronator radii teres carefully defined. Its tendon was separated from the bone. The interosseous membrane was then pierced and the tendon drawn through it. With a drill the radius was pierced, and the tendon, having been drawn round the back of the radius, was fixed in its new position by a ligature passing through a hole in the radius. The flexor carpi radialis tendon was also divided, and the wound closed. The boy had regained (January 1902) very fair power of supination, whereas before the operation he had none whatever. In October 1902 he had acquired complete power of supination.

CASE 53. *Transformation of Pronator Radii Teres from a Pronator to a Supinator.*—Leonard C., aged six years, came under our observation on May 5, 1902.

The history was that he had dragged the right leg, and the right upper extremity had been weak, since he attempted to walk. He also has a brother afflicted with paralysis.

The right lower limb was found to be weak, but not much wasted. The foot was held in the equinus position, and the tendo Achillis and plantar fascia were tense. The right upper limb was weak, the elbow slightly flexed, likewise the wrist, and the forearm pronated with the fingers contracted. The limb could be straightened by passive movements, the spasm being easily overcome.

On May 14 Mr. Muirhead Little, in our absence, performed the operation of transforming the pronator radii teres into a supinator. He also divided the flexor carpi radialis. The tendo Achillis and plantar fascia on the right side were subsequently divided, and the child left the hospital in a much improved condition. He could voluntarily pronate and supinate the forearm, and the flexion of the wrist had disappeared.

CASE 54. *Spastic Paralysis; Operation on Left Arm; Transformation of Pronator Radii Teres into a Supinator, and Section of Flexor Carpi Radialis.*—Maurice B., aged seven, was sent to one of us by Dr. Ker of Balham.

This child was the subject of infantile hemiplegia, and the left arm and left leg were affected. His mental condition was fair, but speech was very defective.

The operation was practised on the pronator radii teres, and the tendo Achillis on the left side divided. So far as the arm was concerned he regained about half of the normal supinating power, and he is able to use a fork and spoon and to button his clothes. His mental condition and speech have improved very much since the operation.

In most cases in which transformation of the pronator radii teres and transplantation of the carpal flexors were effected in spastic children voluntary movements were steadily performed, and one of the patients, a girl of seven, was able to write quite a respectable hand. It is often necessary to divide or lengthen the flexor tendons of the wrist in addition to the above measures, when section of the flexor tendons alone may not be of much avail. The operation of muscle-grafting, especially on the tendons of the wrist, offers a very large number of possibilities for the treatment of these cases, but it has necessarily to be very prolonged when so many tendons have to be grafted and lengthened, and there is considerable risk of matting of the tendons when several of them must be sutured, and the amount of suture material employed is great.

The next stage in treatment consists in educating and training the limb in its new position, after time has been allowed for healing of the parts, which takes from ten to fourteen days. The movements should at first be gradual, so as not to disturb the tendons unduly, but after the sixth week movements are more vigorously practised. In the case of a hemiplegic child we are accustomed to tie up the sound limb, and so to induce the child to use the affected one as much as possible; and it is extremely interesting to observe the gradual education of the member. Whether

the tensor vaginæ femoris and sartorius and ilio-tibial band just below the anterior superior spine will require attention. At the same time contraction at the back of the knees and contraction of the tendo Achillis may be dealt with. If there be any reason to suspect that a series of operations such as we have mentioned will, if performed upon the child at one sitting, prove too much for him, then there is no objection to the case being taken in stages, beginning with the hips, and subsequently attending to the knees and feet. In either event we strongly recommend open operation. The adductors are first dealt with. The skin of the groin and neighbouring parts having been suitably prepared, an incision $1\frac{1}{2}$ inches long is made on the inside of the adductor longus tendon, and just below the fold of the groin.

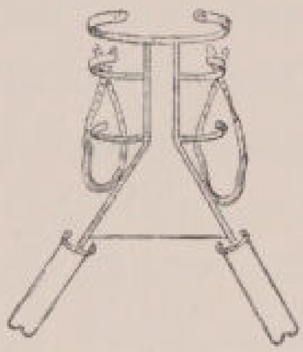


Fig. 83.

Double abduction frame with extension arrangement for the legs.

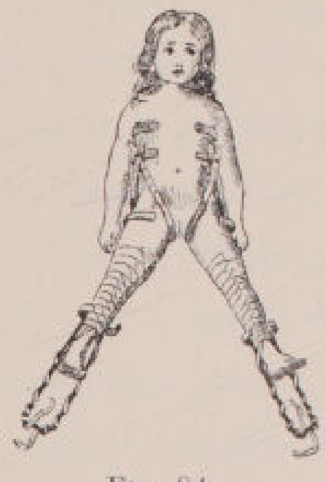


Fig. 84.

The same applied.

This tendon is then freed by passing a finger round it, and three-quarters of an inch of it is exsected. The limb is then abducted, and portions of the adductor brevis and gracilis are exsected in a similar way. If required, the horizontal portion of the adductor magnus and the pectineus are divided; in fact any and every tissue which limits free abduction. There is but little hæmorrhage, and the wounds should always be closed without drainage and covered with collodion and gauze so as to render them waterproof. It is astonishing how seldom suppuration occurs. We can only record four cases. The great advantages of this open method of removing the adductors are obvious, effecting at one stroke what may take months to accomplish by subcutaneous division and stretching, and then only with a probability of recurrence of the adductor spasm.

The sartorius and the tensor vaginæ femoris and the ilio-tibial band are attacked in the same way, by the open method. The knee is then dealt with, and incisions should in every case be longitudinal over the tendons, and not transverse. As a rule one incision on the outer and one on the inner side suffices.

By burrowing underneath the subcutaneous tissue and retracting the skin the various bands of fascia can be reached and divided. The hamstrings are then divided, and a portion exsected if need be. One of us (R. J.) practised exsection of the hamstrings in 1885. We mention the fact because Lorenz of Vienna has quite recently written on the advantages of exsecting portions of the hamstrings. The tendo Achillis is then elongated by the L-method, and the patient is stretched comfortably upon the abduction frame, or a simpler arrangement of calliper splints (Fig. 85), with the lower extremities fully abducted, the knees straight, and the feet at right angles.

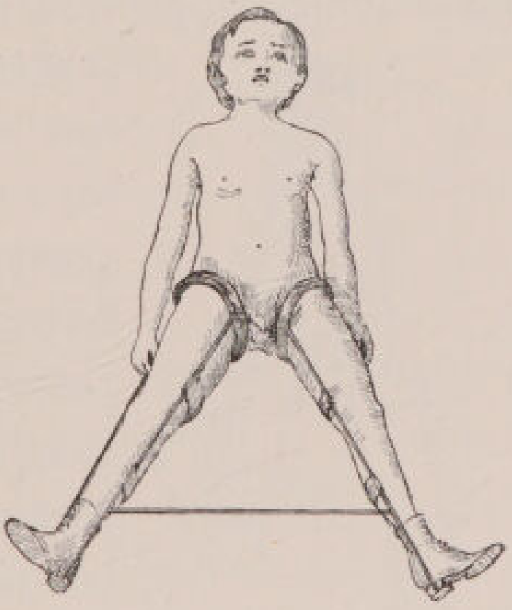


FIG. 85.

Apparatus designed to maintain the abduction after operation. It consists of two Thomas' knee calliper splints, with a cross-bar.

At the end of three months the splint is taken off during the day, and movements are sedulously practised. At first these are painful; but if both passive and active movements are carried out vigorously the pain disappears, and the patient will make efforts to walk. But walking must only be carried out under the proper guidance of a trained nurse or of an intelligent parent, and it behoves the surgeon to impart instruction as to the character of the exercises, and maintain general supervision of this latter stage of treatment. He will order splints of a simple kind designed to prevent the knees from bending (Fig. 86). The boots should be made of felt with substantial soles, and the nurse should be instructed to keep both boots and splints upon the patient day and night; and for the first two weeks, frequently during the day, adduction, flexion, and extension of the hips must be carried out. This should be done with and without resistance. At night-time the feet should be attached to the sides of the bed in order to maintain abduction (Fig. 87). After the first

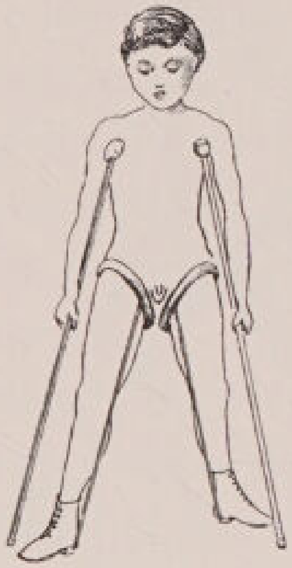


Fig. 86.

Calliper splints fitted for walking after operation for spastic paraplegia.

few days of this latter stage of treatment the splints should be removed twice a day, the muscles well massaged, and both active and passive movements of ankles, toes, knees, and hips encouraged. Walking may now be taught; in fact it is most necessary to teach patients to walk properly; and the operation, by overcoming entirely the adduction of the thighs, has given the child a wider basis of support for the trunk. The special points of direction which must be given to the nurse as to walking are, that swinging of the lower limbs must be prohibited, and therefore crutches should not be allowed until the patient has been taught to stand unsupported, and during the early stages of walking the nurse must see that the limbs are not approximated. Every step must be deliberately perfected, the feet being maintained a proper distance apart, and the toe and heel coming in contact alternately with the ground.

Fig. 87.

Scheme for maintaining the abduction of the limbs at night after operation for spastic paraplegia.

As to the *prognosis*, the patient and his parents and guardians should know that if the case is deemed suitable for treatment by the surgeon, and if they give their consent to operation, the surgeon can only enter upon the treatment with the clear understanding that he shall have the opportunity of supervising the after treatment, the parents undertaking to give every facility and to take a careful and thorough interest therein. If such an understanding be arrived at, we are able to say that a child, aided by hands or sticks, will be able to walk distances in from twelve to twenty-four months, and this with perfectly straight limbs, and toes and heels on the ground. Later on many cases will manage to walk with one stick only, and others will dispense with all kinds of artificial aids.

Apart from the improvement in the physical condition we have to chronicle this important point. With the change for the better in the physical condition the mental condition improves in greater degree. The probable reasons for this are twofold. In the first place, improved range of movement in the limbs and improved powers of locomotion mean closer contact with persons and things, and hence the mental outlook is widened; and in the second place, the cessation of perpetual irritation owing to contracture and spasm, from the periphery to the central nervous system, leaves the latter less occupied, less perturbed, and therefore more receptive to outside impressions.

We strongly advocate that the treatment of spastic paralysis should be rigorously systematised, and any treatment must involve at least three stages—operative, mechanical, and educational. It is impossible to separate the treatment into parts, and if the surgeon is not satisfied that the case is to be fully under his control for at least twelve months, he will consult his interests best by leaving it alone. His work does not cease with the operation, but he becomes in reality the patient's physician for both mind and body. The three months' time limit at general hospitals must materially blight the prospects of paralytic subjects. They are neglected at home, and wander from one institution to another—often the victims of conflicting theory and diverse practice. Successful hospital management of infantile spastic paralysis is not complete without an organised system of education carried out by specially trained nurses, and the system must be of the visual and practical, as opposed to the abstract type. In fact we hope the time will come when scholastic institutes for the care of paralytic children of all classes will be instituted, and so fill a most undesirable gap.

If the contractures and spasms are pronounced, as is usually the case when the surgeon is consulted, nothing short of a bold operative procedure will suffice; but we do meet with a limited number of cases running a mild career, where no operation save the division of the Achillis tendon is needed. In these cases, however, the adductor muscles must for a period of several weeks undergo uninterrupted extension. This is effected by placing the patient with both limbs fully abducted in a splint figured on p. 235. This splint is generally needed for three months, during which time the recumbent position is assumed; nor must this position be changed until, by practising appropriate exercises with assiduity, the patient is able without spasm to put his hip-joint through its normal movements. When these are complete the patient must not

assisted by friends, but is quite incapable of any movement which may be liberally interpreted as a walk. If the mental deficiency be but slight, if convulsions are absent, and if the hands are under fair control, one can safely predict an improvement sufficient to delight the parents and encourage the surgeon. In such a case it is desirable to operate upon the ankles, knees, and hips at the same time. We begin by making an incision over the tendon of the adductor longus just below the pubis, then passing a finger round it, clearing a way above and below, and remove an inch of the muscle. Similarly each adductor muscle should be attacked, and every obstacle to a free adduction overcome. The sartorius and ilio-tibial tendons are, if necessary, divided at the same sitting.

The hamstring muscles are then attacked, and we would strongly deprecate subcutaneous tenotomy for this purpose, as we have on some occasions come across disastrous results, owing to the wounding or severance of nerve trunks. We therefore divide the tendons and contracted bands of fascia in the popliteal space by means of an open incision of sufficient length, and the direction of this incision is a matter of importance. The incision should in all cases be longitudinal, and not transverse. Sufficient space is at once afforded for the required purpose, and no painful transverse scar on the skin is left. The division of tendons and fasciæ should be quite free, and if the ends do not retract freely, it will be desirable to remove half an inch of the tendon. At the same time the tendo Achillis can be severed as well, if there is no contraction in the sole of the foot; but, should the latter exist, it will be preferable to cure this before dividing the tendo Achillis, as the latter serves as a fixation point upon which to unfold the contracted foot. Finally, the tendo Achillis is divided, and the limbs are then in their normal position of rest.

The wounds having been stitched and dressed, the patient is placed upon a splint so constructed that the limbs should be kept in marked abduction. The degree of abduction should correspond to the severity of the contractions; the more pronounced the spasm, the more the abduction. The limbs should be kept in this position for at least two months; in obstinate cases even four months will be required. As a preliminary to release from the splint, the bandages should be undone for certain hours during the day, and extension, flexion, abduction and adduction, douching and massage, sedulously practised. When the patient is able to move his limbs in slow, steady fashion, splints are applied to enable him to walk, care being taken to keep the knees stiff. Prolonged tuition in the art of walking materially aids in perfecting the result.

It now remains to discuss the question of *after treatment*, as the patient will often show a strong habit and inclination to revert to the old vicious manner of walking. We therefore employ an apparatus, consisting of a pelvic band, with a simple joint opposite the hip, ring-catches at the knee-joints, which fixes them, and flexion-movements at the ankle.

If there should be any signs of return to the contraction of the knees, it is advisable to lock the ring-catch joint, and allow the patient to get about, with a temporarily fixed knee-joint. Or the pelvic band can be dispensed with and splints applied which reach no higher than the thighs. They should be worn at night time as well as by day, the legs being held abducted and secured to the sides of the bed. In the large majority of cases it is advisable to keep the legs well extended for some months, until all probability of contraction has ceased. In our experience, with these precautions, we have not found it necessary to operate a second time in any single case.

In conclusion, we would say that there is every inducement to treat suitable cases of spastic paralysis, infantile hemiplegia, and cerebral diplegia on a surgical basis, and not to leave them, as has so often been done, to the care of the masseuse, in the hope that "nature" will eventually do something towards their cure.

SECTION III

PARALYSIS AND DEFORMITIES ARISING FROM INJURIES AND DISEASES OF NERVES, AND SOME DEGENERATIONS OF THE SPINAL CORD

SECTION III

PARALYSIS FROM FRACTURES AND DISLOCATIONS —ISCHÆMIC PARALYSIS—PARALYSIS AND DEFORMITY FROM SECTION OF NERVES—MULTIPLE NEURITIS AND LEAD PALSY—LOCOMOTOR ATAXY—HEREDITARY ATAXY OR FRIEDREICH'S DISEASE—PROGRESSIVE MUSCULAR ATROPHY — PERONEAL PARALYSIS—SPINA BIFIDA—SYRINGOMYELIA—COMPRESSION PARAPLEGIA

Paralysis following Dislocation and Fracture

(1) Dislocations of the shoulder are sometimes complicated by injuries to the brachial plexus. These injuries may be due to pressure and bruising of the displaced head of the humerus, the nerves being compressed by the head of the bone on one side, and the clavicle and ribs on the other. The damage done

largely depends on the degree of force expended by the dislocated head, and may merely bruise a single nerve trunk, or hopelessly rupture the entire plexus. The single nerve most frequently affected is the circumflex, and the variety of dislocation chiefly productive of injury to nerves is the subclavicular. The biceps muscle sometimes escapes when all the other muscles are paralysed. This may be due to the high origin of its nerve from the spinal cord.

Attempts at reduction are frequently accountable for brachial paralysis, and we would wish to enter a protest against the time-honoured heel in the axilla. Of 38 cases tabulated by us of paralyses and injuries to vessels following dislocated shoulder, 29 had been submitted to heel-traction, 5 had not been reduced, 2 were complicated with fracture of the neck of the scapula, and 2 were compound. Reduction of dislocation of the shoulder should *never* be attempted by placing the heel in the axilla.

The symptoms of injury to the plexus vary from paralysis of the deltoid to paralysis of the whole arm; from a painful tingling to complete anæsthesia. An arm apparently completely paralysed may wholly recover, and a paralysis, when due to neuritis, may pass from being partial to complete. If the paralysis has lasted months, the tissues of the hand and arm may appear normal, and at other times grave ischæmic changes may result; and the nails become curved, the skin mottled, the wrist and fingers rigid.

Dislocations of the elbow sometimes involve the ulnar nerve; the injury is nearly always recovered from, although there have been cases recorded where the rupture was complete. We have known two instances where after a dislocation of the hip the great sciatic was permanently paralysed. In both cases the displacement had lasted several days, and considerable traction force had been exercised during reduction. This accident has also occurred after reduction of congenital hip dislocation by Lorenz's forcible method.

(2) *Paralysis following Fracture.*—Paralysis may follow fracture, especially when considerable force has been expended. The most common examples are found in the upper extremities. The paralysis may come

on immediately after a fracture, or some time later. If it comes on immediately after a fracture, it may be temporary or permanent. If it be temporary, it is generally due to (*a*) pressure of a displaced fragment, (*b*) pressure on vessels, (*c*) hæmatoma, (*d*) tight bandaging. The most typical example of the pressure of displaced fragments is involvement of the musculo-spiral nerve in fracture of the humerus. For instance, a painter fell a depth of 20 feet and sustained an inter-condyloid and oblique fracture of humerus. Paralysis of the musculo-spiral was immediately noted. An incision was made over the upper end of the lower fragment, when the nerve was seen to be stretched by a projecting fragment. This was removed and the humerus wired, and in less than a week restoration of function was almost complete. Pressure on vessels may be noted in trans-epiphysial fractures of the lower end of the femur, and perfect apposition of the fractured ends is required to relieve the pressure. The projection of the lower end of the femur against the popliteal vessels and nerves necessitates very careful adjustment. If, aided by the

X-rays, the surgeon cannot sufficiently accurately adjust the fracture so as to relieve pressure on the vessels, he should cut down and wire. As an example of loss of power from a hæmatoma, we record a case of fracture of the internal condyle of the femur, where, when seen next day, the foot was swollen and paralysed, and a large collection was noted in the popliteal space. It was thought the popliteal vein was ruptured and an exploration was made. The effusion was arterial, and about a pound of blood-clot was removed. The popliteal artery and vein were not injured, the hæmorrhage being due to a branch-vessel. The patient made a good recovery.

Permanent disability will follow a rupture of a nerve, and sometimes the function of a nerve may be irretrievably lost by crushing or prolonged pressure. The paralyses which come on later may be illustrated by crutch palsy and by the involvement of a nerve in adhesions or in callus.

The treatment of the paralyses due to fracture and dislocation is based on the same principles as we have before discussed. The groups of muscles which have been affected must be kept free from tension, and in a position opposed to the deforming tendency. If the paralysis is complete and rupture of the nerve or plexus is suspected, primary suture must be attempted. If adhesions are suspected, and they sometimes involve the branches of the brachial plexus, they should be broken down and passive movements prescribed. Should pressure be due to malposition of fragments, a wiring operation may be called for. If a nerve is involved in callus it should be dissected out. The authors can relate a case where recovery took place, although the musculo-spiral had been pressed upon by callus for over four months, the restoration of power beginning four days after the operation. In this case the nerve had been thinned to half its calibre for three-quarters of an inch of its length.

Ischæmic Paralysis

Tight bandaging, generally accompanied by malposition and excessive callus-exudate, gives rise to a condition described by Volkmann as "ischæmic paralysis." It is most commonly noted in the forearm. The fingers are found contracted, the nails often degenerate, the hand and fingers blue, with very limited movement. Although this form of paralysis does not come on immediately, we can recall cases where complaints of numbness of the hand were said to have been present from the beginning.

The treatment requires special care. The majority of cases will yield to mechanical measures. On this point the authors speak from an experience of eighteen cases. The wrist should be primarily flexed to its utmost; this is essential. When the wrist is flexed each finger should be separately straightened. This cannot be effected if the wrist is midway between flexion and extension. When the fingers are straightened a palmar splint is applied, and by degrees wrist and hand are extended and then hyperextended. In this way the seriously contracted flexors are lengthened. In a pronounced case the wrist must be kept hyperextended for some months, aided by massage and heat. This mode of treatment has proved very successful. Some surgeons recommend lengthening the flexor tendons in obstinate cases, but in our opinion it is better to resect and remove portions of the radius and ulna and re-unite them by wiring.

Deformities arising from Section and Injuries of Nerves

Complete division of nerves is due to incised wounds, stabs, and gunshot wounds. Either partial or complete severance of an important nerve trunk has occurred as an accident at a surgical operation. The most usual example is that of section of the external popliteal nerve in dividing subcutaneously the biceps tendon behind the knee. In genu valgum the tendon is displaced outwards, and there is an appreciable interval between it and the nerve, so that subcutaneous tenotomy is moderately, but not entirely, free from risk. But in cases of contracted knee, the nerve lies quite close to the inner side of the tendon, and it may be easily severed. Three such cases have subsequently come under the authors' notice, and the greatest difficulty has been experienced in obtaining approximation of the divided ends by secondary suture, and the final results were not encouraging. At any rate these facts are strong arguments in support of open section of tendons in places where adjacent and important structures may be injured.

After a nerve is divided, if an immediate examination be made, the ends may be found (*a*) in close approximation. This is very rare, and is not met with in the case of large nerve trunks, for they are very elastic, and when intact are quite taut in certain positions of the limb; hence after section the ends are (*b*) separated from one to two inches, and are subsequently found embedded in fibrous tissue, that around the proximal end being the more abundant and constituting a traumatic neuro-fibroma; or (*c*) a portion of tissue, such as a piece of torn muscle or fascia or bony callus, may lie between the ends.

Immediately on section of a nerve, degeneration sets in of the proximal part as far as the node of Ranvier above the point of division, and of the distal part throughout its whole course; and this is followed by a rapid degeneration of the muscles deriving their supply below the site of nerve section, and by trophic lesions of the skin and its appendages, and vaso-motor disturbances. If the ends of the nerve are fairly close together, regeneration efforts set in very shortly, commencing at the first or second node of Ranvier in the proximal part. The axis cylinders push themselves down into the band of fibrous tissue between the cut ends, thence into the distal part, and so to the muscles and skin. It has been asserted, notably by Bowlby, that regeneration also proceeds in the distal end, new axis cylinders being formed from the nerve nuclei. Such regeneration is probably the case, and the existence of recurrent nerves from the periphery cannot be denied. It is well known that sensory fibres pass upwards along the motor nerves. And it is only in accordance with what we know of the behaviour of the proximal end, that the recurrent fibres in the distal end should seek to bridge the gap. If, however, the gap is large, and if much intervening tissue or foreign body is present, the hindrance to the restoration of complete conduction is too great, for many of the axis cylinders, on arriving at the cicatricial tissue, do not penetrate it completely, but are lost in it, and so there is formed a bulbous swelling —the traumatic neuro-fibroma. In other cases no attempt is made to bridge the gap. Finally, if no attempt be made to restore the nerve path, degeneration extends upwards. Punctured wounds of nerves cause some loss of power in the muscles supplied, but they are noteworthy on account of the pain arising from neuritis. Partial section of a nerve trunk gives rise to temporary paralysis of the parts below, but as a rule the complete function of the nerve is restored.

The prognosis of a case of nerve section depends upon many points, but the most important is whether suture of the nerve trunk be immediate or delayed. Then, even after immediate suture, the functions of a large nerve trunk are rarely completely restored. The age of the patient is influential; the younger the patient is, the less the time taken in restoring the path of nerve impulses. When the ends have been brought into continuity some time after the injury, dependent upon the duration of the time, recovery is very slow indeed. It may be months or years, and is very seldom perfect.

The treatment of a severed nerve is either by immediate or secondary suture. In wounds, especially at the wrist, great care should be taken to ascertain that the nerve trunks, especially the median, are uninjured. If any one of them be found cut, the ends must be approximated by a full flexion of the wrist, and carefully sutured, and the wrist kept in this position by a splint for at least six weeks, and then extension be gradually undertaken. The ends of the nerves should be united with prepared gut or some absorbable material, and the wound must of course be aseptic, for nerve-union in an inflamed or suppurating wound is not possible. Rarely will definite signs of recovery in the affected parts be perceptible for two or more months, and the immediate results to the patient will be disappointing. Even after fair movement has been regained, there may remain difficulty in localising sensation. Such was found in the case of a patient of one of us. A captain of Royal Engineers in the Tirah campaign was slashed down to the bone of the right leg by a creeping Pathan, with division of all the structures. The parts, including the nerves and tendons, were carefully adjusted. But three years afterwards there was still some paralysis of the interossei, and localisation of sensation in the plantar surface of the toes was incomplete.

Secondary suture of a nerve often presents great difficulties. These consist in finding the nerve ends, especially the distal, which is often thin and atrophied and at a greater distance from the proximal end than is thought possible; and when the ends have been found it may be that they cannot be approximated, even with extreme flexion or extension of the joints. Such a difficulty was experienced in the case of the ulnar nerve by our friend, the late Dr. Gardner of Melbourne. He mentioned the case to us in conversation, and described how he successfully overcame the difficulty by turning up the ends of the ulnar nerve with the surrounding tissues, and transplanting them to the front of the forearm, and on flexing the elbow the nerve-ends could be successfully approximated. For secondary union of nerve trunks, the operation must be conducted on the strictest aseptic principles. It is well to use an Esmarch's bandage until the nerve-ends are found, and then to release it, so as to allow oozing to take place before the wound is closed. When the nerve-ends have been found, and the cicatrix thoroughly removed, the nerve-ends are refreshed lightly with scissors, approximated and sutured with two catgut sutures passing through the epineurium. If there be a great strain in the nerve, it may be relieved by passing small absorbable sutures between the nerve sheath and the surrounding tissues, and then drawing firmly together the structures adjacent to the nerve trunk by stout sutures—in fact quilting the adjacent structures. In cases of exceptional distance between the nerve-ends various devices have been resorted to, such as grafting a portion of the sciatic nerve of a rabbit, or connecting the two ends by bone tube or by strands of catgut. The time occupied in regeneration is very great, three to four months being a short period for perception to return, while motion may require twelve months or more.

In those cases where it is impossible, on account of anatomical difficulties, to restore the nerves, as in the case of the roots of the brachial plexus, or lumbar or sacral, and if it be found that there is no prospect of power returning, muscle-grafting may be resorted to, often with great success. Thus we were enabled to restore the power of flexion to the fore-arm in the following case.

CASE 55. *Permanent injury of the Fifth Cervical Nerve-root. Paralysis of Biceps and Deltoid, treated by Muscle-grafting.*[1]—A carter, aged fifty-seven, a heavy man, was thrown from the box on to his left shoulder, which was not dislocated. He found himself, however, unable to raise his arm at the shoulder, and had lost most of the ability to flex the elbow. It was evident that he was suffering from injury of the upper root of the brachial plexus: the fifth (Erb-Duchenne type). Electricity and massage were tried for twenty months without avail. So, with the object of restoring good flexion to the elbow, without which he was unable to earn his living, the lower part of the outer head of the triceps was separated from its distal attachment, brought forward, and passed through the lower part of the biceps. The result after two months was that he was able to fully flex the elbow. An attempt was made to replace the atrophied deltoid by transferring the clavicular part of the pectoralis major. The freed end of the muscle, about 6 inches in length, was brought over the acromion, and carried down and fixed firmly into the wasted deltoid. As it passed over the acromion, the transferred pectoralis major was fixed to the

[1] *Clin. Soc. Trans.* vol. xxxv. p. 181.

periosteum.[1] The result here was not so successful as in the case of the triceps and biceps, but he acquired a better fixation point at the shoulder joint for the movements of the arm.

Multiple Neuritis and Lead Palsy, and their Deformities

The most common causes of multiple neuritis are chronic alcoholism and the introduction of lead, arsenic, or other mineral poisons into the body. But other and less frequent causes are recognised. Thus, multiple or peripheral neuritis may arise from diabetes, gout, rheumatism, syphilis, and as a sequel of septicæmia. Many acute septic disorders have been complicated by loss of nerve-conduction, among such septic diseases being diphtheria, smallpox, influenza, typhus and enteric fevers. According to Gowers and Taylor[2] tubercular neuritis undoubtedly occurs, but "it is a form regarding which we have still much to learn."

[1] Since this operation was performed one of us (A. H. T.) has modified the operation by pressing the trapezius into service. The clavicular portion of the pectoralis major was freed from its distal attachment, and the clavicular part of the trapezius separated. These two portions of muscle were then united at their distal parts, and the new muscle so made was inserted as low down on the outer aspect of the humerus as possible, so as to replace the atrophied deltoid.

[2] *Diseases of the Nervous System*, ed. 3, vol. i. p. 147.

With alcoholic neuritis, in the first place there are often premonitory symptoms, such as numbness, tingling of the hands and feet, and cramps in the calves of the legs and elsewhere. These are followed by muscular weakness, especially affecting the dorsiflexors of the ankle, the extensors of the toes, the extensors of the wrists and fingers, so that wrist-drop and foot-drop result; and subsequently other muscles may be affected, so that the patient may become utterly unable to walk and is confined to bed. As the result of loss of power in the muscles there is inco-ordination. Combined with the above, certain sensory symptoms are well marked, such as tingling, pains (either dull or acute), tenderness of the skin, of the nerve trunks and of the muscles, and loss of sensation in the skin. The affected muscles quickly waste and the reaction of degeneration sets in. In early stages the reflexes from the skin may be increased; but in later cases the skin reflex is lost and trophic changes occur in the skin, the hair, and the nails.

The diagnosis of multiple neuritis should not be very difficult. Symmetrical weakness of the extensor muscles of the wrists and the dorsiflexor muscles of the ankle, with the associated wrist-drop and foot-drop, together with hyperæsthesia and muscular tenderness, should at once suggest multiple or peripheral neuritis.

Treatment.—So far as the surgeon is concerned the treatment of these cases of alcoholic and other forms of neuritis should be (*a*) Preventive of deformity, and (*b*) Remedial.

(*a*) *Preventive.*—Inasmuch as most cases of alcoholic neuritis are benefited by complete rest in bed, there is a natural tendency, owing to gravity, the weakness of the dorsiflexor muscles, and the weight of the bed-clothes, for the feet to point downwards, and secondary contraction of the calf muscles and tendo Achillis follows. This should be anticipated and prevented by the following measures:—Morning and evening the feet should be fully dorsiflexed, the affected muscles should be well rubbed and stimulated by the interrupted current daily, and at all other times the feet should be kept at a right angle or less with the leg by means of one of the following apparatus:—A tin shoe with a quadrant; or a poroplastic shoe with the foot-part at right angles. But in all cases care must be taken that pressure sores do not form about the heels, and it is well to harden the skin in those situations by the daily application of methylated spirit and water. On account of the weakness of the extensors of the knees and of the hips, contraction of both these joints may occur, and this must be prevented either by means of weight-extension or by a splint, such as a Thomas' hip splint.

(*b*) *Remedial.*—When contractions have formed, the question of section of the tendons must be considered, but operation should not be undertaken too early, for if the muscles recover power, much of the contraction disappears with the effort of walking. But if, after milder measures, such as gentle extension and continued massage of the weakened muscles, have been tried, persistent contraction of their opponents remains, then tenotomy is called for. The contraction of the flexors of the wrist occurring in alcoholic neuritis is quite comparable to that which occurs in lead palsy; but the distinctive feature of neuritis arising from metallic poisoning, such as lead or arsenic, is that in the metallic forms the paralysis remains as a rule limited to certain muscles, and does not show a tendency to spread to others. The wrist-drop of lead palsy has been used in Section I. as an illustration of the *principle* we advocate *in the treatment* of paralysed muscles. The first essential is to take the strain off the weakened muscles. In fact, we take it that such a strain should not be allowed to occur, and this constitutes the prophylactic or anticipatory part of the treatment of wrist-drop. When the extensors are found to be weak, the right thing to do is to place the fore-arms and hands on splints. These splints may be made of malleable iron, or of leather or poroplastic material. They are applied to the flexor surface of the forearm and hand, but their important feature is that the part which is adjusted to the hand is bent at an obtuse angle with the forearm part, so that when the limb is placed on the splint the wrist is hyperextended. If the limb be so fixed up from the first, the amount of weakness and loss of power will be less than otherwise, and the recovery is correspondingly quicker. If a case of wrist-drop from lead palsy be brought to us, we invariably place the forearm and hand on a straight splint applied to the flexor surface of forearm, wrist and hand, and from time to time the hand and wrist are hyperextended, while the extensor muscles are well beaten with a "muscle-beater" (Fig. 7) and vigorously massaged twice a day. The hand is kept in the straight position so long as any tension of the flexors remains. When this has subsided, the splint is bent so that the wrist is slightly hyperextended. Gradually the angle is increased, until the hand is almost at a right angle with the forearm. This position is maintained until what we term "the test of recovery" is applied. The patient is asked to try to lift his fingers from the splint. If he can do so, recovery is practically assured by such a proof of the restoration of muscular balance. The splint, however, is not taken off at once, but instead of the hand-plate reaching to the finger tips, it is cut off below the knuckles in order to allow the finger movements to take place, while the wrist remains fully extended. At night the fingers are again extended. During the whole of the treatment no bandages should exert pressure upon the muscular tissue, but they should be applied around the tendons, as depicted in the diagram on p. 47; and muscle-beating and massage are sedulously applied daily. Recovery will not be long delayed, and it is assured when the patient can easily extend his wrist and fingers.

Deformities arising from Degenerations of the Spinal Cord

Locomotor Ataxy.—The diseases which give rise to arthritic and other deformities are locomotor ataxy, hereditary ataxy or Friedreich's disease, progressive muscular atrophy and syringomyelia; and taken with this group may be included, pseudo-hypertrophic muscular paralysis. This, although it is primarily muscular, and has not been shown to be dependent upon disease of the central nervous system, is usually included for the purposes of description with the above.

The symptoms of locomotor ataxy are sufficiently well known not to need extended description. But the most interesting complications from a surgical point of view are spontaneous fractures of the bones, and the peculiar joint lesion known as Charcot's disease. Fractures may occur in any of the long bones, and they apparently arise from the bones becoming brittle and then giving way. The curious feature of these fractures is that they unite readily, and with the formation of much callus.

The typical affection of the joints known as Charcot's disease usually affects the knee. According to Gowers the percentage of joints affected is as follows:—The knee, 45 per cent; hip, 20 per cent; shoulder, 11 per cent; tarsus, 8 per cent; elbow, 5 per cent; ankle, 4 per cent. Mr. Targett has described two cases of Charcot's disease of the joints of the spinal column giving rise to a very exaggerated form of curvature.[1] The changes in the tarsal articulations and tarsal bones cause the foot to become flat, giving rise to the condition designated by Charcot and Féré as tabetic club foot.

The nature of the changes in the joints is

[1] *Guy's Hospital Gazette*, Aug. 6, 1895, pp. 133-135.

now fairly well understood. They sometimes succeed an injury, and often the arthritic structures become rapidly inflamed, much swollen, and acute disorganisation follows. The cartilages are eroded, the articular surfaces rapidly waste and disappear, the ligaments are lax and the joint becomes flail-like. Such changes constitute the atrophic form of the disease; but in a fair proportion of cases it happens that the heads of the bones become enlarged, the ligaments ossify, and there is great effusion into the soft tissues around the joint, so that it is enormously swollen, and this is the hypertrophic variety.

Treatment.—So far as treatment is concerned, immediately a fracture is detected, or signs of the joint affection are noticed, the patient is to be placed at rest and suitable splints applied; for the arm, malleable iron, and for the lower extremity the knee-calliper splint is useful; and, as we have mentioned above, the fractures unite. Sometimes too the joint condition subsides, and for a time its functions may be resumed, but this is not the usual rule. In all cases of Charcot's disease of the knee, much weakness and disability may be avoided if the calliper knee-splint be applied as soon as possible; and when the joint has become disorganised and flail-like, this form of splint enables the patient to stand and possibly to walk. The treatment of ataxia consists in strengthening of the muscles, as suggested by Prof. V. Leyden[1] and Prof. Goldscheider,[2] or by the more recent methods of Dr. Frenkel. The systems associated with the names of Von Leyden and of Goldscheider aim at an increase of muscular power by means of gymnastic exercises aided by apparatus; while that of Frenkel[3] consists of carefully devised systematic and graduated exercises, which require no apparatus and can be practised in the home. These movements are of a simple character, stress being laid on their frequent and careful repetition. No claim is made of any influence on the tabetic condition, but merely on its most distressing symptom, the ataxia. Unquestionably, in many instances,

[1] E. Leyden, "Die Behandlung der Tabes" (*Berlin Klin. Wochenschr*, Nos. 17, 18, 1892).

[2] Goldscheider, *Anleitung zur Uebungsbehandlung der Ataxie* (Leipzig. G. Thieme, 1899).

[3] Frenkel, *Bemerkungen zur Uebungsbehandlung der Ataxie* (Leipzig. G. Thieme, 1899).

much improvement has resulted from carefully conducted efforts in this direction.

The late H. O. Thomas strongly advocated what he called spinal depletion in pronounced ataxic cases, and one of the authors (R. J.) had many opportunities of noting marked improvement in their gait. The treatment consisted of vigorous pummelling and massage of the spine and spinal muscles.

In a painful disorganisation of the ankle (Charcot), which completely crippled an ataxic, one of the authors amputated the foot with considerable advantage to the patient. The wound healed uneventfully. But excisions of joints are most unpromising. Of 18 cases in which resection was performed by Ullman,[1] 10 affected the knee-joint, and 9 only were purely tabetic. Of these 9 all resulted unfavourably, 2 dying as the result direct of operation, 3 required amputation, and in 1 non-union followed.

Hereditary Ataxy or Friedreich's Ataxy has the following characteristics. There are muscular inco-ordination of arms and legs, with loss of the knee reflex, unsteady movements of the neck and head, blurring of the

[1] *Deut. Aerzte-Zeit.*, Oct. 1, 1900.

articulation, nystagmus, absence of optic atrophy, but as a rule no lightning pains and visceral crises. These signs, together with the age of the patient at the time of onset of the disease, are sufficiently distinctive.

The deformities associated with Friedreich's ataxy are lateral curvature of the spine and

Fig. 88.

Deformity of the feet in a case of Friedreich's ataxy. The view is taken from above.

talipes equino-varus, and occasionally contraction of the knees. The lateral curvature of the spine is due in the first place to muscular weakness, and then to the effects of posture. It should be combated by every possible means, but as a rule, despite recumbency and supports, it increases and becomes permanent.

The condition of the foot is very typical. It is one of talipes plantaris. The heel is raised, the instep is excessively arched, and in the sole of the foot bands of contracted plantar fascia may be felt. The heads of the metatarsal bones are at a lower level than the heel, the toes are hyperextended at the first phalanges, and flexed at the second and third, and the whole front part of the foot is adducted (Figs.

FIG. 89.

The left foot taken from the side. The patient is the same as in the preceding figure.

88 and 89). The result is a partial or entire loss of equilibrium by the patient.

As the prognosis of the disease is so serious, it is certainly inadvisable in the majority of cases to interfere surgically. But if the degree of inco-ordination is slight, and it can be clearly shown that the loss of walking power is due to the abnormal position of the feet, an attempt should be made to remedy their position, as it may afford the patient some relief for a time; but it should clearly be understood that the improvement will be temporary only.

Progressive Muscular Atrophy.—In progressive muscular atrophy lordosis is met with, due to involvement of the trunk and hip muscles, and especially to weakness of the extensors of the hip-joint. The claw hand is almost always seen, and less often the claw-like foot. The peculiar position of the fingers and toes is due to paralysis of the interossei and contraction of the long flexor and extensor muscles. For these conditions little can be done, but in the event of severe lordosis occurring, or falling of the head forwards or backwards owing to muscular weakness, the patient may derive considerable comfort from the use of a spinal support, with an occipital head-piece and chin-lever attached.

The Peroneal Type of Muscular Atrophy.—In a thesis published in 1886 Dr. Howard Tooth drew attention to a form of muscular atrophy at first apparent in the peronei muscles, or in the extensor proprius pollicis or extensor communis digitorum. While certain of the cases are of the nature of amyopathy, others appear to be of neuritic origin. A description of the disease and its treatment is contained in an article in the *Lancet* of December 1901,

FIG. 90.

Peroneal paralysis. Wasting of first dorsal interossei and slight club foot.

by Dr. Warrington and one of the authors (Mr. R. Jones), and we insert it here in full with illustrations (Figs. 90, 91, 92).

The three cases of muscular atrophy here recorded are examples of a comparatively rare type of disease, and Hammond mentions that when the legs are the first affected, the condition is often hereditary. The distinct features of such an hereditary type of peroneal atrophy

FIG. 91.

Peroneal paralysis. *Main en griffe* and pes cavus.

were, however, clearly indicated by Howard Tooth,[1] and Charcot and Marie[2] in 1886. Hoffman[3] in 1889 and 1891 exhaustively

[1] *The Peroneal Type of Progressive Muscular Atrophy*, Cambridge University Thesis, 1886; *St. Bartholomew's Hospital Reports*, vol. xxv.

[2] *Révue de Médécine*, 1886.

[3] *Archiv. f. Psychologie u. Nervenheilkunde*, xx.; *Deutsche Zeitschr. f. Nervenheilkunde*, 1891, p. 95.

discussed the subject, adopting a distinct pathology for this type of disease, as shown by the title of his papers ("Ueber Progressive Neurotische Muskelatrophie"). A further im-

Fig. 92.

Peroneal paralysis. Wasting of the thenar eminences and the condition of the feet after operation.

portant communication was made in 1893 by Bernhardt,[1] and in 1899 Sainton[2] gave the results of a thorough microscopic examination of the nervous system in a case of this type.

[1] Virchow's *Archiv.* Band 133, p. 287.

[2] *Nouvelle Iconographie de la Salpêtrière*, 1899, pp. 206 and 317.

advanced and unequally developed on either side. On the right the foot was hollowed and inverted, and also somewhat dropped. The tendon of the tibialis anticus stood out like a taut cord. The toes and ankle-joint could be freely moved in all directions except that of eversion, owing to complete paralysis of the peronei muscles. The left foot exhibited the same characteristics, but to a more marked degree, for not only was the power of the peronei less, but also neither the toes nor the hallux could be extended. In addition to the pes cavus there was some equino-varus. The other muscles of the lower extremity were capable of causing powerful movements. There was no distinct wasting except that of the external group of leg muscles, yet the lower part of the thigh became rather sharply thinner than the upper part. No loss of sensation was noted, and there was no pain, either spontaneous, or on pressure of the muscles or nerve trunks. Fibrillary twitchings were absent. The bladder and the rectum were normal. The cranial nerves and optic discs were normal. The knee jerks could not be obtained. The plantar reflex gave the usual flexor response. As to electrical excitability, in the upper extremity no reaction could be obtained in the thenar eminences either to the induced or the constant current. The first interossei muscles reacted slightly. The other muscles and nerves of the upper limb gave a normal response. In the lower extremity there was no reaction in the peroneal group of muscles. The other muscles of the thigh and leg reacted naturally.

Case 57.—A man, aged thirty-one years, the third child of the above patient, dated his condition as far back as he could remember. He had always had excellent general health, and could successfully carry on his work. There was marked club foot on both sides, and the feet were inverted and dropped, but without any contracture of tendons. The power of dorsiflexion and of eversion was completely lost. The toes were in the characteristic position of *griffe des orteils.* Wasting in the front and outer side of the leg was obvious; the calf muscles seemed well developed, the lower parts of the thigh tapered off somewhat sharply from the upper portions, but no obtrusive atrophy was present. The thigh muscles acted powerfully, and the patient could readily raise himself to the sitting posture without using his hands. The gait was that usual in cases of "dropped foot," but there was no waddling, and the patient could stand with his eyes closed. In the upper extremity there was extreme wasting of the small muscles of the hands, with typical *main en griffe.* The movements of the wrist, elbow, and shoulder-joints were normal, and there was no wasting. The extremities were cold and bluish. No fibrillary twitchings were present. There were no subjective nor objective disorders of sensation. The bladder and the rectum were normal. Slight nystagmus was obtained at the end of excursion of the globes. The cranial nerves and optic discs were normal. The knee jerks were feeble. No plantar reflex could be obtained. With regard to electrical reactions, no reaction to either the faradic or constant current could be obtained in any of the atrophied muscles (15 milliampères being insufficient). With regard to the other muscles, which were capable of powerful voluntary contraction, it was observed that very strong currents had to be used before they were excited. A faradic current, which to the observer was unbearable, and a constant current of 15 milliampères, produced only a slight contraction. This condition obtained in the muscles of the thigh, forearm, and arm. The face unfortunately was not examined.

Case 58.—The younger brother to the above, aged twenty years, noted weakness in the ankles when he was twelve years old. He had always had good general health. Some time after the feet were affected he noticed wasting in the balls of the thumb and that he had difficulty in sewing. In the early part of 1900 he consulted one of us on account of the deformity of his foot. And the report shows that this was very similar to that present in the case of his brother. An account of the surgical treatment is appended (p. 289). It was highly successful, and when seen by us the patient had a fixed ankle-joint and was able to place the soles of the feet flat upon the ground. The muscles on the front and outer side of the legs were greatly wasted, and so also were the calf muscles, though these retained a moderate degree of power. The lower parts of the limb were cold and sweated considerably. The thigh muscles and those of the trunk acted powerfully. In the upper extremity the only abnormality noted was marked wasting of the thenar eminences. The knee jerks were distinct, and a slight plantar reflex was obtained. There were no disorders of sensation. The bladder and rectum and the cranial nerves and optic discs were normal. With regard to electrical excitability, this was similar to the condition described in the preceding case.

These cases conform fairly well with the classical descriptions of Tooth and of Charcot and Marie, namely—they present a hereditary form of progressive muscular atrophy in early life, commencing in the lower extremities and producing a paralytic club foot, then invading the hands and giving rise to a varying degree of *main en griffe*. Such a combination, as Gowers says, when present in early life is almost characteristic of the disease. The knee jerks are usually absent or feeble, and fibrillary tremors are present in the majority of cases.

Much attention has been given to the electrical reactions, which are peculiar and of great diagnostic value. A true reaction of degeneration may be present in the atrophied muscles, or an entire absence of excitability to either the induced or constant current. Further, there is the important fact that even those muscles which are not atrophied, and in which there is a full amount of power, can only be stimulated with the greatest difficulty. Oppenheim mentions in his *Lehrbuch* (1898) one case in which this condition obtained in almost all the muscles of the body, whilst the atrophy was confined to the lower extremities. Bernhardt and Hoffman record cases in which even the facial muscles did not react to electrical excitation when either the nerve itself or the individual muscles were stimulated.

Dubreuihl[1] remarks in this connection: "Either the functions of the muscles persist in spite of almost complete disintegration of nerve fibres, or those nerve fibres which one holds for empty sheaths have not really lost their functions." It is possible that some peculiarity in the skin may *partly* account for this phenomenon. The patients were insensitive in a remarkable degree to the faradic current, a fact which has also been noticed by others, and a higher voltage was necessary in order to get a current of a given milliampère strength to pass through the body than is necessary in a normal individual. This symptom must rank as one of the characteristics of the disease.

Etiology.—Isolated cases have been recorded, but are rare. There is either an hereditary history, or several members of the family are affected. In Herringham's[2] case the heredity could be traced through five generations, and involved twenty-six indi-

[1] *Révue de Médécine*, 1890, p. 441.
[2] *Brain*, 1888, p. 230.

viduals, the males alone being affected. The symptoms usually appear in the first or second decade. Sainton states that in fifty-two cases the onset was noticed forty times before twenty-two years of age, and twelve times after that period, the extreme limits being two and forty. It never appears immediately after birth. In the majority of cases nothing in the nature of an exciting cause can be ascertained. In others some form of toxæmia has preceded the illness. Thus measles had occurred in the cases of Ormerod[1] and Donkin.[2] Egger's[3] two cases had been workers in lead, and Hoffman mentions alcohol and syphilis. But even if such blood states act as causal agents, the primary lesion must be sought in the nervous system enfeebled by hereditary influences.

Anatomy.—In discussions to which this type of muscular atrophy has given rise, the observations of Virchow[4] and Friedreich have been discovered which refer to the state of the nervous system in cases probably of the

[1] *Brain*, vol. vii.

[2] *Ibid.* vol. xiii. 1890, p. 456.

[3] *Archiv. f. Psychiatrie und Nervenkrankheiten*, Band xxix. p. 400.

[4] Virchow's *Archiv.* 1885, Band viii. p. 537.

class now considered. These authors describe fatty and degenerative changes in the muscles, with increase in the connective tissue nuclei, great atrophy of nerve fibres in the peripheral nerves, and increase of connective tissue between the bundles of fibres. The posterior columns of the cord were also affected. The changes consisted of atrophy of fibres and the presence of branching fibres and corpora amylacea. Sainton describes a case which was seen during life by Marie. The condition of the nervous system showed that there was no diminution in the number of the cells of the anterior horn. They were, however, smaller than normal and had lost their processes. Some were in an advanced state of chromatolysis, with a large amount of pigment present, and occasionally the nucleus was absent. The cells of the posterior horn were diminished in number and atrophied; the cells of Clarke's column were present and the network of fibres was atrophied. In the white matter, the antero-lateral region was normal in a case of Marinesco's,[1] slightly sclerosed in the pyramidal region of Sainton's

[1] *Archives de Médécine Expérimentale*, 1889.

case, this being perhaps connected with an old hemiplegia. Important lesions were found in the posterior columns, and were present throughout their whole extent. Lissauer's zone was, in the lumbar region, slightly affected, but elsewhere normal. In Marinesco's case the posterior roots were affected throughout the length of the cord; in Sainton's very little change existed in the cervical region. The ganglia themselves showed no definite changes, except that the presence of pigment was very marked. With regard to the nerves there was nothing abnormal to the naked eye, but microscopically some of the fibres showed complete degeneration, with breaking up of the myelin; in places, naked axis cylinders were found, sometimes surrounded by empty sheaths. The nerve fibres were diminished in number, and there was an increase of interstitial tissue. The muscles showed very marked changes, diminution in the number of fibres, loss of striation, fatty changes and increase in connective tissue. Hoffman considers the best title for the disease to be "Progressive Neural Muscular Atrophy," implying that it is a general affection of the neuron. Cases have been recorded which, whilst resembling the peroneal type, have certain added symptoms showing a wider primary weakness of the nervous system. Vizioli[1] mentions the case of a father and two sons who, in addition to peroneal atrophy, suffered from burning paroxysmal pains, and in two of the three there was optic atrophy. In Ormerod's, Sainton's, and one of Egger's cases there was some difficulty in passing urine. Dubreuihl mentions myosis as being present, and Siemerling[2] has noticed the Argyll-Robertson pupil. In some of Déjerine and Sotta's cases the symptoms resembled Friedreich's disease; in some they were more like tabes. Dubreuihl mentions in one of his cases that the facial muscles were, under emotional conditions, absolutely immobile. Oppenheim and Cassirer[3] have recorded an isolated case of paralysis of the peroneal group and atrophy of the small muscles of the hand, of the supinator longus, triceps and orbicularis oculi. In this curious

[1] *Medicinisch Chirurgische Königliche Akademie zu Neapel*, 1889. (Reference in Hoffman.)

[2] *Neurologisches Centralblatt*, 1897, p. 569.

[3] *Ibid.* 1896, p. 718.

case no change was found in the cord nor peripheral nerves, and the writers considered it as one of primary origin.

As to the surgical condition of the feet, the patient in Case 58 complained of considerable pain in both feet, more especially in the left. They were both rigid in every direction, in contrast to the ordinary paralytic type: voluntary movements of the toes being very limited. The right foot, which presented the less severe symptoms, required only division of the tendo Achillis and tibialis posticus, followed by an energetic application of a club-foot wrench, massage, and exercise. The right foot, in addition to the equino-varus, exhibited hyperextension of the toes and pes cavus. The tendo Achillis, tibialis posticus, plantar fascia and deep ligaments were divided, and an incision made across the dorsal aspect of the foot opposite the heads of the first phalanges of the toes. An interesting condition was found, all the phalanges being dislocated upwards and backwards. The heads of the first phalanges were removed, and the foot by these measures restored to normal shape. The patient made an excellent recovery and can walk long distances. Sachs[1] has recorded similar success from operative treatment in these cases.

Pseudo-Hypertrophic Muscular Paralysis.—This is now classed amongst the muscular dystrophies, for it has not been shown to be dependent upon a lesion of the spinal cord or nerves, but we include it in this section for convenience of description. It is characterised by wasting and loss of power in certain muscles, followed in some cases by excessive overgrowth of the affected muscles, and in others by continued atrophy. The first signs to attract attention are loss of power, a tendency to fall, and inability to rise again with ease. Following this, it will be noticed that some of the muscles are rapidly increasing in size, especially the calf and the extensors of the knee, the glutei and infraspinati; and this enlargement of the muscles, with increasing weakness, puzzles the parents and leads them to seek advice. The mode of progression is of a peculiar waddling nature, and is very similar to that seen in double congenital dislocation of the hip, and the cases have been occasionally

[1] *Brain*, vol. xii. 1890, p. 445.

confused from want of sufficient examination. The peculiarity of the gait, the mode of rising from the recumbent position, the history of the patient and his family, the enlargement of some muscles and the wasting of others, especially of those mentioned above, and the wasting of the lower part of the pectoralis major and the latissimus dorsi, are sufficient means of distinction. As the result of the shortening and contraction of the muscles, various deformities occur. Thus the knee-joint and elbows become contracted, partly owing to the habitual flexion of those joints and partly to the retention of some power of the flexors. Contraction of the calf muscles causing a condition of talipes equinus is common, and the patient becomes able to walk less and less. As a result of the shortening of the gastrocnemii and other calf muscles, and contraction in them, plantar flexion of the foot occurs, and subluxation of the ankle-joint may follow. The weakness of the extensors of the hip is responsible for lordosis of the spine, but as the paralysis progresses, and the spinal muscles become more involved, the lordosis is replaced by antero-posterior bending or kyphosis, and subsequently lateral curvature sets in.

While the prognosis of the disease is admittedly grave, and a very large number of children so affected do not attain adult life, yet there is no doubt that its progress may be retarded by properly planned muscular exercises, and these do more to improve the condition than rubbing and massage, although the latter measures are of considerable benefit. If it be clear that the contraction of the calf muscles is such as to cause greater interference with walking than is due to mere weakness, then section of the tendo Achillis is undoubtedly called for; and if the patient survive long enough and contracture recurs, a second division is judicious, and it will enable the patient to walk again. We have seen the late Mr. Adams divide the tendo Achillis in a patient, aged twenty-four, who suffered from this affection, and the patient experienced much benefit from it. For the curvature in the spine, supports are necessary, but these should be used in combination with rubbing and massage.

Spina Bifida.—In spina bifida paralysis of the muscles of the legs is frequently met with, and the most common form of foot deformity is talipes varus, due to the fact that the tibialis anticus is least likely to be affected. The degrees of loss of power in the legs vary enormously, from paresis of one or two groups of muscles to wasting, blueness, and hopelessly useless legs and feet. Trophic changes of the skin, such as perforating ulcer, are seen, and changes in the tarsal and metatarsal bones like those of tabetic arthropathy are also met with.

As to the treatment of the condition of the lower extremities, much will depend upon the degree of the affection. If one or two groups of muscles alone are paralysed, some improvement may be effected by tenotomy or by muscle-grafting, but great care should be exercised in the selection of cases, and comparatively few are capable of improvement.

Syringomyelia.—Syringomyelia is a condition of the spinal cord in which cavities arising from the defective closure of the neural canal are found. Lining these cavities is a layer of gliomatous tissue, and outside this is the white substance of the cord, which is often deficient in amount and undergoing pressure from the fluid which accumulates in the cavities. The main features of the disease are loss of sensibility, chiefly to pain and temperature, and a muscular atrophy very similar to that which is found in progressive muscular atrophy. The loss of sensation usually affects the arms or upper part of the trunk, and corresponds to the area of muscular wasting or is a little greater than it. When the compression affects the pyramidal tracts it gives rise to a form of spastic paralysis. As a result of the atrophy of the muscles of the trunk, lateral curvature of the spine occurs, and generally the convexity is to the right. If the dorsal and lumbar regions of the cord are affected, the lower extremities are seen to be in a spastic condition, but this is rather rare. On account of the interference with the trophic impulses, thickening of the bones is met with, and occasionally joint symptoms, such as Charcot's disease, result. Unfortunately no treatment is of avail, but the spine should be supported so as to lessen, if possible, the degree of curvature.

Compression Paraplegia

This occurs sooner or later in about one in eight cases of spinal disease, but fortunately is by no means a prominent complication in most instances. It is not due, except in rare instances, to direct pressure of bone on the spinal cord, but arises from the presence of granulation tissue in the spinal canal, or is due to the formation of intraspinal abscess; or, as the writers believe, the most frequent cause is the thickening of the membranes, a tubercular pachymeningitis. With reference to pressure on the cord by pus, it is a very true observation that abscess and compression paraplegia are very seldom associated, and further, that if an abscess makes its appearance the nerve symptoms subside. Unfortunately, when paralysis has existed for some time, ascending and descending degenerations set in. The paralysis is usually bilateral. It affects the legs generally, although the arms may suffer later, or both may be paralysed. Its onset is, as a rule, gradual, occasionally sudden, and Sir William Gowers mentions the case of a child aged three, a sufferer from disease of the cervical vertebræ, who lost the power of moving the legs in the course of twenty-four hours. During the second day the left arm became paralysed, and at the end of a week the right arm.

The effect of the peripachymeningitis on the spinal cord itself is as follows:—It suffers slow compression and becomes much narrowed, even to the size of a goose quill or less, and then it undergoes myelitic softening, which is followed by increase of the neuroglia, sclerosis, and ascending and descending degeneration. At the same time the nerve roots suffer from pressure and exudation of new material round them.

Symptoms of Compression Paraplegia.—These necessarily vary with the site of disease. The onset is in some cases very sudden, and is due then either to displaced bone, rupture of a blood-vessel, acute myelitis, or tubercular meningitis. As an instance of acute onset another case of Sir William Gowers' may be quoted:—"A woman, aged forty-five, who had suffered from pain in the spine, one day sneezed violently three times, and immediately felt 'pins and needles' in the right knee and foot. The right leg became powerless during the next three days, the left leg followed suit, and at the end of six weeks both legs were motionless. She died six months later." The symptoms may be best arranged, not in the order of their onset, but from a functional point of view.

(*a*) *Motor.*—The patient complains of being tired easily, and the legs begin to drag and the toes to catch in walking. Then follow loss of equilibrium and inability to move the lower extremities. If the disease is in the cervical region, the arms suffer before the legs.

(*b*) *Sensory.*—The most usual sign of onset is a girdle pain due to irritation of the nerve roots. Oftentimes there is no anæsthesia, for sensation is at times present when motion is lost. Anæsthesia dolorosa in patches is not uncommon.

(*c*) *Reflexes.*—The superficial ones are exaggerated, and so too are the deep, especially of the knee and ankle, but when degeneration has set in they are lost.

(*d*) *The Sphincters.*—Incontinence of urine and fæces occur in severe cases.

(*e*) *Trophic.*—The affected muscles waste and reaction of degeneration is more or less marked. Before wasting occurs, distinct spasm of muscles is found, notably if the disease is in the dorsal region. Acute bed-sores are not uncommon.

(*f*) *Vaso-motor.*—The limbs are often cold, and sometimes perspire persistently.

(*g*) *Special to Various Regions.*—In the cervical region the pupil may be dilated or contracted, and sweating of one half of the forehead may be marked. In the dorsal region the intercostal muscles are affected, and in the lumbar region the knee and ankle reflexes are lost.

Prognosis.—A very large proportion of these cases recover under treatment by recumbency and continuous extension, and do not require operation. The number is said to vary between 55 and 83 per cent; we have records of 87 cases, in 84 of which recovery from paralysis took place without any form of operation. Some cases have had four attacks and many three attacks with a good recovery. Even in the most hopeless cases recumbency and extension should be tried, and we have now a case under our care which has entirely recovered after two years. There is no condition so hopeful for treatment.

Treatment. — The treatment is of two kinds, conservative and operative. The expectant or conservative plan of treatment is undoubtedly the best, and its prognosis is exceedingly good. It necessitates complete rest in bed, with extension of the spine, either on the spinal frame (Fig. 93) or by weights applied to the legs and counter-extension of the shoulders and the neck, or by the use of the convex couch of Bradford and Lovett, or by means of a suspension couch; and the time needed for recovery varies from a few weeks to twenty-four months. Bed-sores should be carefully guarded against.

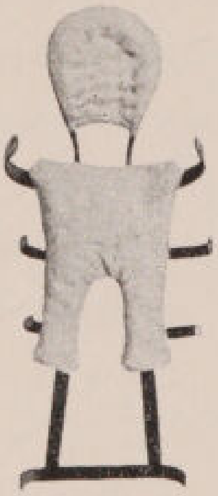


FIG. 93.

The spinal frame, for use after rapid rectification of the spine.

Treatment by operation is either by forcible extension of the spine or by laminectomy. Of 31 cases in which paralysis was present, 17 were relieved by forcible extension, 4 were partially relieved, 2 were unrelieved, and no statement was made as to the paralysis in 8 cases. The authors have had considerable experience of this method and are much in its favour. Records of their cases and of the treatment adopted by them are to be found in *Clin. Soc. Trans.* vol. xxxi. p. 15 and vol. xxxiii. p. 146. Some cases recover entirely and some partially, and much assistance can be given to the latter by mechanical means. Rapid extension of the spine presents greater advantages than laminectomy, because it is safe, it is more successful, and has not the objection of further weakening the spinal column, such as occurs by removal of the laminæ in laminectomy. If, however, prolonged treatment by recumbency and by forcible extension fail, then we may consider the propriety of laminectomy. The statistics of this operation are not very reliable, because it is not distinctly stated in how many cases the treatment by recumbency had been tried. And knowing the great probability of cases recovering spontaneously in that way, it is justifiable to surmise that some of the laminectomy cases would have recovered without the operation. Laminectomy, however, can only be considered as a remote hope, and it is a very disappointing operation. Its risks are very considerable. Of 75 cases collected by Lloyd 29 died, and in 58 surviving cases there were 20 recoveries, 7 were improved, and in 8 no good result followed. So that the prognosis of the operation, both as to the possible cure of the disease and as to life, is by no means good, and it is not applicable to those cases where symptoms of extensive degeneration of the cord are present.

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