

RESULTS OF 256 TRIARTICULAR
ARTHRODESES OF THE FOOT IN SEQUELÆ OF
INFANTILE PARALYSIS¹⁾

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As is well known, the term triarticular arthrodesis of the foot signifies the concurrent arthrodeses of the talo-crural joint, the talo-calcaneal joint and Chopart's joint (that is, the talonavicular and calcaneo-cuboid joints). The calcaneo-cuboid joint was, as will be pointed out later, not included in the arthrodesis to begin with. The operation is performed to improve the poor static conditions resulting from the paralysis, as in complete paralysis of the foot this operation is intended to immobilize the above-mentioned joints and thus to counterbalance the complete lack of stability when the foot has to carry a load. In the partial paralysis of the foot, one tries to combine this effect with a correction of the developed deformities of the foot. To obtain this result, it is thus required of the arthrodesis that it gives firmness of the foot as well as correction of the deformities.

When the ankylosis of these 3 joints is established, the crus is continued as one bone through the talus and the calcaneus, so that the tuberosity of the calcaneus keeps the upper part of the leg from being drawn backwards and thus it tends to prevent the individual from falling on his back — provided, of course, that the knee and the hip are capable of active fixation. In order to make this outcome as efficient as possible, it is therefore essential always to make the point of support of the tube-

¹⁾ Read in abridged form before the meeting of the northern orthopedic society, Copenhagen, 1930.

rosity against the ground fall as far back of the axis of the leg as practicable. The opposite movement — that is, the forward fall of the upper part of the leg — is counteracted by the fore part of the foot. From a static point of view, complete firmness of the fore part of the foot is very desirable, as in such cases the incapacity for dorsal flexion of the foot is more important to the stability than is the incapacity for plantar flexion. This is obvious when one keeps in mind that, in standing, the line of gravity of the body falls in front of the talo-crural joint, thus furthering a forward fall through dorsal flexion of the foot. The greatest static stability in walking and standing on plane ground would therefore be obtained with a foot that is stiff clear out to the metatarso-phalangeal joints. But, such a stiff foot is lacking another important property of the foot: it is incapable of adjustment to different inclinations of the ground it has to rest upon. Various authors differ in their estimate of the importance of this adaptability; still, one has to recognize the fact that mobility is obtained only at the expense of stability.

As will be pointed out later, it is our experience that the triarticular arthrodesis gives sufficient elasticity in addition to good stability. This is partly due to the fact that the motion between the tarsus and the metatarsus has been preserved, so at least pronation and supination of the fore part of the foot is practicable to a fair extent, and partly owing to the fact that the ankylosis of Chopart's joint frequently is not osseous but fibrous, so it consequently gives some degree of elasticity. The adaptation for walking up-hill is the most difficult. Walking and standing on ground sloping downwards or upwards to the side is comparatively easy to the patients, as the capacity of the forefoot for pronation and supination is sufficient to bring the sole in contact with the ground. On descending, a slight flexion of the knee is sufficient for adaptation; but, of course, then a sufficient function of the quadriceps femoris is required.

In ascending, the only possibility of getting the sole on the ground involves a rotation of the extremity, so that the longitudinal axis of the foot forms approximately a right angle with

the direction of the step, the foot being sometimes rotated inward, sometimes outward. But, even in normal individuals there is in fact some tendency to outward rotation of the feet in going up-hill. So we can not but think that there is no urgent reason to sacrifice the best stability possible and compromise by aiming at less stability and more mobility as is done in the operations competing with the triarticular arthrodesis of the foot.

We have not tried the *Whitmann* talus exstirpation, as in our opinion the stability after this operation is bound to be rather slight, it being based entirely upon the strength of the connective tissue, and it is a general experience that in the long run the connective tissue is unable to withstand the weight of the body or the activity of the muscles. This is illustrated very plainly, for instance, in *tenodesis*, of which we have seen a large number that were performed in this clinic a good many years ago. The first years after this operation, the results are excellent; but sooner or later there develops nearly always some laxity, and the malpositions are reproduced. It is partly owing to this experience that we have preferred the arthrodeses to operations in which the stability is based upon connective tissue.

Putti's arthrorisis is rather tempting, as it prevents any motion of the ankle in the most unfavourable direction — namely, the dorsal flexion — while at the same time it permits of some motion of the joint. Still, we can not see that this operation gives much better conditions for walking on uneven ground. For in cases where there is a deviation of the foot to the side, it has to be combined with subtalar arthrodesis; and then the sideward mobility of the foot is not much different from the condition in the triarticular arthrodesis. Further, the capacity for walking up-hill is not much greater, as the dorsal flexion has to be checked at a rather early stage of the motion, if the operation is to be effective. If we had met with fairly frequent complaints of the stiffness of the foot as a hindrance, we would certainly have tried this operation, although there are as yet but insufficient data on the fate of the transplanted »stop-bone«, and as to whether the joint is able to bear this

change in function. Nor does the after-examination of our cases, we think, invite to give up the triarticular arthrodesis.

As to the *subtaloarthrodesis*, which is employed particularly much in France, it is chiefly corrective. The increase of stability is minimal; so, to obtain any favourable result, one has to make such great requirements of the knee and hip muscles that the indication field of this operation is much smaller than that of the triarticular arthrodesis.

It falls without the scope of this paper to enter into the details of the indications for the triarticular arthrodesis of the foot, especially its limitation to tendon transplantations in the foot, and its value as a supplementary measure in other operations on a paretic extremity. For illustration it suffices to refer to the great importance an arthrodesis of the foot may have to the result in plastic operation on the quadriceps. If we are to make a general statement on this question, it will be this, that after our experiences as to the possible results of an arthrodesis and the rather unsatisfactory late results of tendon transplantations in the foot, we are inclined to extend the indications for arthrodesis at the expense of tendon operation; something similar holds good with regard to the arthrodesis as a supplementary operation in the treatment of paretic extremities, where it is of marked value as an improvement in the static condition of the extremity.

Practically, the *indication* for triarticular arthrodesis has been considered present in every instance where this operation might do away with the wearing of a bandage. In addition, we have considered the operation indicated in cases where a malposition of the foot could not be corrected, or where such a correction could not be expected to give a good position that would be permanent.

Nor will we in this paper enter into the details of the technique. Yet we would like to mention the time for the performance of arthrodesis in relation to the onset of the poliomyelitis and to the age of the patient.

As to the first of these points, we insist upon the rule that operation is not performed till at least 2 years after the acute

stage. For it is our view that improvement — at least in functional respects — may still be traced for such a long period, as it often takes a long time before the patient learns fully to utilize the remaining muscle capacity; and, on the other hand, it is seldom that deviations of the foot go on to more marked degrees; at any rate, this may be prevented by means of night bandages.

The later years we have insisted on 12 years as the earliest age for arthrodesis. The choice of this age limit is somewhat arbitrary; but, judging from the X-ray plates, it is our impression that at this time the osseous substance in the bones of the foot has almost reached its full development; and, in addition, there comes a practical consideration, that when the arthrodesis is performed at this age, its functional capacity is fully established by the time the child is through school, and then the patient is not retarded in his further training by the necessity of an operation.

We have been able to follow these rules fairly well, because we have had no particular difficulty in providing our patients with bandages, so that we are able thus to counteract the malpositions as well as to equip the patients with supporting bandages that permit of walking. These bandages are always constructed so that they fix the foot — and fix it in the same position it will have after the arthrodesis. Thus the patients, who have been wearing bandage prior to the arthrodesis — and, as will be shown later, they make quite a large number — have been getting used to walk about with a stiff foot, and this accounts perhaps to some extent for the small degree of discomfort these patients have from their relatively stiff foot.

The technique of the arthrodesis has largely been the same throughout this material. But, of course, there have been minor modifications — and we think too that the routine experience obtained is an additional favourable factor. As already mentioned, in early days arthrodesis was limited to the posterior joints and the talo-navicular joint; but as this operation seems to give a tendency to inflexion of the forefoot, the arthrodesis was extended to include the calcaneo-cuboid joint too.

Another modification was the introduction of the trans-malleolar entrance into the foot. This method,¹⁾ which was first described by one of us, has been used in every case since 1924. It gives several advantages over the previous method in which the entrance was made through Kocher's incision for resection of the ankle joint. The advantages are above all that marginal necrosis of the wound is of much rarer occurrence after the linear incision, and at any rate it is always minimal, whereas previously, where the loosening of a rather large flap was necessary, this operation frequently caused extensive necrosis of the flap; as trophic disturbances were frequently present, it is no wonder that necrosis developed. Of other advantages in the transmalleolar incision we shall merely mention the easier access to the various joints, the easier luxation of the foot, and, finally, the lesser tendency to »dead« spaces of soft tissues with the resulting risk of infection.

As to the details of the technique, we may refer to a previous paper.²⁾ The technique given in that paper has later been adhered to, without any particular modifications — neither in operative technique nor in after-treatment. In the course of time, there will naturally come some small modifications which are considered practical. If we are to mention any such, it will be this, that gradually we have become less saving in the removal of the cartilage, while we have been attaching more and more importance to the apposition of large bony surfaces. This applies in particular to the talo-calcaneal joint, where not only the cartilage is removed from both bones of the articulation but also the entire mass of ligaments in the tarsal sinus, so that one winds up by having one bony surface extending over the entire inferior surface of the talus, and a corresponding osseous superior surface on the calcaneus. As in addition the deviations of the foot toward varus and valgus are corrected to a great extent by the removal of greater or smaller wedges of the talus, the height of this bone is often markedly reduced;

¹⁾ Revue d'Orthopédie. 1926, nr. 2.

²⁾ Nordisk Orthopædisk Forenings Forhandlingar. Acta chirurgica.

and besides, the connections of this bone with other structures — chiefly on the medial surface — are only slight, nay, once this bone has become entirely loose under the chiseling, but is then replaced and has healed in situ without any discomfort.

Finally, it should be stated that we have continuously made efforts to correct and hinder the tendency to deviations of the foot, and that these efforts have steadily been more circumspect, as we have gradually been sacrificing more and more of the bone in order to make the correction as complete as possible, and by additional tenotomy and tendon transplantation we have tried to overcome the forces that might be expected to bring on a relapse.

Before we turn to the results of the after-examination, we would like to say some words about the position in which the foot is to be placed in the operation. For there seems to be some divergence of opinion as to this point.

In text-books of surgery the statement is often made that the position should be middle and rectangular; this applies, for instance, to Garré and Kütner's *Operative Surgery*. Other authors give the position of choice as slight dorsal flexion and varus. We have always placed the foot in a very slight valgus position with a plantar flexion of 15—20 degrees, that is, if the extremity is not shortened too much; for in such a case the foot is placed in a stronger plantar flexion in order to avoid the ugly, big and clumsy sole in balancing the shortage. Even when the shortening amounts to 4—5 cm., the patient may walk on an ordinary shoe sole and a high heel, if the foot is plantar-flexed sufficiently. The reason why we place the foot in a slight valgus position is not so much that we think this measure may prevent a subsequent varus position — we have always had the impression that varus is the most common form of malposition after arthrodesis — but, rather because the slight valgus foot is much easier to fit with shoes than a foot in varus position. The first position requires merely a slight medial heightening of the sole; or the patient is provided with a flat-foot plate; by either measure he will walk well. A fixed varus foot, on the other hand, requires a boot, which is much harder to make if

the foot is to rest properly and have its treading surface in such a position that abduction of the foot is not necessary in order to get the whole sole to the ground, without forcing the knee into valgus (cf. p. 224). Plantar flexion of 15—20° corresponds with the elevation of the heel that is required to balance the difference between heel and sole in ordinary shoes. In women wishing to wear higher heels, the plantar flexion has to be increased accordingly. If the foot is placed at a right angle — and still more, if it is placed in dorsal flexion — the outcome will be that the forefoot will point straight ahead, elevated to the height of the heel, when the patient is standing with the heels together; and in such a patient, it is only at the end of a step, in which the normal leg is put forward, that the forefoot will touch the ground. For that matter, the position we have been employing is the same one, we think, that nowadays is adopted by all orthopedists for the foot in prostheses.

Our material comprises the cases of foot arthrodesis performed on poliomyelitis patients in the Clinic for Cripples during 1920—1927 inclusive. We have left out 6 cases of subtalo-arthrodesis, and also 10 cases of triarticular arthrodesis on which no after-examination could be made at least 2 years after the operation; and finally we have omitted the case of a patient who died a few hours after the operation without the cause of death being demonstrable — there was no sign of fat embolism.

The 6 subtalo-arthrodeses are left out because this number is too small as a group by itself for comparison with the triarticular arthrodeses. Besides, talo-crural arthrodesis was later performed in one of these cases; and this operation was also advised in another of these cases, but the patient refused.

In all probability, the 10 cases of triarticular arthrodesis left out would at least correspond with the average result of this material; at any rate, they did not show any particular features as long as they were under observation. It is reasonable to assume that they have stayed away because they did not need any further orthopedic treatment.

Leaving out these, there remain 256 cases of triarticular arthrodesis that have been under observation at least for 2 years.

We have decided on a minimal observation period of 2 years because one may hardly feel sure that the foot has assumed its permanent shape before this time. Various deviations may develop — or, at any rate, be accentuated — within this period. After this period, on the other hand, there is hardly apt to be any important change in the form of the foot.

Now and then it has been rather difficult to estimate the cases objectively. In many cases the information furnished by the patient will be doubtful because his memory fails him to some extent, partly because the patient is mixing up elements not concerning the matter with their private interest f. inst. the wish to get invalid pension, and sometimes because the patient does not compare the result of the operation with his pre-operative condition, but with his expectations of the operation.

This survey is based primarily upon our material of case-records. Whenever a record falls short — e. g., because the patient has stayed away from observation or after-treatment — so it does not give an observation period of 2 years at the least, we have sent the patient a questionnaire.

In judging the condition before and after the operation, we have tried to classify the cases after muscle power, after position, after shortening, after the firmness of the arthrodesized joints, after the function of the foot, and after the necessity of bandaging.

We have further tried to compare these aspects mutually as well as with other factors that might conceivably have some influence upon the result — as the age at the onset of poliomyelitis, the age at the performance of the arthrodesis, and the condition of the other lower extremity (better, just as bad, or worse than the operated limb).

In our tables, the power of a muscle is indicated by 0, +, ++, or +++. 0 meaning no or a non-definitely demonstrable function, + meaning a definite but very ineffective function, ++ designating an effective but less than normal function, +++ a practically normal function.

For practical reasons, the muscles are estimated by groups, namely: 1) »hip muscles«, 2) »thigh muscles«, 3) »leg muscles«.

»Hip muscles« is a collective term for the *glutæus maximus*, *glutæus medius*, flexors and adductors of the hip.

Among these muscles, the *glutæus maximus* is playing the greatest rôle in the static bearings of the entire extremity, especially when the function of the extremity is impaired by paralysis in the thigh and leg. In estimating the power of this muscle group, we have therefore attached a greater importance to the *glutæus maximus* than to the *glutæus medius*. Least regard is paid to the adductors and the flexors of the hip, as upon the whole their power is of minor importance — nay, sometimes the flexors may even be impeding by giving contracture.

»Thigh muscles« covers the quadriceps and the hamstring muscles. In estimating the functional value of this group a relatively great importance is attached to the quadriceps.

The »leg muscles« are estimated so that a comparatively great importance is credited to the triceps, while a comparatively little rôle is ascribed to such muscles as the flexors of the toes, for instance. In calculating the result, we have not taken into account whether the pareses are distributed relatively even so that the various muscle groups are balanced fairly well, or whether the pareses are combined so that some muscle groups are greatly impaired and others slightly. We have employed this method because we feel that the muscle value might be an indication of the mechanical forces the bones have been exposed to, and therefore, perhaps, of their trophic condition. The more or less efficient balance is determinative of the position of the foot, which is characterized by itself.

The position of the foot is estimated partly after:

marked valgus, slight valgus, middle, slight varus, marked varus,
partly after:

marked calcaneus, slight calcaneus, middle, slight equinus,
marked equinus,

and after:

marked deflexion, slight deflexion, middle, slight inflexion,
marked inflexion.

As already mentioned in the triarticular arthrodesis, we

have aimed to produce a certain degree of equinus. In the tables, we have designated this position as middle, and only when the position obtained was more equinus than desirable or uncomfortable in other ways, we have used the designation equinus.

For the sake of convenience, a few instances of post-operative inward or outward rotation of the axis of the foot in relation to the crus are entered under the groups deflexion or inflexion.

As to the non-infrequent torsion of the leg from muscular paralysis, the case-records give only rather incomplete information; so we have not made any classification in this respect. The same applies to the outward rotation in the hip that is not infrequently met with in extensive pareses.

As to the position of the arthrodesis foot in the malleolar fork — far to the back or to the front — the available informations are too incomplete for any inferences.

The shortening is given in centimeters. It is determined by placing blocks under the heel till the pelvis is straight. As a rule the shortening is equal to the heightening of the heel that has been employed. The arthrodesis does not imply any substantial increase of the shortening. We have not been able to find any rules for variations in the shortening before and after the arthrodesis.

We have found that in the arthrodetic foot a certain degree of mobility in Chopart's joint is a frequent feature, and that this gives a favourable elasticity to the foot. In estimating the firmness of the arthrodesized foot, we have therefore taken into account only the talo-crural and the talo-calcaneal joints. Undoubtedly, the benefit from the »arthrodesis operation« on Chopart's joint is chiefly consisting in a correction of the position and only to a minor degree in a restriction of the motion in this joint. (Besides, in arthrodesis of the talo-calcaneal joint it is of great help at least to have the talo-navicular joint opened.)

The bandage or the footwear which the patient uses is an indication of the serviceability of the extremity. If after the operation the patient is able to do without a bandage or go on

from orthopedic footwear to the use of ordinary footwear, it means a marked progress — and for many reasons. The bandages in question are chiefly »brace with foot capsule« and »foot-capsule with crural splints«. By »brace« we mean a supporting apparatus consisting of two long splints, one on the lateral and the other on the medial side of the extremity, connected with metal loops on the posterior surface, and kept in place by transverse leather straps on the anterior surface of the leg. The uppermost loop is resting against the ischial tuberosity. At the bottom the two splints are connected with a plate that fits the posterior part of the sole. This apparatus is equipped with a leather capsule that envelopes about one half of the leg and two thirds of the foot; it is laced in front. Thus the apparatus immobilises the knee as well as the ankle. A »foot capsule with crural splints« is constructed after the same fashion, but the splints are extending only to a little below the knee, and hence this apparatus is merely supporting the foot. A boot is to be worn outside the bandage.

Other types of braces have been used now and then, especially in earlier days; and amongst these, one may mention the crural splints that are fastened to the heel of the boot by means of a metal clamp. As these braces have been employed in cases where we now are using foot-capsules with crural splints, they are tabulated as foot-capsules.

In several instances the patients were operated on shortly after their first application for orthopedic treatment. In such cases we have tried to decide which bandage or footwear the patient ought to have been wearing according to our indications, and in working up our material we have then entered the case as if he really had been using this adjuvant.

In several instances where the arthrodesis patients have not been consulting the Clinic for Cripples for some time, it is very likely that they have gone on to use ordinary footwear. As it may be, however, that they are getting supplied with orthopedic footwear somewhere else, to be on the safe side we have put them down as using the kind of footwear last prescribed for them.

To get a survey of the operation results we have classified the cases in the following groups: 1) Functionally and anatomically good results; 2) functionally good results (anatomically not quite good); and 3) functionally (and anatomically) unsatisfactory, this group being subdivided in »improved«, »unaltered«, and »aggravated«.

»Anatomically good« applies to cases in which the outcome is complete fixation of the talo-crural and talo-calcaneal joints, the foot being in middle position in the directions mentioned. The fixation is estimated by the usual clinical examination measures.

»Functionally good« applies to the cases in which the patient now walks decidedly better than he did before, the result coming up to our expectations functionally but not anatomically. »Improved« applies to cases in which the patient now is walking better than he did before, but not as good as was to be expected from the general condition of the extremity.

Out of the 256 arthrodeses, 133 are performed through Kocher's j-shaped incision, posterior and inferior to the external malleolus; osteotomy of the fibula is done in connection with the arthrodesis operation. In the remaining 123 cases the arthrodesis operation is made transmalleolar through an oblique incision running across the basis of the external malleolus and down on the dorsum of the foot.

Throughout working-up of the material it has been divided into the two groups; »non-transmalleolar« and »transmalleolar« operations. As each of the two groups falls in separate periods (1920—24 and 1924—27, respectively), the whole operative technique as well as the indications are naturally somewhat different in the two groups. On the whole, however, we shall tabulate and discuss the two groups together, in order to make the subgroups as large as possible; and only where there might appear to be some difference between the two groups, we shall deal with the non-transmalleolar and the transmalleolar arthrodeses separately.

In the 256 patients, 111 are males and 145 females. In 17 of these cases arthrodesis is performed on both feet — in 3 of

these, however, the operation is triarticular arthrodesis on one foot and subtalo-arthrodesis on the other.

The age of the patients at the onset of poliomyelitis is given graphically in Fig. 1.

Thus the majority of the cases fall within the 3—4 first years of life, and a non-inconsiderable number of these in the first year of life.

It looks as if the result of the arthrodesis operation is almost just as good in the patients who have come under orthopedic

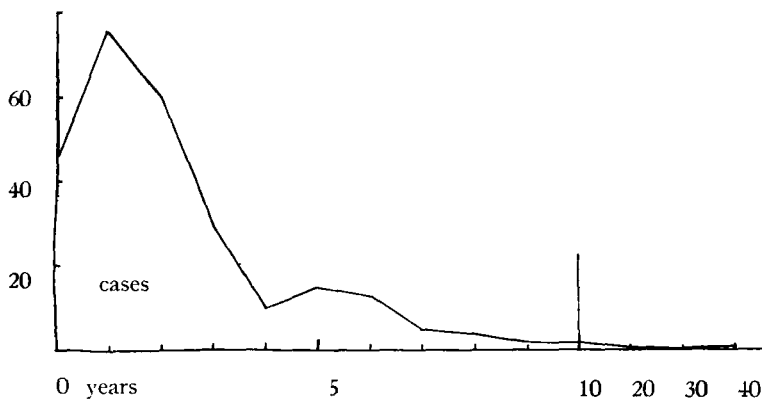


Fig. 1.

treatment relatively soon after the acute attack as in the patients coming late. About half of the patients have been admitted within 3 years.

There can hardly be any doubt that a timely bandage, which prevents too great a degree of deformity and permits of the use of the limb, is of benefit also to the result of the arthrodesis. When nevertheless we are unable to point out any difference in the results on this account, the reason may probably be that as a rule it is the relatively mild cases which hesitate in submitting to orthopedic treatment.

The age of the patients at the time of the arthrodesis operation is given in Fig. 2.

It will be noticed that the age of 13—16 years is by far the most frequent. This fact has been accentuated in the later years; but, at the same time there seems to be a tendency to perform

the operation a little later than before (taking the patients that are operated on before their 20th year, the average age is 15 years in the first group, 15.6 years in the last group).

This change in the age has not been intentional, however; nor has it been indicated, as will be pointed out later.

The age limit for the arthrodesis has been established on the score of various considerations. For one thing, one has to insist upon a certain degree of development of the bones — i. e., a certain age which we are now putting at 12 years. Below this limit, we have operated on one patient of 9 years and a few of

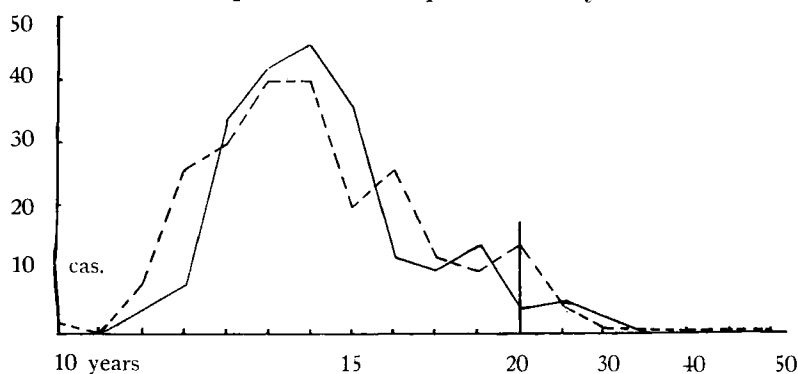


Fig. 2.

Age of patients at time of arthrodesis operation. — Non-transmalleolar operations. - - - - Transmalleolar operations.

11 years. In a number of cases the X-ray examination of the ossification centres has been decisive of the time of operation.

In the next place, it is often desirable to perform the operation during the period between the end of the school-days and the beginning of apprenticeship. In a few cases the operation has been postponed til the patient has finished his apprenticeship.

Finally, it may happen that the deformity of the foot is getting worse at such an age that one has to choose between the performance of the operation a couple of years before it was intended or to submit the patient to an operation for correction of the position and subsequent arthrodesis operation some years later.

The *observation period* from the time of the arthrodesis operation averages 5.7 years in the first group, 3.7 years in the last group.

The *position of the foot and the muscle power prior to the operation* are given in

Table 1.

	Valgus		Middle	Varus	
	Marked	Slight		Slight	Marked
Non-transmall.	6	34	38	36	19
Transmalleolar	16	15	42	24	26
Total	22	49	80	60	45

	Calcaneus		Middle	Equinus	
	Marked	Slight		Slight	Marked
Non-transmall.	8	14	49	45	17
Transmalleolar	9	8	56	34	16
Total	17	22	105	79	33

Leg muscles	0	+	++		
Non-transmall.....	56		12		
Transmalleolar	52		14		
Total	108	122	26		

The two groups, non-transmalleolar and transmalleolar operations, come out very near alike.

Varus and equinus are the most frequent deformities, calcaneus the most infrequent. The most frequent combination is equinovarus; next comes calcaneovalgus.

Table 2.

	Valgus		Middle	Varus		Total
	Marked	Slight		Slight	Marked	
0	7	19	45	27	10	108
Muscle +	12	26	32	30	22	122
power ++	3	4	3	3	13	26
Total	22	49	80	60	45	256

As shown in table 2, vigorous muscles have generally given varus deformity, whereas weak muscles have naturally brought about a foot in middle position.

As to the *thigh muscles*, the tabulation shows:

Muscle power	0	+	++	+++	Total
Number of cases	10	48	81	117	256

The hip muscles:

Muscle power	0	+	++	+++	Total
Number of cases	14	32	65	145	256

Weak thigh or hip muscles — i. e., thigh or hip muscles 0 or + — are found in 76 cases.

As a rule the power of the leg muscles is a little more impaired in the cases which show a marked impairment of the thigh and hip muscles. The degree of the foot deformity comes very near to the average.

A number of the patients have previously been submitted to operative treatment. This consisted in:

Lengthening of the tendo Achillis	24
Shortening of the tendo Achillis	5
Lengthen. of t. Achill. w. transpl. to peronei	2
Tenodesis	35
Tenotomy	10
Transplantations	65

Total 141 patients.

In the great majority of these cases it was the very relapse of the old deformity that constituted the indication for the arthrodesis operation. Here we shall not attempt to estimate the value of these operations. Still, there is no doubt that these operations have been required in several of the cases in order to adapt the foot to wear a foot-capsule till the patient reached the arthrodesis age.

Turning to the operation results, we may tabulate the material as follows:

Table. 3.

	Non-transmall.	Transmall.	Total
Function. and anat. good	63	64	127
Only functionally good	41	44	85
Improved	25	10	35
Unaltered	4	3	7
Aggravated	0	2	2
	133	123	256

	Non-transmall.	Transmall.	Total
Laxity of talo-crural joint ...	1	2	3
Laxity of talo-calcan. joint...	2	1	3

	Before	After	Before	After	Before	After
Marked valgus	6	3	16	6	22	9
Slight valgus	34	14	15	13	49	27
Middle	38	79	42	79	80	158
Slight varus	36	32	24	22	60	54
Marked varus	19	5	26	3	45	8
Marked calcaneous	8	0	9	0	17	0
Slight calcaneous	14	20	8	7	22	27
Middle	49	110	56	112	105	222
Slight equinus	45	3	34	3	79	6
Marked equinus	17	0	16	1	33	1

It will be noticed that the varus deformity of the arthro-detic foot is more frequent than the valgus deformity. It is somewhat less frequent in the transmalleolar operations, which, for one thing, is quite in keeping with the fact that in the later years we have on purpose been inclined to over-correction toward valgus, because the varus is more frequent and more unfavourable than the valgus.

The calcaneus deformity is more frequent than the equinus. This difference is less pronounced in the transmalleolar operations than in the first group.

Table 4.

	Non-transmall.	Transmall.	Total
Slight deflexion	0	1	1
Slight inflexion	11	8	19
Marked inflexion	4	3	7

It appears too as if the inflexion is more infrequent in the last group.

Table 5. Bandages and footwear.

	Non-transmall.		Transmall.		Total	
	Before	After	Before	After	Before	After
Brace	25	1	12	0	37	1
Foot-capsule	74	3	61	4	135	7
Total	99	4	73	4	172	8

	Non-transmall.		Transmall.		Total	
	Before	After	Before	After	Before	After
Orthoped. footwear	29	72	44	87	73	159
Flat-foot plate	5	18	1	4	6	22
Ordinary footwear	0	39	5	28	5	67
Total	34	129	50	119	84	248

Thus, in 164 out of 172 cases (about 95 percent) the patient has been freed from his former bandage.

As to the use of ordinary footwear, the transmalleolar cases are faring relatively unfavourably. Undoubtedly, this is chiefly due to the fact that the observation period of this group is shorter than that of the first group. For it is found that many patients do not go over from orthopedic footwear to ordinary shoes til 3—4 or more years after the operation.

The outcome of the comparison between the two groups will then be that upon the whole, a better result is obtained with the group that is designated as transmalleolar operations. But, it is very likely that also other technical improvements, increased experience and routine are largely contributory to this difference.

We shal then go on to consider the importance of various other factors to the result.

As already mentioned, weak thigh and hip muscles were found in 76 cases which did not differ particularly from the average as to leg muscles and position of the foot.

In comparing these 76 cases with the total material we find:

Table 6.

	Group of 76	Total material, 256
Function. and anat. good	49	127
Only functionally good	17	85
Improved	7	35
Unaltered	2	7
Aggravated	1	2
Laxity	2	6
Marked valgus	4	9
Slight valgus	9	27

	Group of 76	Total material, 256
Slight varus	8	54
Marked varus	1	8
Slight calcaneus	5	27
Equinus	0	7
Inflexion	1	26

	Before	After	Before	After
Brace or capsule	60	3	172	8

So in this group of 76 the operation result falls in no ways below the average of the entire material, neither as to function nor with regard to the position of the foot.

Extremities with a shortening of 4 cm or more — a total of 80 cases.

Table 7.

	Group of 80				Total material, 256			
Muscles	0	+	++	+++	0	+	++	+++
Leg	48	25	7		108	122	26	
Thigh	8	10	24	38	10	48	81	117
Hip	7	25	25	23	14	32	65	145

This shows that there are comparatively many extensive paralyses, and that a marked shortening is by no means equivalent to very extensive paresis.

Table 8.

Operation result:	Group of 80	Total material, 256
Function. and anat. good	36	127
Only functionally good	31	85
Functionally unsatisfactory	13	44
Laxity	0	6
Valgus	15	36
Varus	16	62
Calcaneus	8	27
Equinus	2	7
Deflexion	1	1
Inflexion	7	26

	Before	After	Before	After
Brace or capsule	66	2	172	8
Orthoped. footwear	13	64	73	159
Foot-plate	0	4	6	22
Ordinary footwear	1	10	5	67

In the group of 80 the result does not differ noticeably from the rest of the material. Naturally it is only comparatively few of these individuals that are using ordinary footwear. Still, there are 10 who by doing so have given up having the shortening balanced. This may happen for various reasons; one may do so for the sake of vanity, another will do it for economical reasons (expensive travelling), while others will do it because an ordinary boot fits more securely than does a very high shoe. The last point of view may be warrantable when the position of the foot is not quite good. In insufficiency of the *glutæus medius* it may also be advantageous not to balance the whole shortening; by this the patient can more easily put his weight over on the disabled side. On the other hand, there can be no doubt that the risk of scoliosis in youth and static pains in a more advanced age is a warning not to neglect the shortening too much.

The significance of the age at the onset of poliomyelitis.

Table 9.

Operation result	Age at onset of poliomyelitis					Total
	< 1 y	1 y	2 y	3 y	?	
Function, and anat. good.....	13	35	30	41	8	127
Only functionally good.....	5	32	22	26	0	85
Functionally unsatisfact.	5	9	7	20	3	44
Total...	23	76	59	87	11	256

There is no distinct difference in the results. As far as that goes, one might have been inclined to expect that poliomyelitis in the early age would give some more accentuated trophic changes in the bones together with a lower capacity for regeneration.

Significance of the age in the arthrodesis operation.

Table 10.

Operation result	Age at operation			Total
	< 15 y	16-20 y	> 20 y	
Function, and anat. good.....	74	37	16	127
Only functionally good.....	51	26	8	85
Functionally unsatisfact.....	14	16	14	44
Total...	139	79	38	256

In this classification of the material we meet with greater differences in the groups than in any of the other tabulations. In percentage the group of 16—20 years shows twice as many unsatisfactory results as does the group of operations within the age of 15; and this percentage of unsatisfactory results is doubled once more in the group of patients operated on after their 20. year. Thus there seems to be every reason to consider the age of 12—15 years the most suitable for the operation and, in particular, not to postpone the question of arthrodesis, because »it is early enough to settle this later«.

Cyanosis or chilblains of the leg (marked degree) was present before the operation in 18 cases. In these the operation results were: 6 functionally and anatomically good, 5 only functionally good, and 7 functionally unsatisfactory. Although these numbers are small, they probably indicate, we think, that cyanosis and chilblains are frequently associated with trophic disturbances of the bones which involve a risk to the result.

One would be inclined to think that by increasing the use of the foot the arthrodesis might influence the circulation to such an extent that cyanosis and chilblains would be less frequent or less extensive. The statements of the patients, however, are just as often to the effect that the trophic disturbances have been aggravated as that they have improved.

The anatomical result.

As already mentioned, 3 cases showed laxity of the talo-crural joint, and in 3 cases there was laxity of the talo-calca-

neal joint. In these 6 cases there is nothing particular to be said of the poliomyelitis age or the arthrodesis age. The power of the hip and thigh muscles was about average; in the leg muscles, on the other hand, it was 0 in 5 cases, and + in only 1 case. Before the operation the deformity was valgus in some cases, varus in others.

The result was functionally good in 1 case of talo-crural laxity and in 2 cases of talo-calcaneal laxity.

In one case, rearthrodesis was performed 6 years after the first operation, but the outcome was a relapse of the laxity.

In this patient, by the way, talo-crural arthrodesis was done at the same time on the other foot where previously talo-calcaneal arthrodesis had been performed — in this foot too without any resulting fixation, so that it is reasonable to assume that special individual conditions are asserting themselves in this case.

In the case-records there is nothing to indicate that the patients have ever made any direct complaint of the immobility of the ankle.

Fig. 3 gives a survey of the valgus or varus relapses after the operation. In the main, their outcome is that middle position is obtained in about half of the cases, and that relapse of the pre-operative deformity is more frequent than development of the opposite deformity. In cases with marked varus before the operation, about one half will relapse into varus after the operation — although, as a rule, to a lower degree. The results are somewhat better in the transmalleolar operations than in the others. Still, there is every reason in the arthrodesis operation to make a marked overcorrection of the varus deformity as we have been doing.

In the 176 cases of pre-operative varus or valgus, the post-operative position of the foot had improved in 127, kept unaltered in 44, and been aggravated in 5. Out of the 80 cases with the foot in middle position before the operation, 23 went on to valgus or varus after the operation.

So one may promise the patient with a fair degree of certainty that the arthrodesis operation will give him firmness and stability in the foot and most likely free him from bandage. But, on the other hand, one has to be more reserved as to the improvement of the position which the patient may reasonably expect from an arthrodesis operation.

Relation between deformity and power of leg muscles.

Table 11.

Post-operative position of foot	Muscle power			Total
	0	+	++	
Marked valgus	5	4		9
Slight "	11	14	2	27
Middle	69	71	18	158
Slight varus	21	27	6	54
Marked "	2	6		8
	108	122	26	256

As far as one may judge, the valgus or varus deformity of the arthrodetic foot is less frequent when the leg muscles are vigorous than when these muscles are flaccid or non-vigorous.

Thus it looks as if it is not the direct pull of the muscles that brings about an eventual relaps into the old deformity. It is most likely, we think, that fairly vigorous muscles bring on a better development of the bones, and that this contributes to a better result of the operation.

Relation between side-deviation and function.

Table 12.

	Valgus		Middle	Varus	
	Marked	Slight		Slight	Marked
Functionally good	4	9	148	38	3
Funct. unsatisfactory	5	8	10	16	5

Upon the whole, varus is the most frequent deformity and correspondingly the most frequent cause of an unsatisfactory result. Judging from the figures for the functionally unsatisfactory results, varus appears about equal to valgus in impairment.

Relation between side-deviation and bandaging.

Table 13.

	Valgus		Middle	Varus	
	Marked	Slight		Slight	Marked
Brace or foot-capsule	1	2	3		2
Orthopedic boot	8	15	92	38	6
Foot-plate		3	13	6	
Ordinary footwear		7	50	10	

Varus and valgus are thus about alike in their requirements of bandaging.

When, nevertheless, we consider the varus deformity more unfavourable, it is partly because it is harder to make a suitable boot for a varus foot, and partly because a patient with varus will try to make up for this deformity by walking with the legs abducted influencing the knee toward genu valgum, whereas a patient with valgus for practical reasons is prevented from compensating this deformity by adduction of the leg in walking, so that he puts the weight on the extremity through its axis.

Equinus deformity.

Table 14.

Operation result:	Calcaneus		Middle	Equinus	
	Marked	Slight		Slight	Marked
Functionally good	0	17	191	4	0
Funct. unsatisfactory	0	10	31	2	1

Upon the whole, equinus deformity is more infrequent than side-deformity, but it may be just as damaging to the function.

*Inflexion deformity.**Table 15.*

Operation result:	Deflexion Middle		Inflexion	
	Slight		Slight	Marked
Functionally good	1	193	16	2
Funct. unsatisfactory	0	35	3	5

Thus inflexion deformity is also more infrequent than varus; it may be very troublesome.

Table 16.

Pre-operative deformity	Post-operative position			
	Deflexion Slight	Middle	Inflexion	
			Slight	Marked
Marked valgus	1	21		
Slight "		49	2	2
Middle		73	6	1
Slight varus		56	4	
Marked "		34	7	4

Inflexion develops mostly in feet that were in varus position before the operation. In the operation, one will then have to take this point into account.

*Bandaging before and after the operation.**Table 17.*

Before operation	After operation				
	Brace	Foot- capsule	Orthoped. boot	Foot- plate	Ordinary footwear
Brace..... 37	1	2	23	3	8
Foot-capsule 135		3	91	8	33
Orthoped. boot.... 73		2	39	9	23
Foot-plate 6			2	2	2
Ordinary footwear. 5			4		1
Total... 256	1	7	159	22	67

In 46 cases, the patient has been wearing the same bandage or footwear before and after the operation. In 2 instances, the

patient was able to get along with orthopedic footwear before the operation, whereas he had to use capsule after the operation. In 172 patients, who were wearing brace or capsule prior to the operation, 166 were enabled to do without this support.

Pains.

Many patients complain of pains in the arthrodetic foot. As a rule, however, the pains appear only after marked exertion. These pains show a tendency to disappear after some years; but, we think, one is not justified in promising anything definite in this respect. The pains are mostly localized to the instep, and surprisingly seldom to the balls of the toes. In view of the fact that only a few of the poliomyelitis patients are complaining of pains apart from the discomfort which the pressure of a bandage may give, it is a frequent disappointment that after the operation a patient is often complaining of pains.

Capacity for walking.

It is naturally impossible to lay down any general rule as to the eventual capacity of these patients for walking. But it is by no means an infrequent occurrence that the patient declares that he »is able to walk any distance«, or that he »walks just as well as anybody else«.

The cosmetic result

is not infrequently so good that it takes a watchful eye to discover any peculiarity in the gait of the patient — provided, of course, that the muscles of the knee and the hip are not impaired too much from paresis.

The unsatisfactory results.

We have tried to estimate what might be the main trouble in the cases where the operation result was unsatisfactory or altogether bad.

In some cases definite anatomical relations were found to constitute the main cause:

Table 18.

	Number of cases
Laxity	1
Inflexion	4
Varus combined with inflexion	3
Varus	7
Valgus	3
Marked shortening combined with varus, valgus, equinus, or calcaneus	6

In the remaining cases it was more difficult to make out the principal shortcoming. None of them were anatomically satisfactory; and, besides, in several cases there were complaints of trophic disturbances (chilblains and coldness) or pains. In several of these cases, both extremities were rather markedly paretic.

Technique of operation.

The technique has been modified in several ways, also apart from the modification involved in the introduction of the trans-malleolar incision.

Thus, in recent years, we have paid particular attention to the avoidance of varus and inflexion, especially in cases of pre-operative varus deformity.

In the first 28 cases operated on, the arthrodesis did not include the calcaneo-cuboid joint. After the operation there developed a slight degree of inflexion in 6 of these cases. Between the 256 cases, there was slight deflexion in 1, slight inflexion in 19, and marked inflexion in 7. Thus these deformities were relatively very frequent in this little group, so there is a good indication, we think, for including the calcaneo-cuboid joint in the arthrodesis.

In the non-transmalleolar operation through the Kocher incision, the skin had to be loosened in part from the underlying structures. In the cases operated after this method, necrosis of one or both edges of the wound developed in 25; in the majority of these, the necrotic process was insignificant, but in one of these the wound stayed open for about 3 years.

After the introduction of the transmalleolar method, necrosis of the wound edges has developed only a couple of times,

and only to a slight degree. In one of these cases the necrosis was due to a tampon left in the wound. When it was removed, the wound healed, but with the foot in varus. Wedge resection was later performed — with good result.

In 7 cases arthrodesis operation has been performed on the least affected limb, while the patient kept on using brace on the leg that was most damaged. In 3 of these cases the condition is functionally and anatomically unsatisfactory. In 2 cases the result is satisfactory as far as the arthrodesis is concerned, but the patient is still walking poorly on account of extensive paresis. Only in 2 cases was the result truly satisfactory to the patient.

As already mentioned, bilateral arthrodesis is performed in 14 cases. In 6 of these the result is functionally unsatisfactory.

Thus the arthrodesis appears to be less promising when both extremities are markedly impaired. On the other hand, as mentioned before, the result of the operation does not appear to be jeopardized by the fact that one extremity is badly impaired.

In several cases the arthrodesis operation has been supplemented with plastic tenotomy when it was thought that the muscle pull would eventually reproduce the malposition. These tendon operations are given in

Table 19.

Achillotomy or Allong. Achillis.....	8 times
Tenotomy of Tib. ant.	6 times
Transplant. of Tib. ant. to forefoot or Extensor comm....	7 times
Tenodesis of the extensors of the foot	12 times

One can not draw any conclusions as to the significance of these measures — for one thing, because the figures are so small.

Combination with other operations.

In 9 cases arthrodesis of the foot has been combined with plastic operation on the quadriceps, and in 9 cases with arthrodesis of the knee. This gives a natural explanation why 18 out of 37 patients, who are wearing braces before the operation,

have been able to do without this support after the operation (cf. table 17).

The remaining 18 patients, who have been wearing braces before but not after the operation, had some paralysis of the thigh and hip muscles, but not more than that they were just on the point of being able to do without any support of the knee. Still, as long as they had to be wearing the heavy foot-capsule, we thought it better to supplement the capsule with a brace.

On the other hand, in these cases, the muscles appeared to be powerful enough to control the motions of the knee and hip when the extremity was relieved of the heavy foot bandage by means of the arthrodesis operation, without detracting from the stability of the foot. Finally, one might imagine that an arthrodetic foot would rest more securely in its boot than a deformed foot in its foot-capsule (the capsule lying inside a boot), and that the arthrodesis operation would therefore improve the stability of the extremity; still, there is hardly any particular difference in this respect. Besides it might conceivably be of some significance to the result that in the arthrodesis the triiceps suræ is made a »one-jointed« muscle through the fixation of the calcaneus in relation to the leg, so that its extension power on the knee is better utilised.

Anyhow, the fact remains that in this group there is but one patient who has had to keep on with his brace.

In 6 cases the patient has undergone a wedge resection for correction of the arthrodetic foot some years after the operation. In 4 of these cases the malposition was varus, in 2 it was inflexion. The results of these corrections have been satisfactory.

As already mentioned, rearthrodesis has been performed once -- without resulting in fixation as late as 10 months after.

SUMMARY

After-examination is made of 256 cases of triarticular arthrodesis of the foot (art. talocalcanealis, art. talocalcanea, and Chopart's joint). The indications and the technique have largely been the same throughout apart from the fact, that in 133 cases the operation is performed through the arcuate Kocher

incision posterior to the external malleolus, while in 123 cases the entrance to the joints was effectuated through a temporary resection of the external malleolus (transmalleolar method).

In all the cases the observation period has been at least 2 years. The various positions of the foot resulting from this treatment have been tabulated and their respective frequency computed.

250 cases show fixation of the talo-crural and talo-calcaneal joints (3 show laxity of the upper joint, 3 of the lower joint).

In this material of 256 cases the result is functionally and anatomically good in 127, functionally good in 85, while the condition is improved in 35, unaltered in 7, and aggravated in 2. As to the value of the operation relative to the improvement of the position, the reader is referred to table 3.

Out of 174 patients who before the operation had to wear a bandage, 164 have now been enabled to do without any bandage. Before the operation only 11 patients could get along on ordinary footwear (and 6 of these had to use foot-plate), whereas now 89 are walking about in ordinary shoes (22 of these, however, have foot-plate). (Cf. table 5).

It is found that the result is not affected to any particular extent even though the thigh and hip muscles be somewhat impaired; nor is the result affected by a shortening of more than 4 cm.; and the age of the patient at the onset of poliomyelitis has no influence whatever on the arthrodesis operation. On the other hand, the age of the patient at the time of the arthrodesis operation seems to be of some significance to the final outcome, as the best results are obtained with operation at the age of 12—15 years (cf. table 10).

But rarely the arthrodesis operation is performed before the age of 12 years.

As to the difficulties in the correction of the side-deviations, the reader is referred to Fig. 3, which shows that the relapse most frequently is bent toward the pre-operative type of deformity, less frequently in the opposite direction. A middle position is obtained in more than half of the cases.

The varus deformity is the hardest to correct.