

TENDON TRANSFERENCE IN POLIOMYELITIS

By

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Tendon transferences have been used with more or less success in the treatment of poliosequelae, for the last 75 years. There has been much discussion about the value of these operations in the years past, but tendon transference is today generally recognized as a useful means of treatment in selected cases of poliomyelitis. The experience gained has led to certain requirements as to the indications and technical details, which must be fulfilled if the operation is likely to be successful:

A fixed deformity must be corrected before transference, and there must some be free passive motion in a joint which is going to be moved by the transferred muscle.

Full power preoperatively in the muscle whose tendon is going to be transferred.

The transferred muscle should have approximately the same amplitude as the muscle it is going to substitute.

The line of pull must be as direct as possible.

Firm attachment of the transferred tendon, preferably into bone.

The tension in the transferred muscle should be nearly 0 when the muscle origin and the new attachment are approximated as much as possible.

Plaster fixation in the corrected position for 3–5 weeks p.o. Functional after-treatment.

There is however not general agreement about certain points in technique and indications. 1. How should the transferred tendon be placed. 2. Indication for tendon transference in children and 3. Should

the tendon transf. be performed on the foot, without stabilizing operations?

1. It is evident that the gliding mechanism of the tendon must be preserved if an optimal functional result of the transference is to be expected. Biesalsky and Mayer published in 1916 their monography on tendon transference, based on careful anatomical and functional observations, and suggested their own physiological tendon transference technique. They tried to preserve the gliding mechanism by placing the tendon subfascially in another tendon or muscle compartment. This technique has since then been much used, and is still considered the best by many authors, especially in the U.S.A. (Reidy, Broderick & Barr 1953). Strict adherence to this operative technique is however apt to limit the possibilities in tendon transference (M. Lange). The subcutaneous rerouting of the transferred tendon has therefore also been widely in use ever since tendon transference was introduced. The tendon is by this method provided with a satisfactory gliding mechanism, if the incisions are so placed that the tendon will not be adherent in a scar. (This technique is used in most of the cases to be presented in this article).

2. Tendon transference in children and 3. tendon transference on the foot and about the ankle without stabilising operations, must be considered together. It has in the U.S.A. been commonly accepted that the best results after tendon transference on the foot are to be expected when the transference is combined with a stabilising operation. But bone surgery is not advisable in a growing foot. If the American standpoint is to be followed strictly, children are excluded from this type of treatment. Thus the majority of patients with muscle imbalance in the foot, are deprived of the possibilities which the tendon transference can offer.

If we on the other hand accept tendon transf. even in very young children, we must accept this method of treatment as an independent procedure. Stabilising operations, if needed, must be postponed 5-10 years. Many authors have from time to time warned against tendon transf. in children and suggested age limits for these operations. Reidy, Broderick & Barr thus presume that operations done before the age of eleven are likely to be unsuccessful while others think that it is preferable to delay operation until the age of five because muscle charting is difficult in younger children (Mortens & Pilcher). Kuhlmann & Bell advise the same age limit and do tendon transf. in younger children only when there is a rapidly progressive deformity. Green & Grice

advise these operations in children (without mentioning age) and hold that in many cases stabilising operations can be avoided later on.

Mortens & Pilcher (1956) came to the same conclusion after re-examining a series of tendon transferences without stabilising operations.

Theoretically, the reason for operating children is clear. We know that deformity in the foot is the result of muscle imbalance. We know further that the serious (gross) deformity usually develops in the growing foot, where the deforming force produces structural deformity (remodelling) of bone. Muscle imbalance arising early in childhood, causes a more severe deformity than does paralysis towards the end of growth. Th. Rosendal 1955 finds that pes calcaneus only is developed in the growing foot. We find analogous circumstances in the paralytic scoliosis (James).

If muscle balance could be restored or the deforming force be reduced, we might expect to prevent further development of the deformity, or to correct it more or less. Braces and splints can not correct or prevent a deformity, and even an arthrodesis would fail if the deforming force persists. The only possibility left in younger children, is to try tendon transference in cases with muscle imbalance, where useful musculature is available for transfer. We must of course realize that this treatment in some cases is not sufficient and that further surgery (stabilising operations) may be necessary at the end of growth. Altogether we must face the fact that these operations in more or less paralyzed extremities can never be ideal, and we must not expect too much from them. The improvement attained occurs always at the sacrifice of another and less important function (this holds good for bone surgery too).

If tendon transferences are performed with this reservation, the same reservation must be taken into consideration when the results are evaluated clinically. This evaluation depends of course on the criteria upon which it is based. It would not be right to put forth normalizing of the condition as a claim for excellent result. The standard for comparison must be the improvement expected before operation. One must therefore compare the post-operative with the pre-operative situation in each case, and see to which degree the desired result has been accomplished. In this way a little improvement may be classified as a good result.

The evaluation of the result after tendon transference is sometimes difficult, especially when other forms of surgery have been done at

the same time. It is known that a paretic m. tib. ant. may improve (gain in power) after the correction of an equinus deformity, probably because it then can work in a more optimal range of amplitude. If the tendon of the ext. hall. long. had been transferred to the first metatarsal bone at the time of the heel cord lengthening, the whole improvement in the dorsiflexion of the foot might be attributed to this tendon transference, which would not be correct. Another example: If the deforming pull of a muscle is transferred to its antagonists, it is afterwards difficult to say to which degree the result is caused by alleviating the deforming force or by the new active function of the transferred tendon. Relations like these must be taken into consideration when the results are evaluated. The same reservations hold good also when more exact measurement is applied in the assessment (electromyography, dynamometry). At Vanföreklinikken, Sophies Minde, Oslo, tendon transferences after polio have been performed sporadically since this clinic was established in 1927. After the last war there has been a steadily increase in the number of transferences. This is caused mostly by a more active attitude to this form of treatment from our side. There seems to be no correspondence from year to year between the epidemics and the number of patients operated upon.

Our operative technique has not changed much in this period, but it should be mentioned that we are more scrupulous than before about secure fixation of the transferred tendon into bone. The transferred tendon is nearly always placed subcutaneously. We have mostly operated upon children and have very few combinations of tendon transf. with stabilization. We have no age limit. To get an impression of our results after tendon transferences, I made a follow-up study of the patients operated upon during the 10 year period 1945-54, in this clinic. In all 120 patients had tendon transference performed in this period, 112 of which have been followed up by personal interviews, that is 93 %. These 112 patients represent 185 tendon transf. on 138 extremities. There were 61 males and 51 females. Average space of time between polio and operation was 7 years and 3 months. In 3 cases we operated about one year after the acute stage of polio. Average age at operation, 11 years 10 months, while the youngest patient was 2 years 3 months old. Other forms of surgery to correct deformity, concomitantly with tendon transf. (fascio-myotomy, lengthening of the tendo achilles) were performed 45 times.

Arthrodesis in combination with the tendon transf. was performed 12 times, 10 of which were in the age group 16 years or more. I have

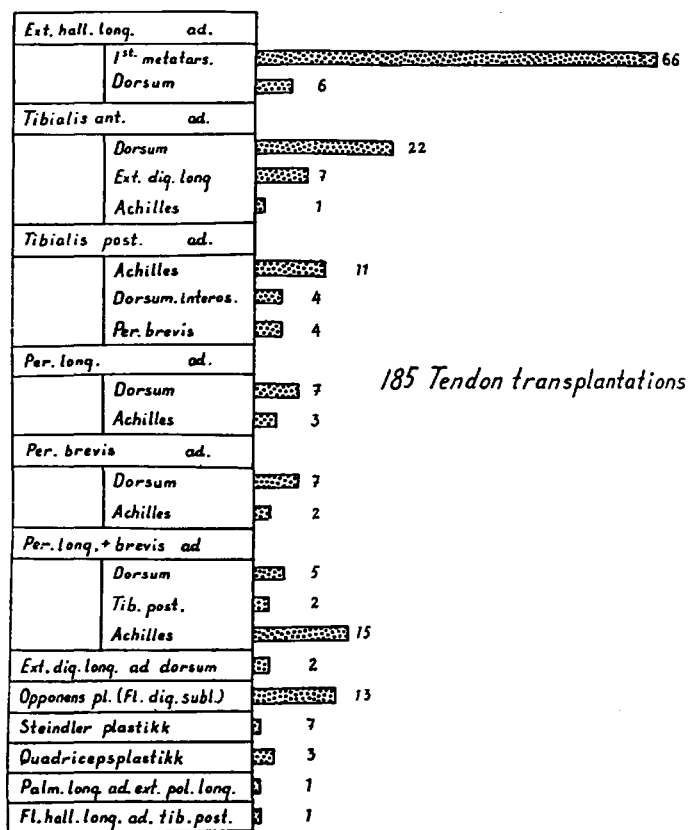


Fig. 1.

tried to get a follow up period of at least 1 year, but have in this series included 3 patients with 6, 8 and 9 months observation, respectively.

The average follow-up period is 2 years and 8 months.

Postoperative complications: 3 times delayed wound healing.

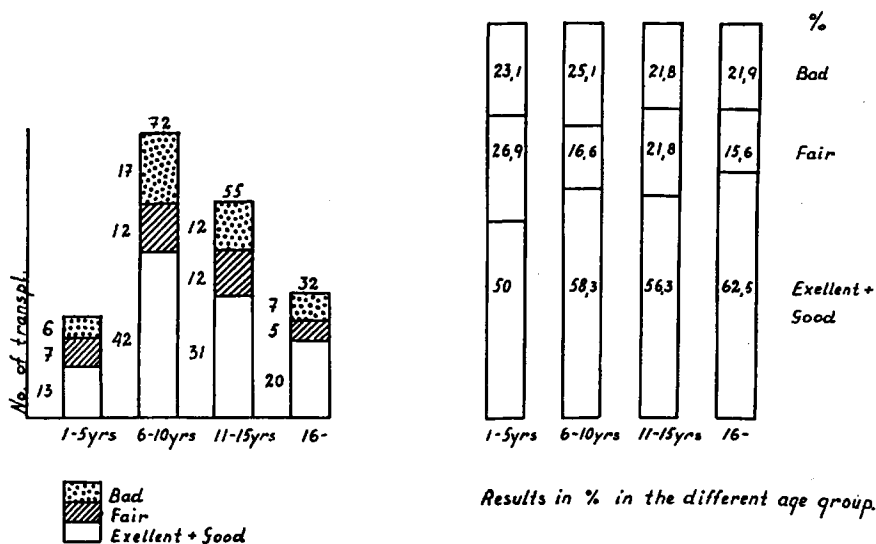
Late complications: 5 times drop of the first toe after transf. of the ext. hallucis. long. to 1st metatarsal (failure of the tenodesis).

18 times the tendon failed to maintain its new attachment.

I 31 cases the transferred muscle, considered normal before operation, lost more or less of its power.

Muscle charting is done pre- and postoperatively.

In the follow-up examination I have tried to evaluate each transferred tendon separately. When the peroneals are transferred at the same time and to the same insertion, they have been evaluated together.

Results of tendon transplantations in different age groups.*Results in % in the different age group.***Fig. 2.**

As mentioned before I have used the preoperatively expected result as a standard for comparison and have classified the results according to this. Excellent means that the result comes up to or is better than expected. Good: satisfactory, but not as good as hoped for. Fair: some effect from operation, but not good. Bad: No effect or benefit from the operation.

The result in the whole series is 30.27 % excellent, 27.56 % good, 19.45 % fair and 22.72 % bad. Chart. 1 demonstrates the number of transferences. The majority of the transferences are at the ankle and foot: 167 of the total of 185.

Chart. 2 demonstrates the distribution of tendon transferences in the different age groups. This shows that most of the tendon transf. are performed in children. We have 26 transf. in the age group 1-5 years, 72 in the age group 6-10 years, 55 in the age group 11-15 years and only 32 in the group 16 years or more. There is no significant difference in the results in these groups, excellent + good ratings lying between 50 and 62 %. The bad results are very constant in the different age groups, varying from 22 to 25 %.

In the age group 16 years or more with an excellent + good rating

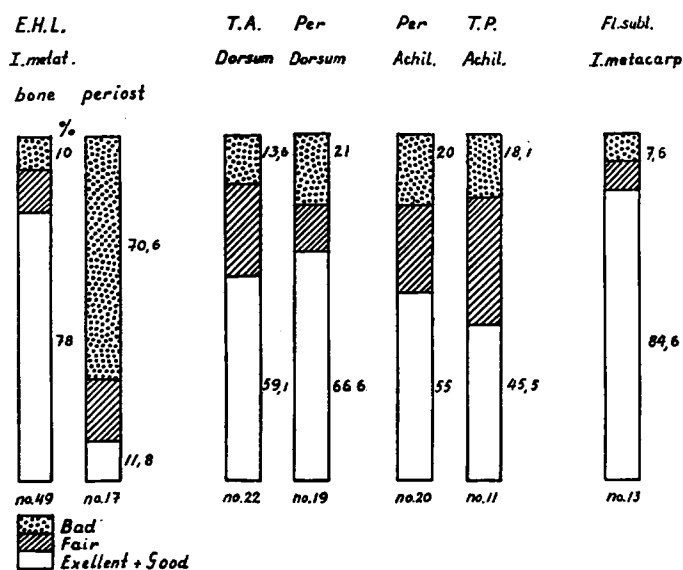
Results in the main groups of the transplantations

Fig. 3.

of 62 % there have been done 32 tendon transf. on 19 patients. 10 of the stabilizing operations in the whole series will be found in this group, and there can be no doubt that this has influenced the result.

Some types of tendon transference give better results than others and one must therefore analyze the different types. Chart. 3 gives a survey of the results in the main groups in this material.

Ext. hal. long to the first metatarsal has been transferred most frequently, in all 66 times. The indications have been "cock up" deformity of the first toe or to improve dorsal flexion of the foot or to prevent development of a cavus deformity with a metatarsus primus flexus, or a combination of these. In a few cases it has been used for a valgus deformity with a weak tib. ant. For a certain period the tendon of E. H. L. was not cut but only attached to the periost of the metatarsal. However, it became soon evident that this fixation was not satisfactory. We now always anchor the tendon to the metatarsal through a drill hole and make a tenodesis in the interphalangeal joint.

The result was bad in 70 % when the tendon was not attached to bone, while the result was excellent and good in 78 % in the cases where secure fixation had been done. (Chart. 3 the first 2 columns)

5 times, that is in about 10 %, the tenodeses in the interphalangeal joint failed.

6 times the E.H.L. was transferred to another metatarsal. Results: 1. good, 1. fair and 4. bad. The cause of the failures was twice insecure fixation of the tendon, once transference of a paretic E.H.L. and once loss of muscle power after transference.

The tib. ant. tendon was transferred to the lateral border of the foot 22 times. The indication for this operation was varus or equino-varus deformity of the foot. In three of these cases bone stabilisation was performed at the same time. The result was excellent + good 13 times, fair + bad 9 times. Among these 9 cases the muscle had lost most of its power after operation twice, insecure fixation was the cause of failure once, rupture of the tendon after accident once and the tendon placed too medially once. In the rest of the failures the deformity persisted although the transferred tendon worked. In some of these cases the tendon was probably anchored only to the peroneus brevis tendon which yields during contraction. In one case the operation resulted in overcorrection, a shift from varus to slight valgus deformity which was easily controlled by an arch support.

The tendon of the paretic tib. ant. was suspended in the tendon of the extensor dig. long., 7 times (Chart. 1. tib. ant. ad.). There was one success and 6 failures. We do not use this operation any more.

Only once in this material was the tendon of the tib. ant. transferred to the tendo Achilles for pes calcaneus. The result was excellent.

The peroneal tendons were transferred to the dorsum of the foot 19 times. (per long. 7, per. brev. 7, per. long. + brevis 5). These transferences were done for valgus and equinus deformity and are in some cases combined with transf. of the E.H.L. to the first metatarsal. 12 times the result was excellent or good and 7 times fair or bad. The result is best when both are transferred. Alone the peroneus long. gives a better result than peroneus brevis. Among the failures the preoperative power in the transferred muscle was reduced 2 times, and in 2 cases the muscle had lost most of its power postoperatively. Peroneals to tendo Achilles: This operation was performed 20 times. Usually both were transferred together (15 times). The indication has been pes calcaneus. Where the tib. post. had sufficient power it was transferred at the same time to the Achilles tendon. The tendons have not been attached to bone (calcaneus). Result: excellent + good 11 times and fair + bad 9 times: The result is best where both peronei are transferred at the same time and in combination with the tibialis

post. We have not noted instability after these operations, except for one moderate valgus deformity. Of the 9 failures 5 were probably caused by the transf. of preoperatively too weak muscles (paretic) and in 2 cases the reeducation of the transferred muscles had not been successful. In one case where the peroneals had only been attached to the tendo Achilles by sutures, without being cut, the fixation had of course been insufficient and the muscles had regained their normal function.

The tendon of the m. tib. post was transferred to the tendo Achilles 11 times and as a rule in combination with the peroneals. Indication, Pes. calcaneus. The evaluation of the results is difficult. 5 have been rated as excellent + good, 6 as fair + bad. Tib. post. was transf. to the dorsum of the foot 4 times through the membrana interossea. Indications were pes equinus and equino-varus. In every case the postop. power was satisfactory, but the amplitude of this muscle is too small to give a normal range of dorsiflexion. According to Bielsalski and Mayer the tib. post. has an amplitude of only 2 cm in adults, while the dorsiflexors of the foot have amplitudes from 3 to 5 cm (tib. ant. and E.H.L.). It would therefore seem reasonable to attach the tendon of tib. post. far back on the dorsum (near the axis of movement) to increase the range of movement. The power of a normal tib. post. should be sufficient for this.

Tib. Post. was 4 times transf. to the tendon of the per. brevis, behind tibia-fibula. Indication: varus deformity. Evaluation of the result is difficult. Result: Good 2, bad 2.

Other tendon transferences in this series:

Transf. of the biceps femoris to the quadriceps 3 times. Result: fair in all three cases. We rarely use this form of transf. because the indication for it is very limited, owing to the fact that the posterior muscle groups (gluteus max., hamstrings and gastrocnemius) and a stable foot in the majority of cases are of more significance in stabilizing the knee joint than a weakened quadriceps reinforced by one of them.

On the upper extremity we have 13 times transferred the tendon of the flex. sublimis to the 4. finger to restore opposition to the thumb. In this group we have 11 cases with an excellent result, that is 84.6 %, one fair and one bad. In this last case the tendon had functioned perfectly for 1½ years when the function was suddenly lost (rupture).

The technique is as follows: The tendon of the sublimis to the fourth finger is led through a hole in the lig. carpi transv. and then sub-

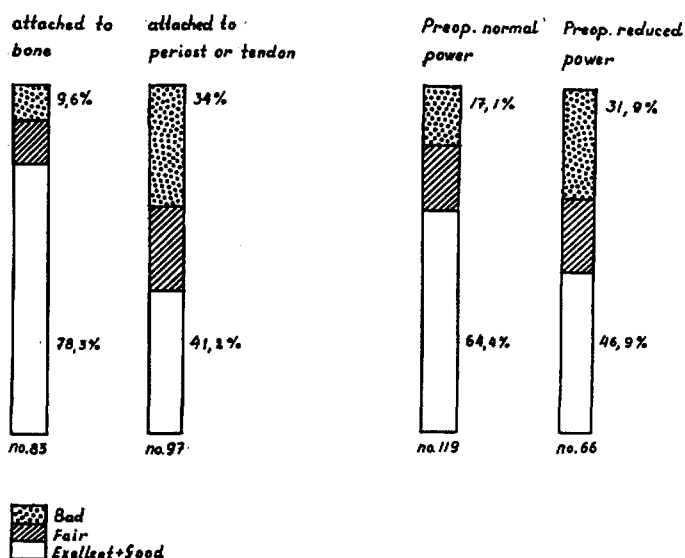
Factors influencing the result.

Fig. 4.

cutaneously to the dorsal aspect of the distal part of the first metacarpal where it is attached through a hole in the bone. On acting the tendon will now rotate (pronate) the metacarpal in addition to the opposition. To ensure a good result we stress the importance of eliminating an adduction contracture of the thumb, before operation.

In the series only one Steindler operation was performed, (transf. of the medial epicondyle to the shaft of the humerus) to improve flexion in the elbow. The result was good. The two tendon transf. left in the material are done occasionally and have little interest.

It will be seen that many of the failures in this material were caused by technical errors (insecure fixation or improper tension of the transferred muscle) or by poor selection of the cases (transference of a weak (paretic) muscle). I will stress the importance of these facts.

Chart. 4 shows that the results in the group with secure attachment of the transferred tendon are better than in the group where the tendon was attached to another tendon or the periosteum.

Chart. 4 shows too the importance of normal preoperative power in the muscle whose tendon is going to be transferred. In this series the muscle had a slightly reduced power 66 times preoperatively and the result was excellent + good in 46.9 % of these, while the result was

excellent + good in 64.4 % in the group where the preoperative power was normal.

In some cases the transferred normal muscle will lose more or less of its power by operation. In the present material this happened 31 times. The cause may be complex. Even if the muscle power is considered normal preoperatively, it may nevertheless be reduced. It is accepted experience that pathological changes sometimes are revealed, during operation, in a muscle which was thought to be normal preoperatively. Another cause of reduction in power, is the tension under which the transferred muscle is secured to its new attachment. Or the muscle has to act against a deformity which is not adequately corrected, or the gliding mechanism may fail. This last factor has not been pointed out as responsible for any of the bad results in this series.

It is commonly accepted that multiplicity of tendon transf. should be avoided. In this series there are 32 patients with two or three tendon transferences performed at the same time. The results in this group do not differ significantly from the results in the whole series. (Excellent + good ratings: 60.8 %).

How often can tendon transference on the foot avoid stabilizing operation later? To get an impression of this I have analyzed 23 children where tendon transference was performed before the age of ten, and where the preoperative deformity in due time would require a stabilizing operation if the tendon transference had not been done. The follow-up period in this group is from 3 to 9 years and we would thus get a good impression of the end results after tendon transference. In 11 of these patients there is no longer need for a stabilizing operation, while 7 will require subsequent surgery at the end of growth. In the rest (5 cases) the question is still doubtful.

This group of 23 children represents the most severe deformities in the series and I think that we may be permitted to expect that bone surgery can be avoided in at least 50 % of the children subjected to tendon transf.

CONCLUSION

Tendon transference in poliomyelitis is not expected to give ideal results but may be a great help in restoring function and in checking or correcting deformity in the growing foot. Tendon transference in children is advisable in selected cases and is expected to avoid further surgery in at least 50 % of these cases according to my experience.

Many of the failures in this series are caused by technical errors or poor selection of cases. The subcutaneous rerouting of the transferred tendon, mostly used in this series, seems to provide the tendon with a gliding mechanism sufficient to ensure a good result.

SUMMARY

The commonly accepted principles for tendon transference are reviewed. The indications for operating on children and for carrying out these operations on the foot without stabilizing operations are discussed and the advantage of placing the transferred tendon subcutaneously is mentioned.

The follow up study of a series of tendon transferences in poliomyelitis operated upon during the 10 year period 1945-54 at Vanföreklinikken, Sophies Minde, Oslo, is reported. The material represents 185 tendon transferences in 112 patients. The majority of the tendon transferences are performed in children, 26 in the age group 1-5 years, 72 in the age group 6-10 years and 55 in the age group 11-15 years. Only 32 of the transferences are in the age group 16 years or more.

The result is strikingly uniform in these different age groups, confirming our view that tendon transference is a useful method in selected cases of polio, even in children of whom 50 % or more will need no further surgery later on. Thus tendon transferences on the foot can give satisfactory results without stabilizing operations. An insufficient gliding mechanism after subcutaneous rerouting of the transferred tendon was in no case the cause of a bad result.

RESUME

Les principes communément acceptés par rapport au transfert de tendons sont examinés. Il est discuté des indications pour pratiquer l'opération chez les enfants et pour procéder au transfert de tendons sur le pied sans opération de stabilisation, en mentionnant l'avantage qu'il y a au placement sous-cutané du tendon transféré.

Il est rendu compte de l'étude d'une série de transferts de tendons pratiqués dans des cas de poliomyélite, opérés durant la période décennale 1945-1954 à la Clinique Orthopédique d'Oslo, Sophies Minde. Les observations ont porté sur 185 tendons transférés chez 112 malades. La majorité des interventions ont eu lieu chez des enfants, 26 âgés de 1 à 5 ans, 72 âgés de 6 à 10 ans et 55 âgés de 11 à 15 ans. Dans 32

cas seulement, les transferts ont eu lieu chez un groupe de malades ayant plus de 16 ans.

Les résultats ont été d'une uniformité frappante pour tous ces différents groupes d'âge, confirmant notre point de vue que le transfert de tendon est une méthode utile dans les cas indiqués de poliomyélite, même s'il s'agit d'enfants chez 50 % ou plus desquels il n'est pas nécessaire de pratiquer plus tard une intervention chirurgicale. Le transfert de tendon sur le pied peut en effet donner des résultats satisfaisants même sans opération de stabilisation. Dans aucun cas un mécanisme insuffisant de mouvement, une fois que s'est opérée la jointure sous-cutanée du tendon transféré, n'a été la cause d'un mauvais résultat.

ZUSAMMENFASSUNG

Die allgemein anerkannten Prinzipien der Sehnenverpflanzung werden besprochen. Die Operationsanzeigen bei Kindern für reine Verpflanzungsmethoden ohne Stabilisierungsoperationen werden diskutiert und der Vorteil der subkutanen Lagerung der verpflanzten Sehne wird erwähnt.

Die Ergebnisse der Nachuntersuchung einer Reihe von Sehnenverpflanzungen in Poliomyelitisfällen, die von 1945–1955 an der Van-føreklinik, Sophies Minde, Oslo, operiert wurden, werden berichtet. Das Material umfasst 185 Sehnenverpflanzungen an 112 Patienten. Die Mehrzahl der Verpflanzungen wurden an Kindern vorgenommen, 26 in der Altersgruppe 1–5 Jahre, 72 in der Gruppe 6–10 Jahre und 55 in der Gruppe 11–15 Jahre. Nur 32 der Patienten mit Sehnenverpflanzungen waren 16 Jahre alt oder darüber.

Das Ergebnis ist erstaunlich gleichartig in den verschiedenen Altersgruppen und bestätigt unsere Auffassung, dass die Sehnenverpflanzung eine nützliche Behandlungsmethode in ausgewählten Fällen von Poliomyelitis ist, selbst bei Kindern von denen 50 % oder mehr späterhin keine weitere chirurgische Behandlung benötigen. Die Sehnenverpflanzung kann daher auch ohne Stabilisierungsoperation zufriedenstellende Resultate geben. In keinem Falle war ein ungenügender Gleitmechanismus nach einer subkutanen Verlagerung der Sehne die Ursache eines schlechten Ergebnis.

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