

ASTRAGALECTOMY AS A STABILISING
OPERATION FOR FOOT PARALYSIS FOLLOWING
POLIOMYELITIS¹

Results of a Follow-up Investigation of 153 Cases

By

H. C:SON HOLMDAHL

The operative procedure initiated by *R. Whitman* in 1901, astragalectomy (AE), which is employed in foot deformities occurring after infantile paralysis, emerged almost as a reaction against the poor long-drawn-out results of the methods previously used. *Whitman* recommended his method first of all for cases with deformities of the type pes calcaneus, but in later articles he widened the indications to include varus and valgus malpositions and drop-foot. In U.S.A. particularly the method was eagerly adopted between 1910 and 1930 by more and more orthopedic surgeons and with wider and wider indications, which in turn produced an ever greater number of poor results. Certain investigations—*Sever* (1920), *Ryerson* (1923), *Henderson* (1929) etc.—into these AE-operations produced a change of opinion concerning the effectiveness of the method and so other stabilising operations, above all panastragalarthrodesis and the various types of subtalar arthrodesis, came to the fore. However when studying the literature on this subject it seemed as if the poor endresults could be attributed to the employment of the operative method in unsuitable cases and also to the too great deviations made from *Whitman's* indications. Since no extensive investigations from the Scandinavian countries had been published when this follow-up commenced in 1949, and since the material available at the Orthopedic Clinic in Gothenburg was sufficiently large and representative, it was thought worthwhile to work upon it and to get it published.

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In 1950 however *O. Leikkonen*, from the Invalid Foundation in Helsinki, set out in a detailed monograph the results of 100 cases with various foot deformities following infantile paralysis, operated on according to *Whitman's* method, and as this investigation undoubtedly is the most thorough and comprehensive of those published on this subject, the results of this previous investigation will be compared as far as is possible with those of the present one. *Leikkonen* gives in his research a close account of the history of stabilising operations of the foot, of the physiology and statics of the foot and also a careful analysis of the end-results following AE. He comes to the conclusion that this operative procedure is almost solely suited to calcaneo-valgus deformities. With other calcaneal deformities (calcaneo-cavus, calcaneo-varus etc.) each case must be judged individually and no precise directions can be given for the use of AE with these types of deformities. *Leikkonen* decisively discourages the use of this method for equinus and varus deformities and even questions the benefits of this procedure for totally paralytic feet. Thus in the main the same indication limits are found for AE as *Whitman* described in his earlier articles.

In 1931 *H. Camitz* reported the results of 64 AEs performed during the years 1920–25 and a number of these cases are also included in my investigation. Almost all the cases were operated on by *Camitz*. He declared that he always followed *Whitman's* description without any modifications. The most important points in *Whitman's* method are: extirpation of the talus, preparation of the new articular surfaces between the medial malleolus and the navicular, and between the lateral malleolus and the calcaneum-cuboid, reposition of the complete foot in the ankle joint together with plastic surgery of the peroneal tendons, which are pulled through a slot in the Achilles tendon and are sutured both to this and their own distal ends so that they may function as ligaments. Plaster bandaging follows this with the foot in moderate equinus position. After about 2 weeks the patient is allowed to bear weight on the leg and after a further 3–4 weeks the plaster is changed and the foot taken up to a medium position. In those cases where an obvious outward rotation of the foot in relation to the lower leg has occurred a corrective osteotomy is carried out simultaneously with the change of plaster. This is performed as a transverse osteotomy some finger widths above the ankle joint. In order to obtain good control over the rotation a nail is inserted into the upper part of the tibia after which the foot is rotated inwards to a medium position. After 3 weeks the nail is removed and as a rule the osteotomy is consolidated after 5 weeks.

In his follow-up, in which however the observation period only

extended to 3-8 years with a series comprising 64 cases, *Camitz* described his results as very good, especially from a functional point of view. *Camitz* estimated that in only one case had he found a result both anatomically and functionally poor. In contrast to e.g. *Whitman* and *Leikkonen*, *Camitz* considered that an arthrodesis was obtained with AE and even found a clinical arthrodesis in most of the cases in his follow-up. Whether it was a fibrous or osseous ankylosis does not emerge from the article, since no roentgen check took place. *Leikkonen* assumes therefore that *Camitz* in his AE chiselled away articular cartilage from the lower surface of the tibia, but this never did occur. This is also seen from *Camitz*' description of his operative procedure, which he quotes word for word from *Whitman's* book "Orthopedic Surgery 1919". Whether bony ankylosis occurred or not will be discussed later.

MATERIAL

During the years 1920-45, the period embraced by the follow-up, 358 AEs were performed upon 348 patients with foot deformities following poliomyelitis. 144 of these patients, 9 of whom had been bilaterally operated upon, were subjected to re-examination, which in all cases but one was carried out by the author during the years 1951-52. 8 patients had died before the time of the follow-up and sixteen patients refused to appear, giving as their reason that the foot operated upon was quite normal and caused no trouble at all. The remaining 180 patients either did not appear, in spite of repeated requests in several cases, or could not be traced.

Table I shows the age at which the disease occurred and the age at operation of all the 144 cases examined. The main group fell ill before the age of seven and most were operated upon between the ages of 9-15. The best age for operation has been a much discussed topic and the majority of authors (*Mac Ausland*, *Thomson*, *Whitman*) warn against AE before the age of 6. The reason for this is said to be that before this age the ossification of the foot skeleton is so little developed that considerable risk of recurrence may exist.

The period of time elapsing between the onset of disease and operation can be seen from Table II. For long now it has been an accepted rule that at least 3 years should pass after the onset of disease before any stabilising operation is performed. In this series there are only 9 cases which do not fulfil this condition, 6 of which were operated on as early as 1 year and the remaining 3 two years after the onset of disease. In the majority of these latter cases totally paralytic feet were involved, which showed no sign at all of muscle restitution, so that to perform

TABLE I
Age at onset of disease and at operation.
(A and B respectively).

Age	Number of cases	
	A	B
<1	25	—
1	32	—
2	18	—
3	15	—
4	9	—
5	9	1
6	9	1
7	6	—
8	2	1
9	3	13
10	5	11
11	2	13
12	2	24
13	—	11
14	1	10
15	1	20
16	—	9
17	—	5
18	1	4
19	2	3
20	1	2
>20	1	16

AE so early in the course of the disease was considered justified. In most cases the operation was performed after 5 years or more had elapsed from the onset of the disease.

The length of the observation period succeeding the operation varied between 4 and 33 years. 99 cases were observed more than 15 years (Table III). All the re-examined cases had reached adult age and the condition of the foot concerned must thus be considered as stationary and final. In order to be able to judge correctly the result of a stabilising operation on a foot deformed by polio one must wait until the individual has attained an adult age and not, as do most authors, content oneself with an observation period of only 1–3 years, regardless of the age at which the operation took place. In this respect the series in this investigation satisfies extremely high standards.

TECHNIQUE OF RE-EXAMINATION

It is practically impossible to evaluate correctly the effect of an operative procedure—in this instance AE—on a disease such as polio,

TABLE II
Time elapsed between onset of disease and operation.

No. of yrs.	No. of cases
<1	—
1	6
2	3
3	4
4	7
5	8
6	4
7	7
8	20
9	8
10	14
11	17
12	9
13	5
14	11
15	3
16	3
17	5
18	1
19	2
20	1
>20	6

where all degrees of invalidity and forms of malposition are met. In some cases the foot deformity is the sole remaining evidence of a polio infection, in others on the contrary it is only a secondary part of the invalidity. Account must be taken therefore of the whole of the lower extremity, of the individual's occupation and way of life etc. In this investigation especial importance was attached to the following: muscle status in the trunk and lower extremities, deformities of the hip, knee and ankle joints and foot, mobility (active and passive) in the ankle and subtalar joints, bone length, presence of pain in the foot operated on, walking capacity, need for splints or orthopedic shoe appliance and also information whether or not the patient was satisfied with the operation. As far as possible the results in each of these points were compared with the status before operation. Roentgenograms of all cases were taken in 3 different planes: one in a dorsoventral direction from the ankle joint, one in a purely lateral direction and one in a dorsoventral direction from Chopart's joint. Furthermore normal photographs were taken of the majority of cases in 2 planes, from the side and from the rear.

TABLE III
Length of observation period.

No. of yrs.	No. of cases
4	5
5	4
6	2
7	5
8	6
9	1
10	4
11	2
12	8
13	6
14	2
15	7
16	2
17	1
18	6
19	5
20	9
21	3
22	4
23	—
24	8
25	5
26	8
27	6
28	5
29	4
30	8
31	15
32	2
33	1

In evaluating the muscular power in the lower extremities a points scale from 0 to 3 was applied: 0—paralysis, 1—muscular activity without any practical significance, 2—sufficient power to possess definite practical importance, 3—normal or almost normal muscular power. The surgical result was evaluated both from an anatomical and functional point of view. In evaluating the anatomical result, the following details were taken into consideration: appearance, deformity, leg shortening and the condition as revealed by roentgen examination (the degree of calcaneal foot position and retroposition, possible bony ankylosis and loose bodies). Functionally particular stress was laid on evaluating the ability to carry the body weight, the presence of pain in walking, capacity for walking, the need for splints or orthopedic shoe app-

liance and also the patient's opinion of the surgical result. In both these main groups the results were classified into good, fairly good and poor. The evaluation of the results was carried out in the same way as in *Leikkonen*, so that a good method of comparison was achieved between the two series.

RESULTS OF THE INVESTIGATION

Anatomically 18.3 % good, 47 % fairly good and 34.7 % poor end-results were achieved (Table IV). The corresponding figures in *Leikkonen's* series were 25, 29 and 46 % respectively. Functionally the figures in my series were 32 % good, 56.9 % fairly good and 11.1 % poor. *Leikkonen's* corresponding percentages were 36, 24 and 40 %. It will be seen therefore that the functional result in my series is considerably better than the anatomical, a point which struck one again and again during the course of the investigation. In many cases in spite of an anatomically less satisfactory result the patient was frequently very pleased with the foot in question. Furthermore the series shows a distinct difference from that of *Leikkonen*. The latter reports 54 % good + fairly good results anatomically and similarly 60 % functionally. The corresponding figures in my series are 65.3 and 88.9 %. The difference is therefore greatest in the group of good + fairly good functional results. Whether this is to be interpreted as a less strict evaluation of the results on the part of the author or whether a true difference exists is difficult to decide. In favour of the latter argument is the

TABLE IV
Endresults of astragalectomies from anatomical and functional viewpoint.

				Anatomical result in %			Functional result in %		
				good	fairly good	poor	good	fairly good	poor
I.	Anat. good	+	funct. good	13.1			13.1		
II.	" "	+	" fairly good	5.2				5.2	
III.	" "	+	" poor	—					—
IV.	" fairly good	+	" good		18.9		18.9		
V.	" "	+	" fairly good		24.2			24.2	
VI.	" "	+	" poor		3.9				3.9
VII.	" poor	+	" good			—	—		
VIII.	" "	+	" fairly good			27.5		27.5	
IX.	" "	+	" poor			7.2			7.2
Total				18.3	47.0	34.7	32.0	56.9	11.1

impression just mentioned of discrepancy between the anatomical and functional results.

From the same table it appears too that the percentage of poor results is considerably lower in my series than in *Leikkonen's* series. On comparing this group's anatomical and functional results in both of these series a considerable difference emerges here too and is most pronounced from the functional point of view (respectively 46 against 34.7 % and 40 against 11.1 %).

TABLE V
Functional results of some large investigations.

Author	No. of cases	Endresults in %		
		good	fairly good	poor
Whitman (1922)	60	85	13.3	1.7
Miltner (1931)	112	90.1	5.3	4.6
Thompson (1939)	100	54	18	28
Leikkonen (1950)	100	36	24	40
Author's series	153	32	56.9	11.1
Total	525	59.4	23.5	17.1

Leikkonen drew up a comparison of some follow-ups, and to this table the author's results were also added (Table V). The figures in these investigations vary greatly. In his series the author has the lowest percentage of good results and amongst the lowest percentage of poor results. One should point out that the percentages give the functional

TABLE VI
Endresults of astragalectomy according to pre-operative deformity.

Group	I	II	III	IV	V	VI	VII	VIII	IX	Total
Calcaneocavus ...	—	—	—	—	1	—	—	4	—	5
Calcaneovalgus ...	1	—	—	4	1	—	—	18	1	25
Calcaneovarus ...	—	—	—	1	1	—	—	2	—	4
Paralyticus	2	1	—	3	3	—	—	2	4	15
Equinus	4	1	—	8	4	3	—	1	2	23
Equinovalgus	9	1	—	1	3	—	—	3	—	17
Equinovarus	3	3	—	9	22	2	—	8	3	50
Varus	—	—	—	2	—	—	—	1	—	3
Planovalgus	1	—	—	1	—	—	—	1	—	3
Valgus	—	2	—	—	2	1	—	2	1	8
Total	20	8	—	29	37	6	—	42	11	153

TABLE VII

Comparison between good + fairly good results (grps. I-V) and poor results (grps. VI-IX) according to pre-operative deformity.

Group	I-V	IV-IX
Calcaneocavus	1	4
Calcaneovalgus	6	19
Calcaneovarus	2	2
Paralyticus	9	6
Equinovalgus	14	6
Equinus	17	3
Equinovarus	37	13
Varus	2	1
Planovalgus	2	1
Valgus	4	4
Total	94	59

and not the anatomical result. As will appear from the above figures even in cases with poor or not so good anatomical results the patient's condition with regard to the foot operated on has often been much better than one could have expected.

In Tables VI and VII the series was classified taking into account the preoperative foot deformity and divided into the main groups comprising groups I-V and groups VI-IX, in which the first main group represents patients with at least fairly good anatomical and functional results. In the second main group at least one of these components is poor. One finds then that the number of good and fairly good results

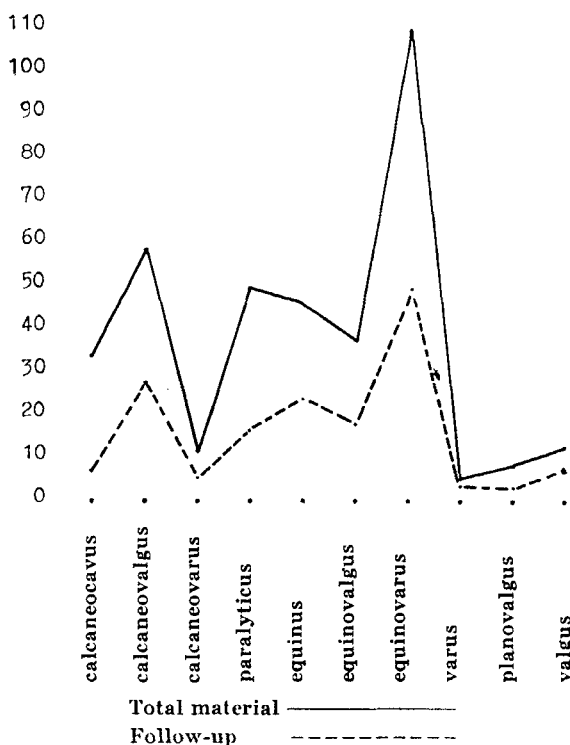
TABLE VIII

Occurrence of bony ankylosis after astragalectomy.

Group	I-V		VI-IX	
	Bony ankylosis	No bony ankylosis	Bony ankylosis	No bony ankylosis
Calcaneocavus	—	1	2	2
Calcaneovalgus	—	6	10	9
Calcaneovarus	—	2	—	2
Paralyticus	2	7	2	4
Equinus	5	12	3	3
Equinovalgus	6	8	1	2
Equinovarus	12	26	6	6
Varus	—	2	—	1
Planovalgus	—	2	1	—
Valgus	1	3	1	3
Total	26 (17 %)	69 (45 %)	26 (17 %)	32 (21 %)

TABLE IX

No. of cases in the total material and in the follow-up according to pre-operative deformity.



both anatomically and functionally (groups I–V) is much larger than the number of poor results (groups VI–IX) in those types of deformity which include the equinus component (equinus, equino-valgus and equino-varus), while on the other hand the group with the calcaneal component (calcaneo-cavus, calcaneo-valgus and calcaneo-varus) show a considerably larger number of poor than of good and fairly good results. These results are striking since all the earlier investigations from *Whitman* to *Leikkonen* have exhibited the contrary. It is difficult to explain this divergency. In this series a fairly large number of AEs led to ankylosis, in contrast to other investigations and it might be thought that this was the cause of the divergency. As Table VIII shows, 34 % had only ankylosis and 66 % had no ankylosis. In the equinus groups the corresponding figures are 36.6 and 63.4 % and in the calcaneal groups 35.3 and 64.7 %, very much the same figures. Whether or not ankylosis is present, it can therefore afford no explanation why the results differ from the other investigations.

In the group of totally paralyzed feet the good and fairly good results exceed the poor results (9 to 6 respectively) while in the remaining groups (varus, valgus and plano-valgus) the number of cases is so small, that nothing certain can be said about the prognosis.

The number of cases investigated forms only 42.7 % of the whole series, but in all the groups apart from one (calcaneo-cavus group) the relationship between the total number of cases and those investigated is similar (Table IX).

TABLE X
Results of astragalectomy grouped according to muscle power in the thigh and lower leg.

Group	I-V		VI-IX	
	No.	%	No.	%
Muscle power 3	27	81.8	6	18.2
" " 2	29	69.0	13	31.0
" " 1	26	50.0	26	50.0
" " 0	12	42.8	14	57.2
Total	94	61.4	59	38.6

It seems extremely probable that the prospect of achieving a better end-result is the more favourable, the less pronounced are the pareses in the lower extremities. If the cases are grouped in this way and if one considers solely the muscle power in the thighs and lower legs (Tab. X) it will be found that the greater the muscle power, the more favourable is the prospect of obtaining a good result. In group 3 the good results are quite 4 times larger than the poor results, in group 2 more than twice as many good results occur as bad results, while in the two remaining groups (1 and 0) no clear difference exists between good and poor results. *Leikkonen* discovered the same proportions, but the distinction in our series is still more striking. The investigation thus shows that the chance of obtaining a good end-result after AE is the greater, the better the muscle power which exists in the thigh and lower leg muscles of the same leg.

In the description of the surgical procedure it was stated that in a number of cases where a pronounced outward rotatory malposition of the foot in relation to the knee joint axis was present, a corrective osteotomy was undertaken on the tibia. In the series investigated such an operation was performed in 19 cases equalling 12.4 %. Most of the cases (9) belong to the equino-varus group, the others are distributed amongst the calcaneo-valgus (2), paralyticus (4), equino-valgus (3)

and plano-valgus (1) groups. No evaluation of the effect of this intervention can be made, since the series is so small. It will be found however that 10 of these 19 cases belong to groups I-V, the remainder to groups VI-IX. Out of the 9 cases which belong to the equino-varus group, 6 can be assigned to groups I-V and 3 to groups VI-IX.

The argument has been put forward against AE that it results in increased shortening of a leg which has already been previously shortened through polio. The exstirpation of the talus means that the leg length is reduced by between 1-2 cm and it is only possible to gain compensation for this diminishment if the operation achieves an increased calcaneal position of the foot. If however the operation results in improved function of the whole leg it may on the other hand be possible that the leg increases in length secondarily and that the shortening present before the operation is lessened or disappears. In order to discover what does happen in this question a collocation was made of leg shortening present in cases where unilateral AE was carried out (Tab. XI). Measurement of the leg length was made from the spina iliaca ventralis cranialis to the medial malleolus both before the operation and at the follow-up. In 89 such cases information was at hand concerning the preoperative shortening. Making reservation for the relative unreliability of the measurement method the result of the investigation was that 52.8 % suffered further shortening of between 1-6 cm. However in the majority of these cases the shortening amounted only to 1 to 2 cm. In 17 cases (19.2 %) the operation did not bring any change

TABLE XI
*Variation in leg length difference before and after astrágalectomy
as compared with the healthy leg.*

Lengthening or shortening in cms. ...	+3	+2	+1	0	-1	-2	-3	-4	>-4
Calcaneocavus	—	—	1	—	3	1	—	—	—
Calcaneovalgus	—	—	2	2	5	2	3	1	—
Calcaneovarus	—	—	1	2	—	—	—	—	—
Paralyticus	—	—	—	3	3	1	1	—	—
Equinus	2	—	2	3	2	2	—	—	1
Equinovalgus	—	1	3	1	4	1	—	—	—
Equinovarus	3	—	8	6	3	7	2	1	1
Varus	—	—	—	—	—	—	—	—	—
Planovalgus	—	—	—	—	1	1	—	—	—
Valgus	1	1	—	—	1	—	—	—	—
Total	6	2	17	17	22	15	6	2	2
%	28			19.2	52.8				

TABLE XII
Results of astragalectomy with respect to age at operation.

Age group	I	II	III	IV	V	VI	VII	VIII	IX	Total	
										I-V	VI-IX
4-6 years	—	—	—	—	1	—	—	—	—	1	0
7-8 „	—	—	—	—	1	—	—	—	—	1	0
9-10 „	5	—	—	—	2	—	—	6	1	7	7
11-12 „	3	1	—	5	8	—	—	6	3	17	9
13-14 „	3	2	—	11	8	1	—	11	3	24	15
15-16 „	5	—	—	7	8	1	—	10	1	20	12
17-18 „	—	2	—	3	3	1	—	4	2	8	7
19-20 „	1	1	—	—	2	—	—	3	—	4	3
21-22 „	1	—	—	—	2	—	—	1	1	3	2
23-24 „	1	1	—	1	—	2	—	1	—	3	3
25-40 „	1	1	—	2	2	1	—	—	—	6	1

in leg length by comparison with the leg not operated on and in 25 cases (28 %) a diminished shortening of between 1-3 cm was revealed instead. This feature can only be explained in that the leg's functioning was so essentially improved through the operation that it could be used in a more normal way. Thus the muscle power and the circulation of the whole leg improved and this in turn led to a postoperatively stimulated growth in length.

In this way it was shown that the leg shortening found in the majority of cases was only slightly or not at all increased through this operation. In no inconsiderable number of cases secondary leg lengthening was gained instead thanks to the operation.

In Table XII figures have been collocated to show the relationship between results and operative age. The highest percentage of good results was obtained in the group aged 11-12 years (65 %), with somewhat lower figures in both the following age groups 13-14 and 15-16 years (61.5 and 62.5 %). The figures in the two youngest age groups are so small that nothing can be stated concerning them. Therefore one should have the best chance of obtaining a good result from the operation when it is undertaken between the ages of 11-16 years. Comparison with corresponding figures in *Leikkonen* shows that he finds his operative optimum at a rather earlier age (8-10 years).

All the cases investigated were submitted to roentgen examination in order to gain information concerning:

1. The presence of osseous ankylosis,
2. The degree of retroposition,
3. The presence of calcaneal malposition and
4. The presence of loose bodies.

TABLE XIII
*Occurrence of bone ankylosis, fibrous ankylosis or retained mobility after
 astragalectomy according to the results.*

Group	Bony ankylosis	Fibrous ankylosis	Retained mobility
I	5	10	5
II	2	2	4
III	—	—	—
IV	3	13	13
V	15	14	8
VI	1	3	2
VII	—	13	—
VIII	20	—	9
IX	6	4	1
Total	52	59	42

1. In 52 cases a solid osseous ankylosis was found between the tibia and the calcaneum. In these cases the operation took on the aspect of an arthrodesis. A further 59 cases revealed a clinical ankylosis although an osseous ankylosis could not be found by roentgen examination. It is striking that such a large number of cases formed bony ankylosis in spite of the fact that the tibial articular cartilage in the talo-crural joint was never removed at operation. In Table XIII the cases were distributed into groups of results I–IX and also according to the presence of osseous or fibrous ankylosis or retained mobility. Of all the cases with good + fairly good results 26.6 % had osseous ankylosis, 41.5 % fibrous ankylosis and 31.9 % retained mobility. The corresponding figures for cases with a poor result (groups VI–IX) are 45.7 %, 33.9 % and 20.4 % respectively. The proportion good: poor results is 2.5: 1 in the group with retained mobility, 1.95: 1 in the group with fibrous ankylosis and 0.92: 1 in the group with osseous ankylosis. The large number of poor results in the osseous ankylosis group is certainly in the majority of cases chiefly due to a lack of success in correcting a calcaneal deformity previously present or to the emergence of such a deformity during the postoperative course.

2. *Whitman* stated that one of the main requirements for a good result from AE was such a retroposition of the foot in relation to the ankle joint that the malleoli would be placed abreast of the navicular and the calcaneo-cuboid joint respectively. If this procedure was not successful there was a great risk that the operation would not lead to improvement of the foot condition.

In order to be able to judge the importance of the retroposition in

TABLE XIV
The importance of retroposition for the end-result.

Group	Good	Fairly good	Poor
I	14	4	2
II	7	1	—
III	—	—	—
IV	12	11	6
V	15	11	11
VI	5	—	1
VII	—	—	—
VIII	6	8	28
IX	1	1	9
Total	60	36	57

gaining a good result figures were collocated on this point (Table XIV). The retroposition was judged as good when it satisfied the criterium given above, as fairly good when the malleoli stood on a level with the forward part of the calcaneum and as poor when no clear retroposition could be discerned. In the same way as in Table XIII the findings were arranged in groups of results. I–IX. A good retroposition was achieved in only 60 cases and in almost as many cases it was poor. The majority of the cases with good or fairly good retroposition also proceeded to show a good result (48 out of 60 and 27 out of 36), while most of the cases with poor retroposition had a poor end-result (39 out of 57). Thus this reveals, even a part from the nature and degree of the foot deformity, the importance of achieving retroposition at the operation and of maintaining this during the period under plaster, so that it becomes permanent.

3. *Pes calcaneus* means the condition where the calcaneum takes up a position more vertical than horizontal, so that the posterior surface becomes the lower and weight-bearing surface. The calcaneo-cavus foot is typical of such a malposition and it is determined by a partial or total paralysis of the triceps retaining short plantar toe flexors.

Out of 34 cases which revealed calcaneal deformity before the operation, 20 showed no change in the deformity at the follow-up, while in 14 cases it was cured. Of the 20 cases mentioned above 18 exhibited poor retroposition while 7 of the second group of 14 cases had a good retroposition. The remaining 7 cases in this group had a poor retroposition. Out of 119 cases which showed no calcaneal malposition before the operation 15 formed such a deformity afterwards. In this group 13 demonstrated poor retroposition and 2 good + fairly good retro-

position. In the largest group of 104 cases where no calcaneal deformity existed either before operation or at the follow-up, good + fairly good retroposition was achieved in 58 cases while it was poor in 47 cases. Thus AE in this series achieved a correction of existing calcaneal deformity in 14 cases out of 34. Where this correction was not obtained it will be found in almost all cases that the retroposition was also poor. This is also true of the group of 15 cases, which revealed a calcaneal deformity at the follow-up where this did not exist at operation. The results show therefore that success in obtaining a retroposition means both an increased chance of correcting this deformity, and also that such a deformity will seldom develop in those cases where it was not present at operation. It seems extremely probable however that other factors as well—e.g. the degree of paralysis in the short toe plantar flexors—play an important part in this question.

4. The presence of "loose bodies" after AE—in the majority of cases originating from residual parts of the talus—is stated by several authors to be one of the causes of a deteriorating result. Such a result is said to be chiefly due to these loose bodies causing pain and an early onset of arthrosis deformans. One or several loose bodies were found in 10 cases, but only one of these patients reported pain of the ankle joint on walking. In a further 14 cases the presence of pain in the ankle joint was reported but no loose bodies could be observed on the roentgenograms. Leaving behind minor parts of the talus therefore does not prove in this series to cause any risk of a painful condition when weightbearing and walking.

The need for permanent splints is dependent more on the spread and the degree of the paralysis in the lower extremity than on the result of AE. Out of 30 cases, which constantly use splints or similar appliance for the whole leg, no less than 26 have total or almost total paralysis of the thigh and calf muscles, very often combined with a pronounced hip paralysis. In almost half of these 30 cases (14) AE led to such a good result from a local point of view that, other considerations apart, orthopedic supporting splints would not have been necessary. Forty cases constantly have to use orthopedic footwear, while 83 cases manage without any orthopedic aids.

As far as choice of occupation is concerned, a certain limitation is an imperative necessity. Only in a minority of cases does the individual concerned successfully carry out heavy work. The majority of both men and women are occupied in lighter occupations. Men take up mostly office work, lighter factory work and also the shoemaker and tailor trades. The majority of women have office work, domestic work or

needlework. There is rarely a change of occupation, since the illness almost always begins in childhood.

79 patients declare that they are completely satisfied with the result of the operation, while 24 have certainly improved but are yet not completely satisfied with the operation. A deterioration is reported in three cases only. The remaining 38 will not give their opinion or do not remember their condition before the operation, so that no comparison is possible.

S U M M A R Y

153 cases out of a series comprising 358 astragalectomies (AE) were submitted to careful re-examination. The object of the operation was to correct and stabilise foot deformities of various types and degrees which had arisen owing to polio. The majority of cases fell ill with polio before the age of 7 and most of them were operated on between 9 and 15 years of age. With 9 exceptions the operation was in all cases undertaken, at the earliest, 3 years after the onset of the disease.

Anatomically the results were 18.3 % good, 47 % fairly good and 34.7 % poor, while functionally there were 32 % good, 56.9 % fairly good and 11.7 % poor results.

As far as the various deformity groups are concerned, the groups with an equinus component show a clearly better result than the groups including some form of calcaneal deformity. The cause of this divergence from what has been observed in other investigations cannot be discovered and is in any case dependent on the presence of the ankylosis so common in this series.

The investigation shows further that the chance of obtaining a good result notwithstanding the types of deformity existing increases, the less pronounced is the paralysis in the thigh and calf muscles.

In quite half of the cases the operation caused for the most part a slight shortening of the leg length, in the remaining cases there was no shortening at all or the operation even contributed towards a postoperative lengthening of the leg, probably as a consequence of improved function gained through the operation.

The highest percentage of good results was obtained in the age group 11–12 years.

The roentgen examination showed that 34 % formed a bony ankylosis (a further 38.5 % had ankylosis clinically).

In cases with retained mobility the ratio of the good results to the poor was 2.5:1, while in the group with fibrous ankylosis the good results were almost twice as numerous as the poor. In the group with ankylosis the number of poor results was slightly larger than the number of good results.

If complete retroposition of the foot at the operation is not obtained the risk of a poor end-result is very great. Sixty cases exhibited complete retroposition and 48 of these had good functional result. Out of 57 cases with retroposition a good functional result was achieved in only 18 cases. Particularly with malposition of the calcaneal type a defective retroposition carries in all probability a risk that the malposition may continue to progress, i.e. so-called calcaneal deformity will develop with a result both anatomically and functionally poor.

"Loose bodies" (as a rule residual parts of the extirpated talus) occurred in 10 cases without giving rise to increased pain in weight-bearing and walking.

The need for permanent splints is seen to depend more on residual paralysis in the hip and knee joint than upon any defective result of the operation. More than half of the cases do not require any form of orthopedical aid after operation.

The majority of the patients had to choose physically light work. 55 % were completely satisfied with the result of the operation, only 2 % reported deterioration. The others had either improved or had no decided opinion about the result.

RESUME

Sur un matériel d'observations comportant 358 astragalectomies, 153 cas ont fait l'objet d'un minutieux réexamen. Le but de l'opération a été de corriger et de stabiliser des déformations du pied de types et de grades variés, consécutives à la poliomyélite. La plupart des malades avaient souffert de la poliomyélite avant l'âge de 7 ans et la majorité d'entre eux ont été opérés entre 9 et 15 ans. Sauf pour 9, l'opération a été pratiquée au plus tôt trois ans après la maladie.

D'un point de vue anatomique, les résultats suivants ont été obtenus: 18.3 % bons, 47 % assez bons et 34.7 % mauvais. Au point de vue fonctionnel: 32 % bons, 56.9 % assez bons et 11.1 % mauvais.

En ce qui concerne les différents groupes de déformations, ceux du genre équin ont donné un résultat nettement meilleur que ceux dans lesquels il y avait une déformation quelconque du calcanéum. Il n'est pas possible d'indiquer pourquoi l'on rencontre cette divergence dans ce matériel d'observation, par comparaison avec les autres observations de malades réexaminés; celle-ci n'est en tout cas pas imputable à l'ankylose que l'on constate si fréquemment dans ce matériel d'observation.

Cette enquête a démontré par ailleurs que les chances d'arriver à un bon résultat, quels que soient les types de déformation, s'accroissent

d'autant que la parésie de la musculature de la cuisse et du mollet est moins prononcée.

En gros, dans la moitié des cas l'opération a entraîné un très léger raccourcissement de la jambe; par contre, chez les autres malades, il n'y a pas eu de raccourcissement. Au contraire, on a pu observer un allongement postopératoire de la jambe, vraisemblablement du fait de la meilleure fonction obtenue grâce à l'opération.

Le pourcentage le plus élevé des bons résultats est enregistré dans le groupe d'âge de 11 à 12 ans.

L'examen radiographique a montré qu'il s'était formé une ankylose osseuse dans 34 % des cas; chez 38.5 % autres, on constata une ankylose clinique. Dans les cas où la mobilité a pu être maintenue, le rapport des bons et des mauvais résultats est comme de 2.5 à 1, tandis que dans le groupe où il y a des ankyloses fibreuses, les bons résultats étaient pratiquement deux fois aussi nombreux que les mauvais. Dans le groupe souffrant d'ankylose, les mauvais résultats sont légèrement plus élevés que les bons.

Lorsque l'on n'obtient pas une rétroposition entièrement satisfaisante du pied par l'opération, l'on risque fort d'arriver à un mauvais résultat final.

Dans 60 cas la rétroposition était entièrement bonne et dans 48 de ces cas l'on a enregistré un bon résultat fonctionnel. Sur 57 cas dans lesquels la rétroposition était mauvaise, l'on n'a obtenu un bon résultat fonctionnel que dans 18 cas. C'est notamment dans la fausse position du type calcanéum qu'une rétroposition mauvaise comporte le risque probable de voir s'accroître la fausse position, c'est-à-dire le développement du pied calcanéum avec un mauvais résultat aussi bien d'un point de vue anatomique que fonctionnel.

La présence de « corps libres » (en règle général des restes du talus qui s'est écarté) a été constatée dans 10 cas, sans qu'elle ait d'ailleurs provoqué des douleurs à la surcharge ou à la marche.

Le besoin d'un bandage permanent semble plus dépendre d'une parésie de l'articulation de la hanche ou du genou qui se maintient que du mauvais résultat de l'opération. Dans plus de la moitié des cas, il n'a au contraire pas été nécessaire d'avoir recours à une forme quelconque de moyens auxiliaires orthopédiques.

La majorité des malades ont été obligés de choisir un travail facile d'un point de vue physique. 55 % étaient entièrement satisfaits du résultat de l'opération, 2 % seulement ont indiqué que leur état avait empiré. Quant aux autres, ils étaient ou bien améliorés, ou bien sans idée précise quant aux résultats de l'opération.

ZUSAMMENFASSUNG

Aus einem Material von insgesamt 358 Talusexstirpationen wurden 153 Fälle einer sorgfältigen Nachuntersuchung unterzogen.

Der Zweck der Operation war die infolge von Kinderlähmung entstandenen verschiedenartigen Fussdeformitäten zu korrigieren und zu stabilisieren. Die Mehrzahl der Fälle waren vor dem Alter von 7 Jahren an Poliomyelitis erkrankt und wurden grösstenteils im Alter von 9 bis 15 Jahren operiert. Die Operation wurde in sämtlichen Fällen, abgesehen von 9, frühestens 3 Jahre nach Erkrankungsbeginn ausgeführt.

Vom anatomischen Gesichtspunkt erhielt man 18.3 % gute, 47 % ziemlich gute und 34.7 % schlechte Resultate. Die Funktion war in 32 % gut, in 56.9 % ziemlich gute und in 11.1 % schlecht.

Hinsichtlich der verschiedenen Verbildungsgruppen wiesen die Gruppen mit equino-varus Komponente ein wesentlich besseres Ergebnis auf als jene, in denen eine der Formen von Calcaneusdeformität vorhanden war. Die Ursache für diese in früheren Untersuchungen beobachtete Verschiedenheit kann man nicht aufzeigen. Sie kann jedenfalls nicht auf die in diesem Materiale so häufig vorkommende Ankylose zurückgeführt werden.

Die Untersuchung zeigt weiterhin, dass die Möglichkeit ein gutes Resultat zu erreichen, unabhängig von der Art der vorliegenden Verbildung, zunimmt, wenn die Paresen der Ober- und Unterschenkelmuskulatur weniger ausgesprochen sind.

In mehr als Hälfte der Fälle hat die Operation eine meist unbedeutende Verkürzung der Beinlänge verursacht, in den übrigen Fällen jedoch keinerlei Verkürzung, ja einigemale sogar Verlängerung des Beines, wahrscheinlich wegen der verbesserten Funktion, hervorgehoben.

Die höchste Prozentzahl guter Ergebnisse wurde im Alter von 11–12 Jahren erhalten.

Die Röntgenuntersuchung ergab knöcherne Ankylose in 34 % der Fälle. Weitere 38,5 % zeigten Ankylose bei der klinischen Untersuchung. In den Fällen mit erhaltener Beweglichkeit verhielten sich die guten zu den schlechten Resultaten wie 2,5:1, während in der Gruppe mit fibrösen Ankylose gute Ergebnisse beinahe doppelt so häufig als schlechte erzielt wurden.

Die Gefahr eines schlechten Ergebnisses ist bedeutend grösser, wenn man bei der Operation nicht eine vollkommene Retroposition des Fusses erhält. 60 Fälle zeigten vollständige Retroposition und von diesen hatten 48 ein gutes funktionelles Resultat. Von 57 Fällen mit unvollständiger Retroposition wurde ein gutes funktionelles Ergebnis nur in 18 Fällen

erreicht. Besonders bei der Fehlbildung im Sinne des pes calcaneus führt eine mangelhafte Retroposition mit grosser Wahrscheinlichkeit die Gefahr der fortschreitenden Fehlstellung, d. h. der Entwicklung eines Hakenfusses mit sich.

Corpora libera, in der Regel zurückgelassene Teile des entfernten Talus, wurden in 10 Fällen beobachtet, ohne dass diese eine Schmerzsteigerung bei Belastung und beim Gehen veranlasste.

Die Notwendigkeit einer Dauerbandage erwies sich als mehr in der vorhandenen Lähmung im Hüft- oder Kniegelenke begründet, als in einem Fehlergebnis der Operation. Mehr als die Hälfte der Fälle benötigte keinerlei orthopädischen Behelf nach der Operation.

Die Mehrzahl der Patienten war gezwungen leichtere körperliche Arbeit zu Wählen. 55 % waren mit den Operationsergebnis vollständig zufrieden. 2 % dagegen gaben eine Verschlechterung ihres Zustandes an. Die übrigen waren entweder gebessert oder hatten keine sichere Meinung über den Erfolg der Behandlung.

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