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CLINICAL EXPERIENCE OF EPIPHYSEAL ARREST OF THE LOWER EXTREMITIES

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Differences in length between the lower extremities may be due to retardation of growth of one limb or overgrowth of the other (general review by Langenskiöld 1957). In an adult, correction of such a difference in length requires a comparatively large operation, whether the intervention is shortening the longer limb or lengthening the shorter one. Especially lengthening osteotomies are still accompanied by considerable difficulties, even risks, however tempting they may be in some cases. Accordingly, several methods have been developed in an attempt to correct, during the growth period, an existing and possibly still growing difference in length between the lower extremities (Goff 1960). In this stage, too, it is possible to strive for the end result by accelerating the growth of the shorter or retarding that of the longer extremity. The safest method of retarding growth in length is to destroy surgically the epiphyseal cartilage and to make sure that the epiphyseal cartilage becomes ossified by making a bony bridge, as was suggested by Phemister (1933). This procedure results in irreversible cessation of growth in the area in question, and therefore it is especially important that it is done at the right moment. In practice, this means determination of the exact time in the growth period of the lower limbs, after which the shorter extremity will have time enough to grow precisely the difference in length from the operated limb. There are several formulas and tables available for this purpose (Green & Anderson 1947, 1957, Tupman 1962, Nordentoft 1964). The operation presented by Phemister is usually performed on the distal femoral and/or proximal tibial and fibular epiphyseal cartilages because they account for the major part of the growth of the lower extremity. Seventy per cent of the growth of the femur stems from the distal epiphysis, whereas the proportion of the proximal tibial epiphysis is 55 per cent of the total growth of the tibia (Tupman 1962). The term proximal tibial epiphyseodesis refers here to proximal epiphyseodesis of both tibia and fibula.

The purpose of the present study was to find out, from an analysis of the material of the Orthopaedic Hospital of the Invalid Foundation, what clinical end results have been achieved with epiphyseodesis of Phemister type. We tried to find answers to the following questions concerning the patients on whom this operation had been performed:

(1) What were the clinically measured differences between the lower extremities at the time of cessation of growth in the patients operated?
(2) How did the presumed correction, in accordance with the Green-Anderson table, agree with the obtained correction?
(3) How important is the determination of bony age in timing the epiphyseodesis?
(4) Is it important to perform orthoroentgenographic measurements when epiphyseodesis is being considered?

MATERIAL AND METHODS

The material comprised 65 patients. For the sake of uniformity, only patients on whom the epiphyseodesis had been performed in a clinically healthy extremity were included in the series (Grenshaw 1963). A clinically measurable difference was regarded as the most significant criterion in assessing both the original condition and the final result. The measuring method used was largely indirect: in other words, boards of a fixed thickness were placed under the shorter extremity until the pelvis assumed a horizontal position. This was complemented by direct measurement of the distance from the superior anterior iliac spine to the medial tibial malleolus with a measuring tape. The measuring accuracy with both these methods, in our estimation, is of the order of 1/2 cm. The clinical measurement was performed immediately prior to the operation and after cessation of growth of the lower extremities. The presumed correction was calculated from the Green-Anderson table (1947). Skeletal age was determined in 54 patients according to the Greulich-Pyle tables (1947) and chronological age was used in only 11 cases. The operations were timed in accordance with skeletal age when this was determined. Orthoroentgenographic measurements of the length of the lower extremities were performed in 17 cases, and the values obtained were compared with the corresponding clinical measurements.

The growth period was taken to have ended in the lower extremities of the normal population in accordance with the investigations by Nordentoft (1964):

	Boys Age yrs./mos.	Girls Age yrs./mos.
According to chronological age	15/8	13/11
According to skeletal age	15/0	13/6

According to these values, the growth of the lower extremities had ceased in all the patients in our series at the time of the last measurement.

RESULTS

Table 1 is a presentation of the entire series. A major part, 46 patients, were suffering from late sequelae of poliomyelitis; 12 had hemiatrophy and seven some other diseases which had made one leg shorter than the other.

Table 2 presents the clinical end result in the various diagnostic groups and in the total series. We considered the result to be good (I) if the ultimate difference in the length between the limbs was less than 2.0 cm. The result was classified as fair if the difference was between 2.0 and 3.0 cm (II) and poor if the difference was over 3.0 cm (III). Accordingly, good results were achieved in 66 per cent of the series. This seems to be of the same order as the results of some other investigations (Morscher et al. 1965).

An answer to the question how the Green-Anderson table agrees with the attained correction is found in Table 3. The presumed correction, according to the table, is subtracted from the achieved correction, and the difference is presented separately in the groups of undercorrected, exactly corrected, and overcorrected limbs. The number of undercorrected cases is considerably higher than the other two results. In particular, there are no overcorrections in the hemiatrophy group, and undercorrection is clearly more common in this than in the other disease groups. This is obviously because the hypoplastic non-operated

Table 1. Material

Diagnosis	Number of patients
Sequelae post poliomyelitidem	45
Hypoplasia congenita extr. inf.	12
Coxa vara infantum	4
Hemiplegia spastica	1
Pseudoarthrosis colli femoris	1
Pes varus traumatica	1
Total	65

Table 2. Clinical result (differences in length as measured with boards after cessation of growth) by disease groups

Difference in length between the limbs after cessation of growth	Disease groups: Sequelae post polio-myelitidem	Hypoplasia congenita	Other diseases	Total
0 –1.9 cm (I)	29	8	6	43 (66 %)
2.0–3.0 cm (II)	12	2	0	14 (22 %)
Over 3.0 cm (III)	5	2	1	8 (12 %)
Total	46	12	7	65 (100 %)

limb ultimately did not grow the presumed amount; in other words, progression of anisomelia was greater in this than in the other disease groups. It is obvious that in timing the epiphyseodesis, at least in patients with hypoplasia, it is advisable to use the amount of correction corresponding to the lowest value given for the age in question in the Green-Anderson table (1947). The same result was reached by Poirier (1968), especially in sequelae of poliomyelitis. However, Blount's "epiphyseal stapling" method was used in his series in such a way that the Blount hooks were not removed until after the growth

Table 3. Achieved correction of the difference in length after cessation of growth minus presumed correction of the difference in length as determined according to the Green-Anderson table (1947)

	Disease groups: Sequelae post polio-myelitidem		Hypoplasia congenita		Other diseases		Total	
	No. of pat.	Average under- or over-correct. (cm)	No. of pat.	Average under- or over-correct. (cm)	No. of pat.	Average under- or over-correct. (cm)	No. of pat.	Average under- or over-correct. (cm)
Under-corrected	30	—1.5	10	—2.0	5	—1.5	45	—1.5
Exactly corrected	5	0	2	0	1	0	8	0
Over-corrected	11	+1.0	0	–	1	+2.0	12	+1.0
Total	46	—0.5	12	—2.0	7	—1.0	65	—1.0

Table 4. Achieved correction of the difference in length minus presumed correction (difference in correction) in those patients in the poliomyelitis group whose skeletal age deviated from the chronological age (17 patients)

Patient no.	Skeletal age minus chronological age (yrs)	Difference in correction when the skeletal age was taken into consideration (cm)	Difference in correction if the skeletal age had been ignored (cm)
3	+½	—2.5	—2.0
8	+1	+1.0	+0.5
20	+1½	—4.5	—8.0
1	—1	—2.5	—2.0
4	—½	+0.5	+2.0
13	—1½	—0.5	+3.0
16	—1½	—5.5	—3.0
17	—1	0	+2.0
24	—1	—0.5	+1.0
28	—2	+0.5	+2.0
29	—1	0	+0.5
31	—1½	—3.5	—0.5
32	—1	—1.0	0
35	—½	+2.0	—1.5
37	—1	—1.5	—0.5
38	—½	—1.5	—0.5
45	—1½	+1.0	+3.0

period was over. In our own series, the group consisting of sequelae after poliomyelitis clearly contained more undercorrected than exactly corrected or overcorrected cases. The average undercorrection in the entire series is 1.0 cm. Taking everything into consideration, we think that the Green-Anderson table is very useful in timing epiphyseodesis.

Table 4 presents the patients whose skeletal age deviated from the chronological age. In three patients the skeletal age was ahead of the chronological and in 14 it was behind it. It can be seen from the Table how disregarding the skeletal age would have affected the correction. A considerable overcorrection would have been the result in eight patients out of 17 if the correction had not been calculated in accordance with the skeletal age. One weakness of the use of skeletal age is that its relation to chronological age is not constant. Skeletal age approaches chronological age when the cessation of growth comes nearer, as was stated by Green & Anderson (1957). Especially because of the obvious danger of overcorrection and in the light of the present investigation we consider that it is evidently necessary to take skeletal age into consideration in determining the time for epiphyseodesis.

Orthoroentgenography is regarded as important in determining the lengths of the lower extremities. However, it only measures the length as far as the distal joint surface of the tibia, and differences in the length between the limbs due to differences in the feet are not taken into consideration. Primarily for this reason, we used as the determining criterion the clinically measured difference and particularly the difference obtained by the so-called board method. In order to elucidate how closely the clinical measurement corresponds to the radiological, we compared the preoperative clinical measurements with the results of orthoroentgenography performed at the same time. We found that radiological measuring of the difference in length gave a higher result than clinical measuring in 24 patients, on average 0.5 cm. In 38 patients, orthoroentgenography gave a smaller difference in length than clinical measuring, average 0.6 cm. In three patients the results were identical by both methods. The differences between radiographical and clinical measuring in determining the difference in length between the lower limbs, are, thus, of the order of 1/2 cm, similar to the accuracy of clinical measuring. Since many physicians may perform the clinical measurements, the error may deviate considerably from the above-mentioned averages. Hence orthoroentgenographic measuring is a very important control of length measurements of the lower extremities. In this respect we completely agree with Jansen (1957).

SUMMARY

The results of treatment of length differences of the lower limbs in 65 patients are analysed. The therapeutic procedure employed in all the cases was distal femoral and/or proximal tibial-fibular epiphyseodesis (Phemister). It was established that the Green-Anderson table is most useful in determining the optimal time for epiphyseodesis (Table 3). For patients with hemiatrophy it is advisable to use the smallest presumed correction in the table (Table 2). Determination of the skeletal age is important because of the obvious risk of overcorrection if it is disregarded (Table 4). Orthoroentgenographic measurement of the length differences is an important control of clinical measuring. The result was good in 66 per cent (difference in length

between the limbs after cessation of growth less than 2.0 cm), fair in 22 per cent (difference between 2.0 and 3.0 cm) and poor in 12 per cent.

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