

THE TIMING OF EPIPHYSIODESIS A COMPARATIVE STUDY BETWEEN THE USE OF THE METHOD OF ANDERSON AND GREEN AND THE MOSELEY CHART

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This retrospective study compares two groups of patients who underwent an epiphysiodesis for leg length discrepancy. In group A (47 patients) the timing of the epiphysiodesis was calculated using the method of Anderson and Green ; in group B (36 patients) the Moseley chart was used. A leg length discrepancy of 1.5 cm or less at maturity was considered a satisfactory result. Group A showed 51% good results, group B 63.9%. In both groups, an important source of the poor results was error in calculation and prediction : 30.4% in group A (or 15% of the total), 61.5% in group B (or 22% of the total). The percentage of patients presenting too late was also considerable and accounted for 34.8% of the poor results in group A and for 23.1% in group B. The unpredictability of growth rate is a lesser problem in group B (15.4% of the poor results) than in group A (30.4%).

If the uncontrollable causes of poor results are omitted, only 18% of the poor results in the total group of patients could be accounted for by miscalculation.

Keywords : epiphysiodesis ; leg length discrepancy.

Mots-clés : épiphysiodèse ; inégalité du longueur ; membres inférieurs.

INTRODUCTION

Epiphysiodesis of the growth plates around the knee is the most frequently used operative procedure for equalization of limb length since its introduction by Phemister in 1933 (9). The low morbidity, relatively uncomplicated operative technique and low incidence of complications make

it an excellent method for correction of moderate leg length discrepancies, if calculations are correctly done.

This study evaluates the results of this technique in our department, with special emphasis on the timing of epiphysiodesis, which is the key to a good result.

MATERIALS AND METHODS

This retrospective review concerns 83 patients (37 girls and 46 boys), who underwent an epiphysiodesis in our department between 1968 and 1986. Patients with incomplete hospital records or who were lost to follow-up, were excluded from the study.

In 47 patients, the timing of the epiphysiodesis was based on the method of Anderson and Green (Group A) (2, 5) ; in 36 patients the Moseley chart was used (Group B) (7, 8). The largest number of patients presented with leg length discrepancy due to growth retardation (57.8%). Growth stimulation was seen in 21.7% of cases. The most frequent cause of leg length discrepancy is congenital (30.1%) or unknown (20.5%) (table I). The average chronologic age at time of epiphysiodesis respectively for girls and boys was 12 years, 5 months and 13 years, 10 months in group A ; and 12 years, 2 months and 13 years, 11 months in group B.

The average bone age, respectively, for girls and boys was 12 years, 3 months and 13 years, 2 months in group A ; and 11 years, 10 months and 13 years, 6 months in group B.

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Table I. — Etiology of leg length discrepancy
(groups A and B)

I. Growth retardation : 48 patients (57.8%)	
Congenital :	
- hemiatrophy	12
- congenital dislocation of the hip	2
- talipes equinovarus	1
- bowing of the tibia	2
- congenital pseudarthrosis of the tibia	1
Inflammatory :	
- arthritis of the hip	4
- osteomyelitis of the femur	4
Neuromuscular :	
- cerebral palsy	4
- poliomyelitis	5
Trauma :	
- femoral fracture	2
- tibial fracture	1
- damage to the epiphyseal plate	1
Legg-Calvé-Perthes syndrome	
Tumor :	
- aneurysmal bone cyst	1
Neurovascular :	
- Volkmann contracture	1
II. Growth stimulation : 18 patients (21.7%)	
Congenital :	
- Klippel-Trenaunay	2
- hemihypertrophy	1
- elephantiasis	1
Infection :	
- osteomyelitis	1
Trauma :	
- femoral fracture	6
- tibial fracture	2
- femoral and tibial fracture	3
Tumor :	
- hemangioma	1
- neurofibromatosis	1
III. Idiopathic : 17 patients (20.5%)	

The average leg length discrepancy in group A measured 3.8 cm, ranging from 1.4 cm to 8.8 cm ; and 2.94 cm in group B ranging from 1.7 cm to 8.2 cm (table II). The measurements were done on a full leg orthoroentgenography.

The site of epiphysiodesis was the distal femur in 8 cases in both groups ; the proximal tibia in 8 cases of group A and in 6 cases of group B ; and the distal femur and the proximal tibia, in 31 cases of group A and 22 cases of group B (table III). These figures show that both groups are comparable with respect to age and site of epiphysiodesis.

In all cases of proximal tibial epiphysiodesis, a proximal fibular epiphysiodesis was also performed. The technique described by Phemister in 1933 was used in all cases (9). Bone age was estimated with the help of the *Atlas of Greulich and Pyle* (6).

The average preoperative follow-up period totalled 3 years, 2 months in group A, ranging from 1 month to 15 years, 4 months ; and 2 years, 2 months in group B, ranging from 2 months to 7 years, 8 months (table IV). The preoperative follow-up was less than 1 year in 36 patients or 43.4%. Postoperative follow-up and last radiological measurement was done at maturity (at approximately 16 years bone age for girls and 18 for boys).

The postoperative follow-up period respectively for girls and boys totalled 3 years, 7 months and 4 years, 8 months in group A, and 4 years, 1 month and 4 years, 9 months in group B (table IV).

RESULTS

A final length discrepancy of less than 1.5 cm (which is well tolerated) was judged as a satisfactory result. At bone maturity, the average leg length discrepancy in group A measured 1.9 cm and in group B 1.48 cm (table V).

In group A, 24 patients out of 47 had a satisfactory result (51%), as compared to 23 patients out of 36 in group B (63.9%). Eight patients (6 or 25% in group A and 2 or 8.7% in group B) developed an overcorrection, and 37 (16 or 66.7% in group A and 21 or 91.3% in group B), an undercorrection.

In 15 patients, the poor results were caused by mistakes in estimation of bone age and thus in determination of the time of epiphysiodesis (30.4% of the poor results or 15% of the total in group A and 61.5% of the poor results or 22% of the total in group B). In 11 patients the poor result was unrelated to the method used and caused by too late a referral, so that full correction of the leg length discrepancy could not be obtained (34.8% of the poor results or 17% of the total in group A and 23.1% of the poor results or 8% of the total in group B). In 9 patients unpredictable changes in growth rate caused a poor result (30.4% of the poor results or 15% of the total in group A, and 15.4% of the poor results or 6% of the total in group B).

Table II. — Average chronologic age, bone age and leg length discrepancy (LLD) at time of epiphysiodesis

	Group A (47)		Group B (36)	
	Female (20)	Male (27)	Female (17)	Male (19)
Average chronologic age	12y. + 5m.	13y. + 10m.	12y. + 2m.	13y. + 11m.
Average bone age	12y. + 3m.	13y. + 2m.	11y. + 10m.	13y. + 6m.
Average LLD (minimum-maximum)	3.8 cm (1.4 → 8.8)		2.94 cm (1.7 → 8.2)	

Table III. — Site of epiphysiodesis

	Group A	Group B
distal femur	8	8
proximal tibia	8	6
both	31	22

COMPLICATIONS

In total, 8 patients or 9.6% presented with a complication (table VI). Two patients had to undergo an epiphysiodesis of the other side due to overcorrection of more than 1.5 cm. In one patient, the leg length discrepancy had not improved one year after the epiphysiodesis of the distal femur. For that reason, an epiphysiodesis of the proximal tibia was then performed, but without a good result.

Three patients developed a valgus deformity of the knee after the epiphysiodesis, secondary to asymmetrical fusion of the physis. This represents a serious complication. In one of them, a varus osteotomy had to be performed. In another patient, who developed a varus deformity after the

epiphysiodesis of the proximal tibia, correction was achieved by stapling of the lateral side of the growth cartilage of the distal femur. One patient had a deep infection that responded well to antibiotics.

Table V. — Results

	Group A	Group B
Average final leg length discrepancy	1.9 cm	1.48 cm
Good ≤ 1.5 cm	24 (51%)	23 (63.9%)
Overcorrection	6/24 (25%)	2/23 (8.7%)
Undercorrection	16/24 (66.7%)	21/23 (91.3%)
Poor	23 (49%)	12 (36.1%)
Mistakes in estimation	7/23 (30.4%)	8/13 (61.5%)
Too late at first visit	8/23 (34.8%)	3/13 (23.1%)
Unpredictable growth rate	7/23 (30.4%)	2/13 (15.4%)
Unknown cause	1	

Table VI. — Complications

— Overcorrection	2
— Absence of closure of epiphyseal plate	1
— Asymmetrical closure	4
— Deep infection	1

Table IV. — Pre- and postoperative follow-up

	Group A		Group B	
	Preoperative (Range)	3y. + 2m. (1m → 15y. + 4m.)		2y. + 2m. (2m. → 7y. + 8m.)
Postoperative	Female 3y. + 7m.	Male 4y. + 8m.	Female 4y. + 1m.	Male 4y. + 9m.

DISCUSSION

Epiphysiodesis is potentially a very effective method of equalizing moderate leg length discrepancies, i.e. differences between 2 cm and 5 cm. Larger discrepancies or discrepancies at maturity must be corrected by other techniques.

In order to time the epiphysiodesis, accurately, several conditions must be fulfilled. Preoperative evaluation of growth over several years with exact radiographical measurements of leg length according to a standard method is necessary. With each measurement of leg length, an estimation of bone age must be done. So far, the *Atlas of Greulich and Pyle* has been used, despite its shortcomings. Sometimes the lapse of time between the bone ages is more than 1 year. The *Atlas* is based on x-rays of North American children in the first half of the Twentieth Century; growth patterns have changed since (4, 6). Some important reference points are the appearance of the sesamoid bone of the thumb and the closure of the growth cartilage of the distal phalanx of the middle finger. An epiphysiodesis performed after the closure of the growth cartilage of the distal phalanx of the middle finger will have no effect on leg length discrepancy.

A third condition which must be fulfilled is that the Moseley chart of the method of Green and Anderson must be used correctly.

Overcorrelation was less frequent than undercorrection. In fact, an undercorrection is better accepted by the patient and his parents; an overcorrection is more often considered a medical mistake.

The number of patients presenting too late for epiphysiodesis is still relatively high (17% in group A and 8% in group B). The percentage of cases in which an unpredictable growth rate was the cause of poor results decreased from 30.4% in group A to 15.4% in group B. The reason is probably that the different variables such as growth inhibition, bone age and relative height are automatically included in the Moseley graphic, which improves predictability. The most important problem, very prominent in group B, remains the determination of bone age. Frequently different

residents and surgeons determine the bone age and fill in the Moseley chart. Some months before operation, a recalculation of leg length and re-determination of bone age should be performed by the same person.

Seven patients had to be reoperated. A high tibial osteotomy appeared especially prone to complications.

Since 1979 Moseley's straight line graph has been used to determine the time of epiphysiodesis. This is a concise, one page, graphic illustration of the growth pattern of the long and short limbs. However, the results in our series using the Moseley chart are not statistically different from those using the Anderson and Green method.

A considerable number of mistakes were still made using the Moseley chart, principally owing to difficulty in estimating bone age, in extrapolating points to straight lines, and in interpreting the data on the graph.

However, when the uncontrollable causes of poor results such as late referral and abnormal growth rate are omitted, the surgeon was responsible for only 18% poor results in the total group of patients (15% in group A, 22% in group B).

CONCLUSION

Epiphysiodesis according to Phemister is a good technique to correct moderate leg length discrepancies in children.

The rare severe complications can be avoided if the relatively simple technique is meticulously applied. The greatest problem still is the timing of the epiphysiodesis. Preoperative evaluation over several years, careful estimation of bone age and accurate use and interpretation of the Moseley chart are primordial. We were not able to improve our results significantly by using the Moseley chart, and our principal source of error was in estimating the bone age.

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SAMENVATTING

J. DEWAELE en G. FABRY. Het tijdstip van de epiphysiodese vergelijking tussen de methode van Anderson en Green en de methode van Moseley.

Deze studie vergelijkt 2 groepen patiënten, die geen epiphysiodese ondergingen voor ongelijke beenlengte. In groep A (47 patiënten) werd het tijdstip van de epiphysiodese vastgesteld volgens de methode van Anderson en Green, in groep B (36 patiënten) werd de Moseley curve gebruikt. Een lengteverschil van 1.5 cm of minder bij maturiteit, werd beschouwd als een aanvaardbaar resultaat. Groep A toonde 51% goede resultaten, groep B 63.6%.

In beide groepen wordt een belangrijk gedeelte van de slechte resultaten veroorzaakt door fouten in berekeningen en voorspellingen : 30.4% in groep A en 61.5% in groep B. In groep A kwamen 34.6% der patiënten te laat tegen 23.1% in groep B. Onvoorzienbare individuele groeievolutie gaf aanleiding tot slechte resultaten in 30.4% der gevallen in groep A, en 15.4% in groep B. Zo men de onvoorzienbare elementen weglaat, lijken verkeerde berekeningen slechts voor 18% der resultaten verantwoordelijk.

RÉSUMÉ

J. DEWAELE et G. FABRY. Le choix du moment de l'épiphysiodèse. Comparaison entre la méthode d'Anderson et Green et la méthode de Moseley.

Cette étude compare deux groupes de patients, ayant subi une épiphysiodèse pour inégalité de longueur des membres inférieurs.

Pour le groupe A (47 patients), la méthode d'Anderson et Green fut utilisée, donnant 51% de bons résultats. Pour le group B (36 patients), la méthode de Moseley fut employée donnant 63.9% de bons résultats.

Une inégalité de 1.5 cm ou moins à la maturité, fut considérée comme un bon résultat.

Les différentes causes, les mauvais résultats furent : erreurs d'évaluation (groupe A : 30.4%, groupe B : 61.5%) ; patients se présentant trop tard (groupe A : 34.8%, groupe B : 23.1%) ; anomalies imprévues dans l'évolution de la croissance (groupe A : 30.4%, groupe B : 15.4%).

En éliminant les éléments imprévisibles, l'erreur de jugement est responsable des mauvais résultats dans 18% des cas.