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ORIGINAL STUDY

Comparison of three surgical epiphysiodesis techniques for the treatment of lower limb length discrepancy

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Three operative techniques for epiphysiodesis to correct lower limb length discrepancy (LLD) are compared : the Phemister technique, the percutaneous drilling-curettage technique and percutaneous epiphysiodesis using a transphyseal screw. Between 1987 and 2008, 92 patients with LLD were treated by surgical epiphysiodesis. Eighty patients were available for this retrospective study. No statistically significant difference was found between the three techniques concerning their efficiency in correction of lower limb length discrepancy. Percutaneous epiphysiodesis using a transphyseal screw appeared to be the best technique regarding mean operative time, mean hospitalisation time, postoperative pain and recovery of ambulation in the postoperative period. Complication rates were similar with the three techniques.

Keywords : lower limb length discrepancy ; epiphysiodesis ; Phemister technique ; percutaneous drilling-curettage ; percutaneous transphyseal screw.

INTRODUCTION

Surgical epiphysiodesis may be indicated to correct a lower limb length discrepancy (LLD) from 2 cm to 4 cm (*9*) and up to 6 cm (*6*). The first surgical technique of open epiphysiodesis was described by Phemister in 1933 (*24,26*). Blount and Clarke developed epiphyseal stapling in 1949 (*1*). Bowen subsequently described percutaneous drilling combined with curettage (PDC) (*4*) and Métaizeau introduced in 1998 the percutaneous epiphysiodesis technique using transphyseal screws (PETS) (*20*).

All these techniques were used in our orthopaedic department. This retrospective study had two main objectives. The first objective was to compare the techniques in terms of perioperative morbidity and complications. The second objective was to evaluate their efficiency in correction of the LLD.

PATIENTS AND METHODS

Between 1987 and 2008, 92 patients followed for LLD were treated by surgical epiphysiodesis. Five patients were excluded because they underwent a contralateral leg lengthening (2 patients) or because of lack of data (3 patients). Only three patients underwent the Blount stapling technique ; they were not included in the study. This technique was discontinued after these three cases , owing to the high rate of complications (2 patients out of 3) : staples dislodgment in one patient and knee

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stiffness requiring removal of the staples in the other. Four patients operated using a combination of two techniques were also excluded from the study.

Eighty patients were thus available for this retrospective study. Two of them underwent two successive epiphysiodesis procedures at two different sites (femur and tibia), giving two additional procedures for study. Overall, the results of 82 operations were analysed : 33 Phemister, 34 PDC and 15 PETS.

LLD and remaining growth assessment

The preoperative LLD was evaluated radiographically with an orthoroentgenogram for 77 cases or a teleroentgenogram for the other five. A teleroentgenogram was preferred when the mechanical axis of the legs had to be assessed. The final LLD was classified according to Kemnitz *et al* (*16*) : a good result was noted when the final LLD was less than 1.5 cm, a fair result when between 1.5 and 2 cm, and a poor result when more than 2 cm. Assessment of skeletal age was performed according to the Greulich and Pyle atlas in 53% of cases, according to Sauvegrain's method in 3% and using the two methods in 44%. The skeletal age was obtained within 3 months prior to epiphysiodesis except for one patient (4 months). The height percentiles of the patients were determined using the growth charts from the American Centre for Disease Control (www.cdc.gov/GrowthCharts). The remaining growth was determined using the Green and Anderson technique (*11*). The growth of the lower limb was considered arrested at 15 years of age in girls and 17 years in boys, or when the Risser staging was 4.

Statistical analysis

SPSS.15.0 for Windows was used to perform statistical analysis. The Kruskal-Wallis non parametric test was used to compare numerical data between the three groups. The Chi-square test was used to compare categorical data. The level of significance was set at 0.05.

RESULTS

Preoperative data

The aetiologic factors of the LLD for the 80 patients are summarized in table I. The sex ratio was 50 boys/30 girls. The clinical data of the whole patient group are summarized in table II. The mean preoperative LLD was 3.2 cm (range : 1.5 to 8.1) for the whole group. No significant difference was found between the preoperative LLD of the 3 groups (table III). The operated leg was left-sided in 46%. The operative site was the distal femur in 42 cases (51%), the distal femur and proximal tibia in 20 cases (24.5%), the distal femur, proximal tibia and fibula in 14 cases (17%), the proximal tibia and fibula in 4 cases (5%) and the proximal tibia alone in 2 cases (2.5%).

Table I. — Aetiologic factors of the LLD

Idiopathic	16
Malformation	10
Fracture	8
Perthes disease	8
Hip developmental dysplasia	6
Infection	5
Hemiparesis	5
Hemihypertrophy	5
Clubfoot	3
Neurofibromatosis	2
Klippel-Trenaunay syndrome	2
Poliomyelitis	2
Sarcoma resection	2
Cobb syndrome	1
Silver-Russel syndrome	1
Simple bone cyst	1
Wiedeman-Beckwith syndrome	1
Ollier's disease	1
Hereditary multiple exostoses	1

Surgical procedures

General anaesthesia alone was performed in 69% of cases. It was combined with a femoral nerve block in 17%, with an epidural catheter in 12% and with a spinal anaesthesia in 1% ; spinal anaesthesia alone was performed in one patient. The details for the different groups are summarised in table III ; the three groups did not differ significantly with respect to mean follow-up, mean age at latest follow-up and mean preoperative LLD.

The mean durations of surgery (based on tourniquet time and anaesthesia time) are summarised in table III. The mean time in the PETS group was significantly lower than in the Phemister group

Table II. — Clinical data of the 80 patients

	Whole group	Boys	Girls
Mean chronological age at time of epiphysiodesis (years)	13.4 (range, 9.3 to 16.3)	13.9 (range, 11.3 to 16.3)	12.6 (range, 9.3 to 15.5)
Mean preoperative skeletal age (years)	13 (range, 9 to 15.5)	13.5 (range, 12 to 15.5)	12.1 (range, 9 to 14)
Mean preoperative child height (cm)	157.9 (range, 132 to 182)	162.1 (range, 143 to 182)	150.4 (range, 132 to 165)

($p = 0.0001$) and not significantly lower than in the PDC group ($p = 0.121$).

Immediate postoperative period

The mean number of nights in hospital (table III) was significantly lower in the PETS group : 2 nights, compared to 6 for the Phemister group ($p = 0.00004$), but not significantly lower than in the PDC group (4 nights).

Only 7% of the patients in the PETS group were offered an antalgic extension splint or a thermoformable brace. Twenty eight percent of the patients in the Phemister group were immobilised and 29% in the PDC group (table III).

For the PETS technique, immediate full weight bearing was allowed in 79% of cases and partial weight bearing in 21%. This was significantly different from the other groups (table III) in which immediate full weight bearing was allowed less frequently (16% in the Phemister group, 29% in the PDC group). The need for crutches in the postoperative period was less frequent (21%) in the PETS group compared to the other groups (84% in the Phemister group, 71% in the PDC group) (table III).

Complications

Surgical complications were encountered in 2 cases in the Phemister group (6%). One patient had a postoperative metaphyseal fracture, probably due to excessive curettage, requiring a bone graft, and had a postoperative haematoma. Another patient needed a second complementary operation at the same site because the epiphysiodesis appeared not to be achieved radiologically. Two overcorrections occurred, of 0.2 cm and 0.5 cm respectively, but were not considered as a complication according to Craviari *et al* (*6*) who consider up to 0.5 cm of overcorrection as an excellent result.

In the PETS group, one complication occurred (7%) : one patient underwent a second operation for exchange of a screw which was too long (fig 1).

In the PDC group, 3 complications were encountered (9%). One patient developed a 6° varus knee deformity. Two other patients needed a second operation at the same site because the epiphysiodesis was not radiologically achieved.

Results at latest follow-up

At latest follow-up, 64 patients had reached skeletal maturity (27 or 82% in the Phemister group, 27 or 79% in the PDC group and 10 or 67% in the PETS group). In this skeletally mature group, the mean follow-up was 3.8 years (range : 1 to 18 years). The mean age at latest follow-up was 17.4 years (range 13 to 34 years) without significant difference between the techniques. A girl who was 13 years old was considered skeletally mature with Risser stage 4. The mean final LLD was 1 cm (range : -0.5 to 4.6 cm). The negative value means an overcorrection. The results classified according to Kemnitz *et al* (*16*) for these mature patients are summarised in table III. Good results were obtained in 74% of patients in the Phemister group, 89% in the PDC group and 70% in the PETS group. Fair results were noted in respectively 7%, 7% and 20%. Poor results were noted in 5 patients : 3 in the Phemister group, 1 in the PDC group and 1 in the PETS group. For these two patients (1 in the DC and 1 in the PETS group), the skeletal age at the time of epiphysiodesis was too advanced to obtain complete correction of the LLD. The

Table III. — Clinical data of the patients in the three groups (in bold are the significant differences)

Technique	Phemister	PDC	PETS	*P value*
Mean follow-up (years)	3.8	3.6	3.1	0.347
Mean age at latest follow-up (years)	17.1	17.2	16.8	0.671
Mean preoperative LLD (cm)	3.3	2.8	3.0	0.284
Postoperative LLD (cm) in skeletally mature patients				0.597
Good results (< 1.5 cm)	82%	89%	70%	
Fair results (< 2 and > 1.5 cm)	7%	7%	20%	
Poor results (> 2 cm)	11%	4%	10%	
Patients arrived at bone maturity	27 (82%)	27 (79%)	10 (67%)	0.033
Mean operative duration (min)	79	61	47	0.00001
Anaesthesia (type)				0.735
General anaesthesia (GA)	73%	65%	72%	
GA + crural block/catheter	10%	20%	21%	
GA + epidural	17%	9%	7%	
Spinal anaesthesia	0%	3%	0%	
GA + spinal anaesthesia	0%	3%	0%	
Mean hospitalisation time (nights)	6	4	2	0.00002
Postoperative immobilisation (type)				0.305
Extension splint or thermoformable brace	19%	26%	7%	
Cast	9%	3%	0%	
Postoperative weight bearing (type)				0.0002
Total	16%	29%	79%	
Partial	75%	47%	21%	
Absence	9%	24%	0%	
Need for postoperative crutches	84%	71%	21%	0.0001
Postoperative complications	6%	9%	7%	0.174
Rate of complications in literature (references)	2.5-15% (*6,21-33*)	2.9-33% (*7,8,10,14,15,17,20,33*)	16-27% (*17,18,21-23*)	

correction obtained corresponded to the predicted correction, but the surgery had been made too late. For the 3 patients in the Phemister group, the obtained correction did not correspond with the predicted one, probably reflecting inefficiency of the epiphysiodesis.

DISCUSSION

The complication rates encountered did not differ significantly between the three groups and were comparable to those reported in literature, except for PETS with which our rate was lower. The disadvantages and complications of the three techniques are summarised in table IV.

Reported complication rates for the Phemister technique have ranged from 2.5 to 15% (table III). Metaphyseal fracture as a complication had not been described before. In our case, it was related with weakening of the tibial metaphysis which required cancellous allografting.

Reported complication rates for PDC have ranged from 2.9 to 33% (table III). Compared with the Phemister technique, the operative duration is

Fig. 1. — Complication noted with the PETS technique : one screw was too long and had to be exchanged.

shorter, as well as the hospital stay. Edmonds *et al* (*7*) compared the single and double portal technique. They concluded that the use of a single-portal approach increased the possibility of major complications by nearly 4-fold as compared with the use of a double-portal approach which avoids crossing the midline of the physis. Major complications were failure to arrest growth, partial arrest with angular deformity, fracture, and joint penetration. Kemnitz *et al* (*16*) proposed to use fluoroscopy with contrast to check the depth of the curettage.

Phemister and PDC techniques were compared by two authors : Surdam *et al* (*31*) and Liotta *et al* (*18*). The complication rates were 2.5% and 4.5% respectively in the Phemister group and 9% and 4% in the PDC group. Growth arrest was achieved in all cases in the Phemister group and in 95% and 100% respectively in the PDC and PETS group. The mean hospitalisation duration was 3.5 days in the PDC group and 1.8 days in the PETS group.

The PETS technique combines the advantages of the mini-invasive technique like PDC and the advantages of the reversibility of the epiphysiodesis like the Blount stapling technique. Reversibility was discovered by Haas and Green (*10,12*) : removal of the transphyseal pin in the rabbit permitted recovery of growth. Khoury *et al* (*17*) observed a restart of the growth after screw removal in patients operated on for angular deformations, in 6 cases out of 13, with a rebound effect and a recurrence of the angular deformity. Overcorrection could thus be prevented by removal of the screw.

Metaizeau *et al* (*20,21*) found that the effect of the screws is delayed after insertion. Growth of the distal femoral physis had slowed down by 68% and of the proximal tibial physis by 56% during the first 6 months. This delay may be reduced by initial compression loading of the partially threaded screws. Transphyseal screws achieved maximum deceleration of physeal growth between 6 and 18 months, slowing down the distal femoral physis by 89% and the proximal tibial physis by 95%.

The PETS technique has a short learning curve. There is no need for a tourniquet. There is no risk of epiphyseal separation. The rehabilitation is fast without need for crutches, physiotherapy or immobilization, with swift recovery of knee mobility. Full weight bearing is allowed after 48 hours as tolerated, with resumption of sports after 8 days.

The disadvantages are linked with the insertion of metallic material : risk of infection, risk of inadequacy in the length of the screw with haemarthrosis and sometimes the need for screw removal or exchange. The reported complication rates have ranged from 16 to 27%. We did not observe genu recurvatum, presumably because the screws were all inserted in the central part of the bone in the tibia.

The mean operation time was 20 minutes for each bone in the study by Metaizeau *et al* (*20*) and the mean time in hospital was 1.3 days. We now perform this operation in a one-day hospitalisation setting.

The results at skeletal maturity were not significantly different between the three groups, but the number of patients who have reached skeletal maturity was different. Sixty-four patients had reached skeletal maturity. The rate of good results obtained by the three groups is similar.

Table IV. — Summarized advantages and disadvantages of the various techniques

	Phemister	PDC	PETS
Advantages	– Efficient to correct LLD – Less need for intraoperative fluoroscopy	– Efficient to correct LLD – Mini-invasive / small scar – Less painful – Simple technique	– Efficient to correct LLD – Mini-invasive / small scar – Less painful – Simple technique – No need for tourniquet – Short operative duration – Short hospital stay – Fast rehabilitation – Direct full weight bearing – No need for immobilization – Theoretically reversible
Disadvantages	– Extensive surgical dissection / less cosmetic scar – Long operative duration – Important postoperative pain – Postoperative immobilization – Rehabilitation with crutches – Non weight bearing for 4 to 6 weeks – More risk of bleeding and infection – Irreversibility – Long hospitalisation duration	– Long operative duration – Postoperative immobilization – Rehabilitation with crutches – Non weight bearing for 4 to 6 weeks – Irreversibility – Risk of epiphyseal separation – Risk of intra-articular perforation	– Risk of intraarticular perforation – Insertion of metallic material
Possible complications	– Metaphyseal fracture – Angular deformation (up to 21%) – Exostoses at the site of osteotomy – Nerve injury (infra-patellar branch of the saphenous nerve) – Collateral medial ligament laxity – Knee stiffness – Superficial and deep infection	– Epiphyseal separation – Intra-articular perforation – Haematoma – Angular deformation, genu recurvatum – Exostoses at the site of osteotomy – Nervous lesion (infra-patellar branch of the saphenous nerve) – Knee stiffness – Superficial and deep infections	– Too long screw with haemarthrosis – Painful screw – Intraarticular perforation – Angular deformation – Genu recurvatum (from too anterior placement of the screw across the tibial physis) – Knee stiffness – Superficial and deep infections
References	(*5,12,13,18,24-28,31,32*)	(*2-4,6-8,10,13-20,30-32*)	(*17,18,21-23,29,32*)

CONCLUSION

The PETS technique is an interesting technique with predictable results and various advantages. It is simple and fast. It is less painful , permitting a short hospitalization and a fast rehabilitation with rapid full weight bearing without immobilisation or crutches. Complications are mostly minor. The scar is cosmetic. The effect is reversible. The major risks are intraarticular perforation and genu recurvatum in case of screw misplacement, too anterior in the tibial physis. With comparable results on the final LLD, the advantages of the PETS technique outweigh its disadvantages.

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