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ORIGINAL ARTICLE

Fixator-assisted medial tibial plateau elevation to treat severe Blount's disease: Outcomes at maturity

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KEYWORDS
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Summary
Introduction: Severe forms of Blount's disease may be associated with medial tibial plateau (MTP) depression. Management should then take account of joint congruence, laxity, limb axis, torsional abnomality, leg length discrepancy (LLD) and eventual recurrence history.
Patients and methods: Eight knees (six patients) were managed in a single step comprising MTP elevation osteotomy, lateral epiphysiodesis and proximal tibia osteotomy to correct varus and rotational deformity. Fixation was achieved using an Ilizarov external fixator. Mean age was 10.5 years. Mean hip-knee-ankle (HKA) angle was 151°; distal femoral varus, 94°; metaphyseal-diaphyseal angle (MDA), 27°; and angle of depression of the medial tibial plateau (ADMTP), 42°. Predicted residual proximal tibial growth was 2.6 cm.
Results: At a mean 48 months' follow-up, results were good in six cases, medium in one and poor (due to incomplete lateral epiphysiodesis) in one. Mean lateral tibial torsion was 9° and final LLD 11 mm. Weight-bearing was resumed at 2 months, and the fixator was removed at 5.5 months postoperatively. At end of follow-up, mean HKA angle was 179.6°, MDA 7.3° and ADMTP 5.4°.
Discussion: This technically demanding procedure gave satisfactory results in terms of axes and congruence; longer term assessment remains needed.
Level of evidence: Level IV. Retrospective study.

Introduction

In 1937, Blount [1] described tibia vara of progressive evolution, often bilateral, with onset in infancy. Since then, the literature has grown richer and the typical aspect has now been fully described. Over and above proximal tibial varus, it comprises excess medial torsion of the lower limb, with

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the growth defect lying in the posteromedial part of the superior tibial shaft; the varus progressively worsens over growth, with definitive epiphyseal-metaphyseal impact.

Once diagnosis confirmed, treatment consists of tibial correction osteotomy. When performed before, the patient is 4 years of age, this will not only restore the mechanical axes but also allow the growth and development of the medial part of the proximal tibia to resume [2—4].

Without treatment, iterative strain in varus may induce formation of a posteromedial osseous epiphysiodesis bridge on the superior tibial physis [5]. This is an evolutive development of the disease, and the deformity inexorably worsens over growth. In severe forms, this proximal tibial varus deformity is associated with medial tibial plate (MTP) depression (Fig. 1A), distal femoral valgus and frontal laxity. Management is consequently much more complicated and must take account of: the mechanical and anatomic axes, the rotational deformity, prevention of recurrence, lower limb length discrepancy, and joint laxity and congruence.

In this complex situation, several treatment options have been recommended, all involving joint congruence restoration by MTP elevation [6—12]. Recent publications recommended a 1-step approach [13,14]; these, however, concerned small series, with short follow-up.

The present study reports results on a series of eight knees managed by 1-step correction of axes, joint congruence and growth, using an Ilizarov external fixator. Patients were followed up after growth plate closure.

Patients and methods

Eight knees (six patients) underwent 1-step treatment, using an Ilizarov external fixator. All presented with severe genu varum associated with infantile Blount's disease. Three had already had one or more tibial osteotomies. Mean age was 10.5 years (Table 1).

Figure 1 Major genu varum. A. Preoperative. B. Postoperative.

Tibial torsion was calculated clinically in prone position with 90° knee flexion, between the axes of the thigh and hindfoot. Lateral tibial torsion is expressed as a positive and medial torsion as a negative angle; the mean normal value for a 5—10-year-old child is +10° [15]: mean tibial torsion in the present series was −4°.

The Catonné [16] and Laville classifications were applied (Table 2) [17]. All patients presented with confirmed Blount's disease with medial metaphysoepiphyseal bone bridge.

Instability was graded according to three levels:

- +: moderate medial laxity on clinical examination;

Table 1 Preoperative assessment.

Patient	Side	Gender	Age at surgery	Tibial torsion (°)	Frontal laxity	HKA (°)
1	R	F	9	−15	3+	135
1	L	F	9.5	−15	3+	135
2	L	F	9	0	2+	165
3	L	M	13	0	2+	158
4	L	F	11	5	2+	160
4	R	F	11.5	5	2+	165
5	L	F	12	10	2+	140
6	L	F	11	−20	3+	150

Patient	Distal femoral valgus (°)	Metaphyseal-diaphyseal angle (°)	ADMTP (°)	Proximal tibial growth (cm)
1	95	40	50	3
1	90	30	34	3
2	90	10	35	3
3	91	20	40	2
4	98	26	50	3
4	96	10	50	3
5	100	58	40	2
6	90	23	40	2

ADMTP: angle of depression of the medial tibial plateau.

Table 2 Laville's classification.

Stage 0	Possible Blount's < 2.5 years
Stage I	Confirmed Blount's Shaft+ (no bridge)
Stage II	Confirmed Blount's Shaft− (medial metaphysoepiphyseal bone bridge)

In stages I and II, MTP may be normal or depressed.

- ++: medial and lateral laxity on clinical examination;
- +++: multidirectional laxity showing as lateral thrust to the knee during the stance phase of gait.

All the knees were graded ++ or +++.

The following measurements were taken on preoperative, postoperative and end-of-FU X-ray:

- hip-knee-ankle angle (HKA): center of femoral head − center of knee − center of ankle;
- metaphyseal-diaphyseal angle (MDA) [18]: angle subtended by the line drawn through the transverse plane of the proximal tibia metaphysis and the longitudinal axis of the tibia, along the lateral tibial cortex and parallel to the fibula (Fig. 2);
- angle of depression of the medial tibial plateau (ADMTP), following Schoenecker et al. [2]: angle subtended by a line running from the intercondylar eminence (tibial spurs) through the most medial part of the epiphysis and a line parallel to the lateral tibial plateau;
- distal femoral valgus: mechanical femoral angle between the mechanical femoral axis and the intercondylar line, measured medially: in severe forms, the medial femoral condyle is often hypertrophied, resulting in a intercondylar line that is oblique with respect to the mechanical femoral axis.

Figure 2 Calculation of axes on large views (MDA: metaphyseal-diaphyseal angle).

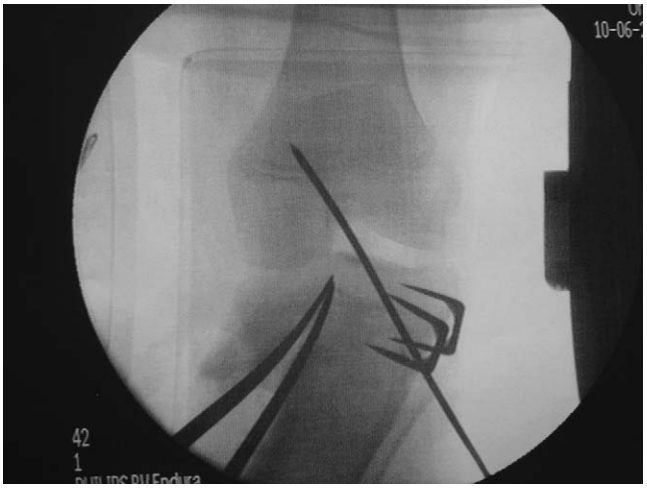

Figure 3 MTP-elevation osteotomy. A temporary wire holds the medial femorotibial compartment open. Lateral epiphysiodesis is performed using staples.

The surgical procedure has been standardized, and comprises four stages (Fig. 3):

- lateral epiphysiodesis: surgery begins with epiphysiodesis of the lateral part of the proximal tibial shaft and the fibula. This is performed at the beginning of surgery so that the surgeon will not be bothered by the external fixator. It was percutaneous in six cases and by external stapling with a short approach in two;
- fibular osteotomy: diaphyseal fibular osteotomy, removing 1/2 cm, in order to allow satisfactory valgization;
- first tibial osteotomy: MTP osteotomy. Using a medial approach at the superior third of the tibia, the inferior part of the inner hamstring muscles is released, exposing the tibia subperiosteally. One Chandler retractor is positioned anteriorly under the patellar tendon, pointing towards the intercondylar eminence, and a second posteriorly in the same direction, to protect neurovascular structures. Osteotomy is performed using a curved chisel under optical control, moving towards the tibial spurs without damaging the joint cartilage, which is to be used as hinge. Elevation is performed progressively, restoring tibial plateau alignment. Elevation is easier if the knee is held in valgus by a temporary femorotibial K-wire, so as to open the medial compartment, and is maintained by Méary forceps. At this point, there may be a posterior MTP slope that needs correcting. The elevation is fixed by an Ilizarov ring with a supporting half-hinge just underneath. The skin should be partially closed before the wires are introduced to avoid tension at closure. This MTP elevation and fixation partially corrects the varus;
- second tibial osteotomy: once the epiphysis has stabilized, one or two more rings are fitted in to the lower part of the limb, and the second tibial osteotomy is performed, just under the tibial tuberosity. A lateral hinge may be conserved if only frontal correction is required; if lengthening (as in three cases in the present series) or rotational

Figure 4 Correction obtained by Ilizarov external fixator (Fig. 2 shows preoperative aspect).

tibial correction is necessary, the osteotomy will have to be completed. Part of the varus can be corrected in this second tibial osteotomy.

The assembly is consolidated and closure performed without excessive skin tension. The skin around the wires has to be broadly debrided. Varus correction is continued over the following days and checked on standing AP view of the lower extremities from hip to ankle (Fig. 4).

Lower limb length discrepancy will have been predicted from the Héchard-Carlioz graph and from bone age calculation, following Greuliche and Pyle; this point will be taken up in the Discussion.

The mean preoperative HKA angle was 151°, distal femoral valgus 94°, MDA 27°, and ADMTP 42°. Residual proximal tibial growth at surgery was 2.6 cm.

Results were assessed on Schoenecker's criteria [2]:

- good: absence of pain, instability or lower limb length discrepancy, normal angle between femoral and tibial mechanical axes (±5°);
- fair: occasional pain, moderate instability, 5°—10° deviation from theoretical femorotibial angles;
- poor: frequent pain, severe instability, major axis abnormalities and final LLD >3 cm.

Results

Results are presented in Table 3.

There were four complications:

- one common peroneal nerve palsy, resolved within three months;
- one premature fibular consolidation during lengthening, leading to proximal tibiofibular subluxation;
- one deep infection, requiring surgical revision;
- one necrosis around the external fixator wires, requiring per os antibiotherapy and prolonged local care.

At a mean 48 months' follow-up, all patients showed growth plate fusion around the knee. On Schoenecker criteria [2], results were:

Table 3 Postoperative assessment.

Patient	Lengthening (cm)	Time to weight-bearing (mo)	Ablation of Ilizarov (mo)	FU (mo)	Result	Mobility flexion	Mobility Extension
1	No	1.5	5	35	Good	130	0
1	No	1.5	4	30	Good	130	0
2	3	2	6	72	Good	140	0
3	1.5	1.5	5.5	44	Good	140	0
4	No	3	6	62	Poor	130	0
4	No	3	6	39	Good	140	0
5	No	1	6	72	Medium	140	10
6	3	3	5.5	30	Good	130	0

Patient	Frontal malalignment	Tibial torsion (°)	Final LLD (cm)	HKA angle (°)	Metaphyseal-diaphyseal angle (°)	ADMTP (°)
1	No	0	1	178	15	9
1	No	0	1	180	0	5
2	No	25	1	185	0	0
3	No	20	0.5	185	0	0
4	Yes	5	1.5	162	22	12
4	No	5	1.5	184	0	0
5	No	15	2.5	180	10	10
6	No	0	0	183	12	7

LLD: leg length discrepancy; ADMTP: angle of depression of the medial tibial plateau.

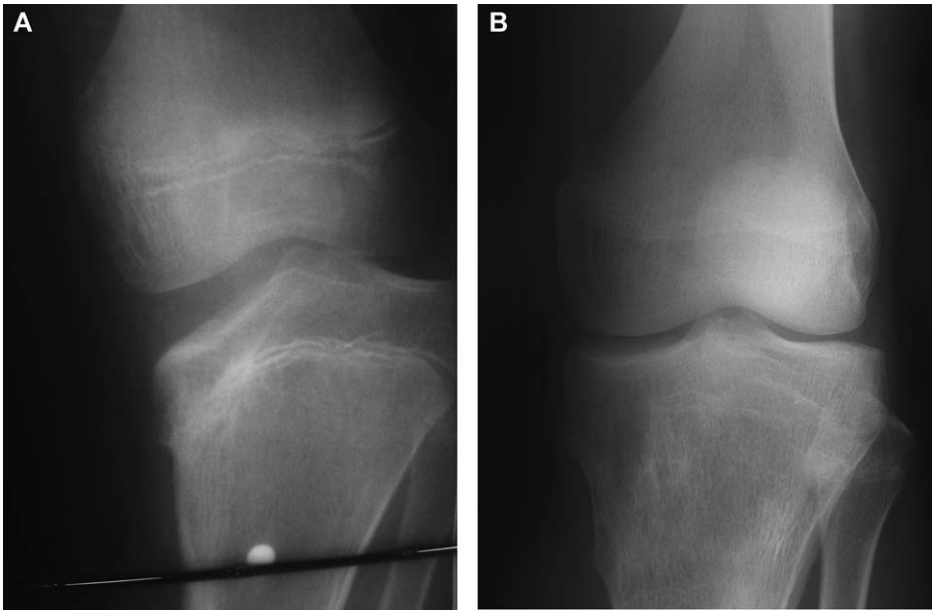

Figure 5 AP knee X-ray showing MTP depression. A. Preoperative. B. Postoperative.

- good: 6/8;
- fair: 1/8: one patient experiencing occasional pain; end-of-follow-up X-ray showed posterior tibial slope of the MTP;
- poor: 1/8: one patient with recurrence of varus due to insufficient percutaneous lateral epiphysiodesis; even so, the ADMTP of 50° fell to and was maintained at 12°; the patient underwent surgical revision for the lateral epiphysiodesis and progressive correction of varus by uniplane external fixator.

Mean knee flexion was 136° without flexion contracture. Mean lateral tibial torsion was 9°, and mean LLD <11 mm. Weight-bearing was resumed at 2 months, and the external fixator was removed at 5.5 months. Mean HKA angle at end of FU was 179.6°, MDA 7.3°, and ADMTP 5.4° (Figs. 1 and 5).

Discussion

In the complex situation of evolved Blount's disease with MTP depression, 1-step treatment of all the problems, with or without external fixator, was recommended, but on the basis of limited series with short follow-up [12—14]:

- epiphyseal distraction with MTP elevation and external fixation [14];
- double osteotomy for valgization, derotation and MTP elevation, with osteosynthesis by plate or staples [10,11].

The present double tibial osteotomy with Ilizarov external fixator has several advantages over previous techniques:

- possibility of postoperative adjustment of valgus by the external fixator;
- systematic lateral epiphysiodesis, avoiding recurrence of varus;
- and resolution of LLD by progressive postoperative lengthening.

In agreement with the literature, the present results were good overall, despite severe initial varus and often severe joint incongruence. The one poor result was related to insufficient lateral epiphysiodesis, inducing recurrence of varus; even so, joint congruence was satisfactorily restored, and simple revision of the metaphyseal osteotomy allowed favorable subsequent evolution.

The complications were entirely non-specific, and typical of those encountered in lower limb lengthening using an external device.

Medial tibial plateau depression

According to Schoenecker et al. [2], MTP depression should be corrected when slope exceeds 30°. We agree that, in such severe forms, MTP height must be restored. Elevation osteotomy here corrected the slope, reducing mean ADMTP from 42° to 5.4°, and improving laxity. The external fixator used in the present series was the Ilizarov model, but other systems can equally be used [12,14].

MTP support by bone graft was not required, as the system was sufficiently rigid to maintain elevation. The gap left under the MTP was progressively filled over a period of a few months in all cases. The one inconvenience is the need to wear the external fixator for 5.5 months on average; weight-bearing, however, could be authorized as of postoperative day 45.

Jones et al. [12] stressed that preoperative planning for MTP elevation should include 3D CT scan, posterior MTP slope, which has to be taken into account during elevation, being difficult to visualize on standard X-ray. In the present series, posterior elevation was insufficient in patient no. 5, due to faulty preoperative assessment, which

may well explain the merely fair result in this case. For good visualization of joint congruence, we now perform systematic complete preoperative imaging including weight-bearing standing AP view of the lower extremities from hip to ankle, AP and lateral knee views and 3D CT centered on the proximal extremity of the tibia.

Age at surgery and growth

Mean age in the present series was 10.5 years (range, 9—13 years). As treatment involves definitive epiphysiodesis of the proximal tibia, it should not be undertaken too early, and is recommended in case of medial metaphysoepiphyseal bone bridge (Laville grade II). In younger children, simple tibial osteotomy with hypercorrection is to be preferred, in the hope of renewed MTP growth [2—4]. The family should be told that, in case of recurrence of varus, more definitive redo surgery is to be performed in the years to come.

The issue of lower limb length depends on the situation:

- in asymmetric or unilateral forms, LLD should be predicted from bone age and growth curves, which is not always easy to do. Depending on the case, lengthening within the subtuberosity tibial osteotomy may be considered after axial correction; templates should, in that case, be used to take account of lengthening induced by varus correction. Residual proximal tibial growth was around 3 cm in the age group of the present series, so that the lengthening to be achieved is moderate and usually unproblematic;
- in symmetric forms, lengthening is not normally indicated if the contralateral side is to be operated on soon after. The final loss of height should be explained to the parents; if insufficient final height is forecast, bilateral lengthening may be considered.

Congruence and laxity

The optimal indication for elevation is medial incongruence with laxity associated with an MTP development deficit: elevation will improve the laxity. Absence of laxity testifies to relative joint congruence, hindering MTP elevation, which is, therefore, to be indicated with caution due to the risk of increasing pressure on the joint cartilage.

Distal femoral valgus

Distal femoral valgus, due to medial femoral condyle hypertrophy, is frequent, probably in reaction to the facing MTP growth deficit. Two situations are possible:

- when distal femoral valgus exceeds 100°, which is unusual in our experience, correction is indicated, either by femoral varization osteotomy or by epiphysiodesis of medial part of the distal femoral shaft. The problem lies in the sequence of procedures: the femoral procedure may have to be performed at the same time as the tibial osteotomy so as not to leave an oblique joint space;
- when distal femoral valgus is moderate, we consider it best to postpone femoral surgery until the end of the growth phase: distal femoral valgus has been observed to diminish with growth, probably due to a modified balance of forces on the femoral condyles.

Study limitations

This was a small series of eight knees, but evolved Blount's disease is rare. Although mean follow-up was only 4 years, all patients were at maturity at last follow-up. There were at the time of writing no signs of arthritic degeneration. This procedure is technically demanding, due to the intra-articular osteotomy, but provided satisfactory results in terms of axes and congruence, although longer-term assessment will be needed.

Conflicts of interest statement

None.

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