



Guided growth vs. Tibial osteotomy at early stage of Blount disease in skeletally immature patients

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ABSTRACT

Background: There are no comparative study between guided growth and tibial osteotomy in early stage of Blount disease (BD) to our knowledge. The aim of this work was to compare the results of patients treated by these two techniques.

Method: This was a retrospective, descriptive, and analytical study over a period of 5 years in including 17 children (24 Knees) with an early stage of infantile BD in two centers. Patient were classified in two groups: *group 1* (treated by guided growth), *group 2* (treated by Tibial Osteotomy).

Preoperative alignment analysis using the tibial femoral angle (HKA) and the proximal medial tibial mechanical angle (mMPTA) were compared with three measurements taken postoperatively in each of the groups. The mean variations of the angles were compared between the two groups.

Results: Socio-demographic characteristics were similar for the two groups. Median age at surgery was 6.5 ± 2.5 [3–9 years] in group 1 and 6.8 ± 2.9 years [3–9 years]. At a follow-up of 24 ± 3.5 months, the limb alignment was significantly corrected (1.03° /month) in group 1 (**median HKA** 144° – 171° ; $p = 0,001$; **median MMPPTA** 78° – 87° , $p = 0,018$), and in group 2 we observed at a follow-up of 23 ± 15 months a progressive loss ($0,52^\circ$ /month) of the correction obtained immediately postoperatively (**median HKA** 160° – 176° (immediate post operative) to $165,5^\circ$; $p = 0,31$; **median MMPPTA** = 78° – 86° (immediate post operative) to $80,5^\circ$; $p = 0,37$).

There was a statistically significant difference between the mean variation in HKA between the two groups (group 1 = $22,5$; group 2 = $4,5$, $p = 0,00$), as well as for MMPPTA; (group 1 = 7 ; group 2 = $2,5$, $p = 0,023$). The rate of correction was 78% in group 1 with no rebound at a median follow-up after removal of the material of 10 ± 2.4 months. Within group 2, the rate of correction was 10% with a recurrence rate of 60%.

Conclusion: Guided growth appears to be the best treatment for early stage of BD in skeletally immature patients.

1. Introduction

Blount's disease (BD) is a common etiology of axial knee deviation. It is a disorder of the medial part of the upper tibial epiphysis resulting in varus, tibial torsion and procurvatum, described by Blount in 1937.¹ Two types are distinguished: infantile tibia vara and adolescent tibia vara. Several classifications based essentially on the degree of deformity and the existence of epiphysiodesis have been proposed with precise

therapeutic implications.^{2,3} We can globally distinguish between the forms without a bone bridge of proximal medial tibial, so-called early stage, and the other so-called neglected forms. For a long time, it was accepted that osteotomy before the age of 4 years would guarantee a better outcome in early-onset cases, but nowadays, several teams recommend transitory growth modulation by temporary hemiphysiodesis, leaving osteotomies for neglected cases.^{4,5} Temporary hemiphysiodesis for guided growth is indeed currently well codified

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with good results in skeletally immature patients with early stage of BD. Although they all aim at restoring the mechanical axes of the limb, restoring growth, correcting laxity and joint congruence, there are no comparative studies between guided growth (GG) and tibial osteotomy (TO). The purpose of this study was to compare the results of GG and TO in patients with early stage of BD in squelletically immature patients.

2. Patients and methods

2.1. Patients

This was a retrospective, descriptive, and analytical study over a period of 5 years in two centers. All the children included had an early stage of infantile BD. The patients were classified into two groups.

2.2. Group 1: Patients treated by guided growth (10 patients, 14 knees)

Growth modulation was performed with a plate or Blount staples. No postoperative plaster cast immobilization was performed. Support was permitted immediately postoperatively as long as pain allowed.

2.3. Group 2: Patients treated by tibial osteotomy (7 patients, 10 knees)

The technique used was the Revisited Rab Osteotomy.⁶ The patients were then immobilized for 6 weeks with a 3-month suspension of sports activities.⁶

2.4. Clinical and radiological analysis

All medical records for each patient were reviewed, including surgical reports and radiographs. Information collected included sex, body mass index (BMI), age at surgical intervention, and outcome. Radiological measurements were performed by a team of 3 persons (02 surgeons and one radiologist). We evaluated the tibial femoral angle (HKA), the proximal medial tibial mechanical angle (MMPTA) preoperatively, immediately postoperatively, at 6 months, and at the last follow-up. Whatever the type of surgery, the aim was to normalize the HKA (180 ± 5) and MMPTA (87 ± 2) angles.¹³ The median degree of tibial varus correction per month was calculated. The variation in these two angles obtained by the difference between the preoperative value and the value at the last follow-up was determined for every subject. The value is negative when the variation decreases. We compared the median angle variations of the two groups to assess the effects of the different techniques.

2.5. Statistical analysis

Statistical analysis was performed with SPSS version 25.0 (SPSS Inc., Armonk, NY, USA). The Wilcoxon signed rank test was used to compare the pre- and postoperative median values of the intra-group angles. Mood's median test was used to compare median angle variations between the two groups. $P < 0.05$ was considered significant.

3. Results

3.1. Study population

Seventeen (17) patients with a total of 24 knees were included. The median age at surgery was 6.6 ± 3 years (range, 3–12). The sex ratio was 5/12. The left knee was the most affected (13/24). The median BMI was 25.2 ± 2.3 Socio-demographic characteristics were similar for the two groups (Table 1).

3.2. Group 1: Patients treated with GG (10 patients, 14 knees)

The median age at surgery was 6.5 ± 2.5 (range, 3–9 years). In ten

Table 1
General characteristics.

	GG	TO
Number of knees	14	10
Average age	$6,5 \pm 2,5$ ans	$6,8 \pm 2,9$ ans
Sex ratio	2/5	3/7
BMI	$25,3 \pm 3,1$	$25,1 \pm 1,3$
Associated distal femur hemiepiphyodesis	04	02
Correction rate	78% (11/14)	10% (1/10)
Recurrence	0	6/10 (6)
Follow up	$24 \pm 3,5$	23 ± 15 mois

cases, the procedure was performed with 8-plates and in four cases, staples was used. In four cases a distal femoral hemiepiphyodesis was associated. With a mean follow-up of 24 ± 3.5 months (range, 15–27), the HKA and MMPTA angles were significantly corrected (Tables 2 and 3). The correction rate was 78.57% (11/14) (Fig. 1). The mean correction of the MMPTA angle was $1,03^\circ$ per month with no association with age ($p = 0.17$). Staple migration was the complication in two patients who were successfully reoperated. No rebound was observed with a median follow-up after removal of the material of 10 ± 2.4 months.

3.3. Group 2: Patients treated with TO (7 patients, 10 knees)

Ten (10) knees were treated with revisited Rab's osteotomy at a median age of 6.8 ± 2.9 years [3–9 years]. Distal femoral hemiepiphyodesis was associated in 02 patients. At a follow-up of 23 ± 15 months (range 12–30), we observed a progressive loss of the correction obtained immediately postoperatively (Tables 2 and 3). Correction was maintained with normal axes in only one patient (10%). The mean decrease in tibial varus of approximately 0.52° /month was independent of age ($p = 0.43$). The recurrence rate was 60% (6/10) and all these patients had to be treated with external fixator assisted correction (Fig. 2).

General characteristics are summarized in Table 1.

3.4. Comparison of median angle variations between the two groups

There was a statistically significant difference between the median variation in HKA ($p = 0.00$) between the two groups (group 1 = 22,5; group 2 = 4,5), as well as for MMPTA ($p = 0,023$); (group 1 = 7; group 2 = 2,5). (Table 4).

4. Discussion

In our series, guided growth was used in patients with a mean age of 6.5 ± 2.5 [3–9 years]. We considered it appropriate to combine it with distal medial femoral hemiepiphyodesis in 4 patients who had a distal femoral valgus greater than 100° . This technique led to restoration of the mechanical axis of the limb in 11 of 14 patients (78.6%) with significant correction of the HKA and MMPTA. Danino et al. reported in a literature review on the effect of growth modulation in BD that there was a significant reduction in the MMPTA angle and mechanical limb axis deviation in patients treated with this technique.⁷

Helfing et al. retrospectively analyzed the effectiveness of guided growth on 27 knees treated with this technique. All patients in their series were skeletally immature and were treated regardless of age or weight as long as there was no medial superior tibial bone bridge. The correction rate was 78% without no major complications.⁸ All subjects under 4 years old had total correction with spontaneous correction of tibial torsion, except for one recurrence. Among subjects older than 12 years, correction was close to normal or complete in only 62% of cases. These patients would have needed osteotomies if they had not been treated by guided growth. Therefore, they consider it to be a relatively safe and effective first-line treatment in this age group, considering the potential complications associated with osteotomy. Several other

Table 2
Evolution of HKA.

	Age	Preoperative	Immediate post operative	6 months	Latest follow up	P value
GG	<5 years (N = 7)	137 (17,6; 113–164)		142 (17,6; 113–164)	168,6 (6,05; 161–180)	0,001*
	> 5 years (N = 7)	153 (5,05; 143–160)		158 (4,32; 146–164)	173 (3,91; 168–178)	
	Total (N = 14)	144 (14,64; 122–164)		152 (10,18; 131–172)	171 (5,75; 163–180)	
TO	<5 years (N = 4)	154 (8,5; 142–160)	177 (3,42; 175-180)	170 (2,31; 165–178)	165 (11,17; 150–175)	0,31
	> 5 years (N = 6)	163 (2,48; 160–168)	176 (3,26; 173–178)	173 (3,12; 151–174)	160 (9,72; 148–172)	
	Total (N = 10)	160 (7,09;142–166)	176 (3,05;174–179)	171 (3,21; 170–176)	165,5 (10,03;150–175)	

Median value (°) (SD; range); * Significant result.

Table 3
Evolution of MMPTA.

	Age	Preoperative	Immediate post operative	6 months	Latest follow up	P value
GG	<5 years (N = 7)	79 (6,2; 67–85)		85 (5,78; 71–90)	88(7,97; 72–94)	0,018*
	> 5 years (N = 7)	79 (4,79; 72–84)		83 (4,48; 78–86)	87 (5,02; 77–89)	
	Total (N = 14)	79 (5,28; 67–85)		83,5 (4,96; 73–90)	87 (6,48; 72–94)	
TO	<5 years (N = 4)	79,5 (4,43; 75–85)	87 (3,22; 84–89)	83 (3; 81–85)	85,5 (85–93)	0,37
	> 5 years (N = 6)	77 (7,17; 68–85)	86 (2,21; 84–88)	85,5 (2,45; 83–87)	80,5 (10,16; 65–93)	
	Total (N = 10)	78 (6,10; 68–85)	86 (2,51; 84–89)	84 (3,05; 81–87)	80,5 (10,16; 65–93)	

Median value (°) (SD; range); * Significant result.

studies reported good results with this technique.^{9–12} The rate of angular correction found by Danino et al. was 1° per month as we observed in our study.⁷

Some complications reported include screw pull-out or breakage at a mean time of 13.6 months, which is much more common in obese patients.^{13,14} The failure rate involving osteotomy after growth modulation varies between 11% and 44% and is mainly in children near skeletal maturity.^{7,8,10,15} These children reach skeletal maturity before total correction. A recent systematic review by Fan et al. found no correlation between age at surgery or implant type and growth modulation failure but their database was heterogeneous.¹⁶ Another complication related to growth rebound with recurrence of the deformity suggests waiting for valgus hypercorrection before removal of the material. All our patients will be followed up until bone maturity. Indeed, the procedure can be repeated even in case of rebound effect as long as there is no medial superior tibial epiphysiodesis bridge. Furthermore, the progressive nature of the correction guarantees a better adaptation of the anatomical elements of the knee, all the more so as the children are growing. The staples migration observed in our series only concerned children with advanced angular deformity. Indeed, staples are known to have poor hold, but we had no choice because of the financial limitation of these patients.^{13,14}

The present study therefore not only corroborates the results of the literature regarding the good results reported but also confirms the superiority of GG over TO at early stage of BD in squelletically immature



Fig. 1. Blount disease in 5 year old boy treated by guided growth. (A) Preoperative X-ray. (B) After 15 months.

patients. The high success rate considerably reduces the need for reoperations, which are numerous in patients treated with tibial osteotomy. In fact, Rab osteotomy was developed in 1988 by Rab, who stated that because all clinical deformities in BD (varus and internal rotation) must be corrected, the osteotomy should have transverse and frontal components, which he achieved by making a 45° oblique osteotomy to the vertical through the anterior tibial tuberosity, directed from anterodistal to postero proximal.^{6,17} The different degrees of the mobility offered by the two sides of his osteotomy thus allow him to correct the deformities as well as possible. The results were good but the follow-up was only 15 months. In our series with a longer follow-up, over two years, we observed that despite a perfect postoperative correction, there was a progressive loss of the axis correction obtained with a recurrence rate of 60%. Like all other osteotomies described in this condition, the Rab osteotomy is performed below and behind the anterior tibial tuberosity.^{17–19} No procedure is performed on the growth plate, which is the site of the pathology. Moreover, the children are young and growing.



Fig. 2. Tibial osteotomy in 5 years boy. (a) Preoperative X-ray; (b,c,d,e) Immediate postoperative (f) Right recurrence after 2 years.

Table 4
Comparison of median angle variations between the two groups.

	N	Median	SD	Minimum	Maximum	P value
Variation HKA (°)						
GG	14	22,5	9,97	14	41	0,00*
TO	10	4,5	9,12	-12	15	
Variation MMPTA (°)						
GG	14	7	7,41	3	15	0,023*
TO	10	2,5	6,21	-7	11	

*Significant result.

The disease therefore evolves on its own account, making the correction obtained transient and explaining the progressive loss of correction and the recurrences observed. In our series, all the patients who were rehabilitated had to be treated with an external fixator, which is still more invasive, because they developed a medial proximal tibial bone bridge after osteotomy. Helfing et al. treated patients with recurrence after Rab osteotomy with good results by growth modulation, but these patients were still skeletally immature and did not have a bone bridge.⁸ Osteotomy in early stage of BD therefore appears to be a transitional treatment making GG the best means of correcting deformities in this stage of BD which is much less invasive with an early return to activity.

5. Limitations of the study

The size of the study population appears to be small, but the pathology is not so frequent and our results are valid in accordance with data available in the literature.

6. Conclusion

Guided growth remains the best treatment for early stage of BD. It is less invasive and highly successful. Tibial osteotomy in the early stage of this disease exposes to the risk of recurrence and should be reserved for neglected form or at the very least to the children close to skeletal maturity.

Declaration of competing interest

No conflict of interests.

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List of abbreviations

- BD Blount Disease
- GG Guided growth
- HKA Tibio femoral angle
- MMPTA mechanical Medial Proximal Tibial Angle
- TO Tibial osteotomy

Authors' contributions

ASSAN BR conceived the idea, designed the study and participated to data collection. ADJADOHOUN S, SEGBEDJI GGS, METCHIHOUNGBE CS participated to data collection, prepared the figures and tables performed the statistical analysis. SIMON AL, SOUCHET P, FIOGBE MA, ILHARREBORDE B and GBENOU AS corrected the final version. All the authors interpreted the data and contributed to the preparation of the manuscript. The authors read and approved the final manuscript.

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Availability of data and materials

The data and materials contributing to this article may be made available upon request by sending an e-mail to the first author.

Ethics approval and consent to participate

The ethics committees of each hospital center approved this study, and all the participants had written the informed consent.

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