Growth modulation may decrease recurrence when used as an adjunct to osteotomy in infantile Blount’s disease

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Abstract

Background

This study aimed to determine whether the addition of a lateral proximal tibial tension band plate, combined with proximal tibial dome realignment osteotomy, would decrease the recurrence rate in a group of children younger than 7 years with infantile Blount’s disease (IBD) and high recurrence risk, defined as a medial physeal slope ≥60°.

Methods

We reviewed the records of 14 children (22 limbs) under the age of 7 years with IBD and a medial physeal slope ≥60° that were treated with a combination of tibial osteotomy and tension band plates (group 2) to determine the recurrence rate and time to reoperation. These results were compared with a matched group of eight children (12 limbs) with IBD and a medial physeal slope ≥60° that were treated previously with tibial osteotomy alone (group 1).

Results

The two groups were matched in terms of age, sex, obesity, Langenskiöld stage, tibio-femoral angle and medial physeal slope. The recurrence rate was 92% (11/12) in group 1 and 77% (17/22) in group 2 (odds ratio 0.31; 95% CI 0.03–3.01, p=0.312). The mean time to reoperation was 2.4 years in group 1 and 1.9 years in group 2 (p=0.319). There were two implant-related complications: one broken screw and one case of epiphyseal fixation failure in the tension band plate group, both in cases of recurrence.

Conclusion

The addition of a lateral tension band plate to a proximal tibial realignment osteotomy may be an option to consider in children younger than 7 years with IBD and a high risk of recurrence. Further research is required to determine recurrence risk in IBD and to develop and evaluate surgical strategies to mitigate this risk with well-designed, multicentre controlled trials.

Level of evidence: Level 4

Keywords: Blount’s disease, tibia vara, guided growth, tension band plate, osteotomy, recurrence

Introduction

Infantile Blount’s disease (IBD) presents as a progressive multiplanar proximal tibial deformity with onset from the age of walking.¹ The deformity is due to disordered growth in the posteromedial proximal tibial physis.² The cause of disordered growth is likely to be multifactorial.³ Once the diagnosis is confirmed, surgery is indicated.⁴

The risk of recurrence following proximal tibial osteotomy is high and has been reported to be between 41% and 72%.⁵,⁶ It is crucial to attempt to prevent recurrence because repeat osteotomy has been linked to worse outcomes at skeletal maturity.⁵,⁶

Several authors have identified risk factors that predict recurrence. These include age at surgery, obesity, the severity of deformity, Langenskiöld stage, LaMont type C appearance, and a medial physeal slope (MPS) ≥60°.⁵,⁶,¹⁰ We previously showed that an MPS≥60° was the best predictor of recurrence in our population.¹⁰ Despite the risk factors associated with recurrence being known, surgical strategy selection based on risk stratification has not been extensively investigated. Overcorrection into valgus, medial epiphysiodesis and lateral epiphysiolysis are all strategies that have been employed in an attempt to decrease the recurrence rate.⁴,¹¹,¹²,¹³ Overcorrection has not been proven to be an effective strategy, medial epiphysiodesis has limited application, and there is a risk of overcorrection and loss of growth potential with permanent epiphysiodasis.¹⁴,¹⁵

Guided growth has become a popular technique to correct long bone deformities in children since the development of the tension band plate.²¹ While reports on the use of growth modulation with tension band plates to correct the deformity caused by Blount’s
disease have been encouraging, the use of a tension band plates as an adjunct to proximal tibial osteotomy as a strategy to decrease the risk of recurrence has not been investigated.22–25

We aimed to investigate whether the addition of a tension band plate to a standard proximal tibial realignment osteotomy could decrease the rate of recurrence after proximal tibial osteotomy in children under 7 years of age with IBD and high recurrence risk.

Materials and methods

We reviewed our paediatric orthopaedic database and identified all children with IBD under the age of 7 years with a high risk for recurrence treated at our tertiary hospital between 2010 and 2018 with at least 18 months follow-up. IBD was diagnosed by observing progressive proximal tibial deformity, typical changes on standing AP and lateral knee radiographs and a tibial metaphyseal diaphyseal angle (MDA) >16°. High risk of recurrence was defined as a metaphyseal slope angle (MPS) ≥60°.12,13,16 We excluded eight children (ten limbs) who had less than 18 months follow-up. We also excluded children older than 7 years because these cases were frequently complicated by knee instability due to medial plateau depression and were treated with medial elevation osteotomy and definitive lateral epiphysiosis.

In children under 7 years with IBD, it was our practice to perform multiplanar deformity correction through a metaphyseal proximal tibial dome osteotomy. We aimed to correct the coronal alignment into physiological valgus, while simultaneously correcting the internal rotation and procurvatum to normal. The normative data published by Salenius and Vankka were used as a reference (diaphyseal tibio-femoral angle between 5° and 6°±4°).26 Pragmatically, we aimed to correct the tibio-femoral angle to between 5° and 10° valgus alignment. During the study period, our practice changed to include the use of a lateral proximal tibial eight-plate (Orthofix, McKinney, Texas, USA), in addition to immediate proximal realignment osteotomy, in children where the MPS≥60° (Figure 1a–d). We compared a subgroup of the initial patients who had an MPS≥60° and were treated with tibial osteotomy alone, with the latter patients who had the additional eight-plate. The two groups were compared in terms of demographics, obesity and disorder severity to ensure they were matched in terms of recurrence risk. Severity was assessed by the Langenskiöld stage, metaphyseal–diaphyseal angle (MDA), anatomic tibio-femoral angle (TFA) and medial physeal slope (MPS). Radiographic measures were obtained on standing AP long cassette radiographs. If these were not available, standing AP knee radiographs that included sufficient proximal tibial and femoral diaphysis to allow measurements were used. The postoperative measurements were obtained from supine AP knee radiographs.

The outcome measures were the recurrence rate and time to repeat surgery. Recurrence was defined as progressive varus ≥10° varus TFA. All recurrent cases required repeat operation. Procedures that were needed to correct alignment and restore knee stability were tibial osteotomy and medial joint line elevation. If medial growth was observed, the eight-plates were removed. If there was no medial growth, a lateral proximal tibial Physiometer epiphysiosis was performed.

Surgical technique

All cases were treated by immediate multiplanar deformity correction through a low energy proximal tibial dome osteotomy.27 An oblique incision from proximal medial to distal lateral was made to access the proximal tibia. The orientation of the incision allowed easy access to the metaphyseal should medial elevation osteotomy be required at recurrence. A section of 5–10 mm of the midshaft fibular diaphysis was resected through a longitudinal incision with a fine oscillating saw before deformity correction. The tibial osteotomy was pre-drilled in the AP plane and completed with curved and straight osteotomes. Varus, internal rotation and procurvatum were corrected acutely, and we aimed to achieve an AP tibio-femoral angle of 5–10° valgus. The congruent corresponding bone surfaces at the osteotomy contributed to stability so that, with the addition of an above-knee cast, internal fixation was not necessary. Closed system suction drains were used routinely, and wounds were closed with absorbable suture material. In group 2, an additional incision was made over the lateral proximal tibial physis. Initially, we used a longitudinal incision but have since transitioned to a transverse incision as we found the scar to have an improved cosmetic appearance. An eight-plate of appropriate length plate and screws was selected and inserted under fluoroscopic guidance according to the standard surgical technique.28 The corrected position was assessed clinically and confirmed under fluoroscopy. The radiolucent diathermy cable spanned between the centre of the hip to the ankle was useful to assure realignment of the axis to neutral or valgus at the knee. The limb was maintained in an above-knee cast (synthetic polyester cast tape) for six to seven weeks. Weight-bearing ambulation was initiated between eight and twelve weeks postoperatively.

Statistical analysis

Statistical analysis was performed using jamovi version 1.2.18.0 open-source software.29 Continuous variables were reported as mean (standard deviation [SD], range) or median (interquartile range [IQR], range), and categorical variables as number and percentages. The Shapiro–Wilks test was used to analyse the distribution of data. Normally distributed data were compared with the use of the unpaired Student’s t-test, whereas the Mann–Whitney U test was used for non-parametric data. Categorical data were analysed using the chi-squared test unless the expected value in any cell was below 5 when Fisher’s exact test was used. All tests were two-sided, and the level of significance was set at p<0.05. Binomial logistic regression was used to determine the odds ratio (OR) and 95% confidence interval (95% CI) of the primary outcome measure.

Results

We identified eight children (12 limbs) that were treated with a tibial osteotomy alone (group 1) and 14 children (22 limbs) that were treated with a tibial osteotomy combined with a lateral proximal tibial tension band plate (group 2). A comparison of the descriptive treatment and outcome data is summarised in Table I. The follow-up duration for group 1 was longer than that of group 2. The groups were matched for obesity, severity as measured by the Langenskiöld stage, MDA, TFA and MPS.

In both groups, the mean TFA as measured on postoperative radiographs was within the physiological valgus range. The mean TFA on the first standing films (within 12 weeks postoperatively) was in less valgus, but still within the physiological valgus range in both groups.

The recurrence rate in group 1 was 92% compared to 77% in group 2 where a tension band plate was used as an adjunct to tibial osteotomy with an OR of recurrence of 0.31 (95% CI 0.03–3.01, p=0.312). The time to reoperation was similar between the two groups.

There were two tension band plate-related complications: one metaphyseal screw breakage and one of epiphysial screw pull-out. In both of these cases, recurrence occurred. There were no cases of vascular injury, peroneal nerve injury, compartment syndrome or infection.
Subgroup analysis in group 2 showed that the median age of the children that did not recur was 4 years (i.e., between 4 and 5 years), compared to a median age of 5 years in the children that did have recurrent deformity ($p=0.177$). The mean TFA of the children that did not recur was 22° (SD 13°, range 10–40), compared to a mean of 33° (SD 14°, range 15–65) in the recurrent group ($p=0.121$). The Langenskiöld stage was a median of stage 3 in the group without recurrence, and stage 4 in the group with recurrence ($p=0.292$).

**Discussion**

We aimed to determine whether the addition of a lateral proximal tibial tension band plate to a proximal tibial realignment osteotomy could decrease the rate of recurrence in children under the age of 7 years with IBD and a high risk of recurrence.

When children under 7 years present with severe IBD, selecting a surgical strategy is challenging because while further medial growth is unlikely, growth arrest is not inevitable. Three techniques have been described to decrease recurrence risk: overcorrection, medial epiphysiolysis and lateral epiphysiodesis. Corrective proximal tibial realignment osteotomy aims to unload the medial physis during weight-bearing, so that the ‘sick’ physis may resume growing under normal weight-bearing loads. The aim of overcorrection beyond the physiological range is to compensate for knee instability (due to medial joint depression and lateral ligament laxity) during weight-bearing and therefore to ensure that the mechanical axis is corrected to a lateral position at the knee. When assessing the evidence for overcorrection, it is essential to note whether authors describe the anatomical TFA (or shaft–shaft angle) or the mechanical TFA (or hip–knee angle). Another complicating factor is that the immediate postoperative radiograph is non-weight-bearing after the osteotomy and does not reflect the extent of knee instability. Loder and Johnston recommended overcorrection to >5° of the mechanical TFA as a strategy to decrease recurrence risk. Schoenecker et al. suggested that realignment to within 5° of neutral was sufficient. The only investigation specifically evaluating the effect of overcorrection was a study by Eamsobhana et al. in 2014 on children with Langenskiöld stage 2 IBD which failed to demonstrate an advantage to overcorrection beyond a TFA of 15° valgus alignment. Langenskiöld advised against overcorrection of the deformity, as he stated that excessive valgus did not remodel reliably. Therefore, we aimed to correct the limb to a valgus anatomic TFA of 5–10° in the above-knee cast as measured on an AP non-weight-bearing radiograph.

Medial epiphysiolysis, first reported by Beck et al., is another technique that may reduce the risk of recurrence. Andrade and Johnston reported that 26% of 27 limbs treated with a combination of valgus osteotomy and medial epiphysiolysis had a normal mechanical alignment (0°±5°) at latest follow-up. This study was limited by selection bias, and the authors acknowledge that adequacy of epiphysiolysis may be challenging to confirm intraoperatively, as there is no well-defined bar. Our previous experience with this procedure was unsatisfactory, and it was not part of our surgical strategy. Lastly, definitive lateral epiphysiodesis will prevent recurrent deformity at the cost of any potential growth. Should growth resume medially after proximal tibial realignment, progressive overcorrection would result. Temporary

![Figure 1](image-url)

Figure 1. a) Standing AP radiograph of the right knee of a 4-year-old girl – the medial physeal slope (MPS) was measured as 70°; b) Postoperative AP radiograph in long leg cast immobilisation; c) Standing AP radiograph one year postoperatively demonstrating divergence of the tension band plate screws and mild overcorrection prior to removal of the implant – the Harris line shows the extent of growth; d) Bilateral standing AP radiograph three years after the initial procedure demonstrating maintenance of correction.
lateral epiphyseodesis with a tension band plate was, therefore, an attractive option to potentially prevent or delay recurrence after proximal tibial realignment without the risk of permanent growth arrest or progressive overcorrection.

Several factors predisposed the children in both groups to recurrence; these included age >4 years, Langensköld stage >III or IV, and MPS≥60°. Correction was achieved through proximal tibial dome osteotomy in both groups to physiological valgus on the first postoperative radiograph. The first weight-bearing TFA, while still within the normal valgus range and comparable between the two groups, was less than that measured on the postoperative radiograph. This joint instability may be due to medial tibial plateau depression, lateral collateral ligament attenuation or a combination of the two factors.

The high recurrence rate in both groups is indicative of the severe impairment of growth potential that exists in children with severe IBD. The 92% recurrence rate in the osteotomy only group was similar to the findings of Kling et al. and Kaewpornsawan, severe impairment of growth potential that exists in children with severe IBD. The 92% recurrence rate in the osteotomy only group was similar to the findings of Kling et al. and Kaewpornsawan, whereas the 77% recurrence rate in the osteotomy and tension band plate group was, therefore, considered an attractive option to potentially decrease recurrence rate, may be an option to consider in children younger than 7 years with IBD and a high risk of recurrence. Further research is required to determine recurrence risk in children under 7 years with IBD and to develop surgical strategies to mitigate this risk accordingly.

### Table I: Comparative analysis of descriptive and treatment data of group 1 (tibial osteotomy alone) and group 2 (tibial osteotomy and tension band plate)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1</th>
<th>Group 2</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agea</td>
<td>5 (5–5)</td>
<td>5 (4–6)</td>
<td>0.398</td>
</tr>
<tr>
<td>Sex</td>
<td>88% female (7/8)</td>
<td>71% female (10/14)</td>
<td>0.486</td>
</tr>
<tr>
<td>Obesity (BMI &gt; 95th centile)</td>
<td>50% (4/8)</td>
<td>29% (4/14)</td>
<td>0.440</td>
</tr>
<tr>
<td>Langensköld stageb</td>
<td>4 (4–5)</td>
<td>4 (3–4)</td>
<td>0.126</td>
</tr>
<tr>
<td>MDAc</td>
<td>38°±10°</td>
<td>34°±9°</td>
<td>0.241</td>
</tr>
<tr>
<td>TFAf</td>
<td>32°±9°</td>
<td>31°±14°</td>
<td>0.845</td>
</tr>
<tr>
<td>MPSf</td>
<td>70°(65°–75°)</td>
<td>66° (65°–70°)</td>
<td>0.507</td>
</tr>
</tbody>
</table>

#### Postoperative

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1</th>
<th>Group 2</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFAa</td>
<td>10° valgus (9°–12° valgus)</td>
<td>8° valgus (5°–10° valgus)</td>
<td>0.101</td>
</tr>
<tr>
<td>TFA weight-bearing</td>
<td>5° valgus (5° varus to 10° valgus)</td>
<td>2° valgus (5° varus to 5° valgus)</td>
<td>0.332</td>
</tr>
<tr>
<td>Follow-upg</td>
<td>7 (6.2–8)</td>
<td>3.5 (2.2–5.7)</td>
<td>0.002</td>
</tr>
<tr>
<td>Recurrence rate</td>
<td>92% (11/12)</td>
<td>77% (17/22)</td>
<td>0.389</td>
</tr>
</tbody>
</table>

#### Reoperation

| Time to reoperationh            | 2.4±1.4 | 1.9±1.0 | 0.319 |
| Lateral epiphyseodesis         | 83% (10/12) | 68% (15/22) | 0.439 |
| Tibial osteotomy               | 92% (11/12) | 59% (13/22) | 0.061 |
| Medial elevation               | 58% (7/12) | 59% (13/22) | 1.000 |

a: age in years as median and interquartile range; b: Langensköld stage as median and interquartile range; c: tibial metaphyseal diaphyseal angle; d: tibio-femoral angle; e: medial physeal slope; f: post-operative TFA in cast; g: follow-up in years as median and interquartile range; h: time to reoperation in years as mean with standard deviation.

**Conclusion**

The addition of a lateral tension band plate has demonstrated a low complication rate, and in the absence of another strategy that may effectively decrease recurrence rate, may be an option to consider in children younger than 7 years with IBD and a high risk of recurrence. Further research is required to determine recurrence risk in children under 7 years with IBD and to develop surgical strategies to mitigate this risk accordingly.
The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010. Ethical approval (BCA268/15) was granted by the University of KwaZulu-Natal Biomedical Research Ethics committee. All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

PHM: Study design, data capture, data analysis and interpretation, first draft preparation, manuscript revision
DMT: Study conceptualisation, manuscript review
LCM: Study design, data analysis and interpretation, manuscript preparation and revision

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