ORIGINAL ARTICLE

Trampoline fracture of the proximal tibial metaphysis in children may not progress into valgus: A report of seven cases and a brief review

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Keywords
Trampoline;
Tibia;
Fracture;
Valgus

Summary
Background: Fracture of the proximal tibial metaphysis in children is a rare injury but notorious for carrying the risk of subsequent valgus deformity of the tibia.

Hypothesis: Trampoline-caused fracture of the proximal tibial metaphysis in children may not progress into valgus.

Materials and methods: We followed up six children who collectively sustained seven fractures of the proximal tibial metaphysis while trampolining with other heavier and/or older children. Initial and follow-up x-rays were reviewed by an orthopaedic surgeon and two radiologists.

Results: None of the patients developed valgus deformity with follow-up.

Conclusion: Trampoline is associated with a specific type of injury to the proximal tibia when children are trampolining with other heavier children even without falling off the trampoline. This fracture is linear and complete, often non-displaced. Unlike “other” proximal tibial metaphyseal fractures, trampoline-associated proximal tibial metaphysical fracture in children is not associated with a risk of subsequent valgus deformity.

Level of evidence: Level 4. Type of study: case series.

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Introduction

Fracture of the proximal tibial metaphysis in children is a rare injury but notorious for carrying the risk of subsequent valgus deformity of the tibia (although this does not happen in each and every case). Cozen in 1953 was the first to report four cases of valgus deformity following proximal tibial metaphyseal fracture [1]. Later on, it was found that the deformity may however improve spontaneously [2–6]. On the other hand, Boyer et al. in 1986 [7] were the first to describe seven cases and to suggest that trampoline caused fracture of the proximal tibial metaphysis in children who are trampolining with heavier children does not progress into valgus deformity.

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This report is trying to confirm that this subtype of proximal tibial metaphysical fracture (i.e., associated with trampolining with other heavier children), is relatively benign and may not progress into valgus deformity. This may help to alleviate the parents’ anxiety while waiting on the fracture to heal.

Subjects and methods

We observed seven cases of fracture of the proximal tibial metaphysis in six children between 2007 and 2009 (five of them were 4 years old and one was 6). One child sustained the fracture on two different occasions in the opposite lower limbs. Original and most importantly follow-up radiographs were available and were examined by an orthopedic surgeon and two radiologists. Circumstances of injury were confirmed with follow-up appointments. All stated trampolining with older and/or heavier children (more than two kids on the same trampoline and at least a 100 lb other kid). There was no history of falling off the trampoline or on the trampoline metal ring in any case. The first patient sustained fracture of the left proximal tibial metaphysis first (Fig. 1a), and then five months later he resumed trampolining again with other heavier children and sustained the same type of fracture on the right proximal tibia (Fig. 1b). The 6th patient, the only six years old, gave a "history" of another child falling on her leg while trampolining. We could not confirm whether this incident happened as a result of the fracture or actually causing the fracture. This patient was trampolining unsupervised with "two" other kids of the same age and body built.

All fractures were linear fractures with no angulations (Fig. 2a, b) except in the 6th patient, which was mildly angled in extension (Fig. 2c). All fractures extended to the tibial tubercle on lateral radiographs (Fig. 2a, b, c). All fractures were complete. Six fractures were on the right side and one fracture was on the left side.

After a median follow-up of almost eight months (12 and 7 months for the first patient (Fig. 1), twelve months for the second and third patients, three months follow-up for the fourth and fifth patients and five months for the 6th patient), none of the fractures progressed into valgus as confirmed by radiography (Fig. 1c).

Discussion

The use of trampoline simultaneously by several persons has been identified as a risk factor for injury [8]. Children may be at increased risk for injury when exposed to situations with potential for transfer of large amount of energy as in trampoline bed recoil because of immature judgment, coordination and strength, and anatomical characteristics such as open bone physis [8].

While prior reports stated that fracture of the proximal tibial metaphysis in children carry a considerable risk of subsequent valgus deformity of the tibia [1], one single report in the literature was found to state that "trampoline" fracture of proximal tibia in children will not progress into valgus [7]. The seven cases mentioned in this series support Dr. Boyer’s report [7] that trampoline caused fracture of the proximal tibial metaphysis does not carry the risk of subsequent valgus deformity unlike "other" proximal tibial metaphysis fractures. The reason could be either because it is a non-displaced and non-angulated linear or buckle fracture, or because of the unique mechanism of injury that probably does not cause much disruption of the epiphyseal-metaphysal region. Dr. Boyer’s explanation was as follow: as the heavier person jumps, the trampoline mat recoil upward from its stretched downward position, if the smaller child lands on the upward moving mat at the time when its elasticity is reversed by recoil and the springs are...
shortening to their outstretched length, there is significant upward impaction force applied to the descending child’s leg. The force applied at just the right time and angle of impact may be sufficient to cause the tibial fracture [7]. This could be the mechanism in the first five patients (six cases). However, the sixth patient gave a history of another child landing on her leg. Whether this happens as a consequence of the fracture or it actually caused the fracture is often difficult to tell. Although this sixth patient in not typical like the other five, we included this case in our report because she was trampolining with “two” other kids of similar age and body built which may suggest a similar mechanism of injury (adding the weight of the two other kids). Furthermore, no valgus deformity was noticed five months later.

Several theories had been stated to explain the valgus deformity that may complicate fracture of the proximal tibial metaphysis in children, each with evidence with and against it, including:

- inadequate reduction of the original fracture due to interposition of local periostium or pes anserinus [9];
- asymmetric growth stimulation at the proximal tibial physis [2,10,11] which could be due to: tethering effect of the intact fibula or iiotibial band [1] on the tibial growth on the lateral side, release of mechanical strain imposed by the periostium on the medial side, increased blood flow to medial proximal tibia, or interposition within the fracture gap of a cartilage bar acting as epiphyseal cartilage and causing bone growth locally [12];
- unbalanced ligamentous relaxation while the tibia is healing in a cast;
- weight bearing before fracture consolidation [13] and plastic deformation of tibia distal to fracture accentuated by weight bearing [14].

It is possible that the relatively milder impact to the proximal tibia due to trampolining was not enough to cause subsequent valgus deformity.

Just as the mechanism of valgus deformity after proximal tibial metaphyseal fracture in children is not clear, it is also not clear which fracture type or shape will progress into valgus, what is the percentage and when is the onset of the valgus deformity.

**Shape of the fracture**

As for the shape of fracture, Skak et al. noticed that valgus deformity was not seen after fissure or buckle fractures (17 patients) and, only four out of 23 patients with greenstick or complete fractures progressed to valgus deformity [15]. Our series (added to the cases of Dr. Boyer et al. [7]) are consistant with this observation since all our cases sustained non-displaced linear fractures. Douglas et al. also noted that all of their ten patients with valgus deformity (three of them were follow-up from Cozen’s original report of fracture proximal tibial metaphysis progressing into valgus) had greenstick (eight patients) or complete undisplaced fractures (two patients) [12]. Robert et al. noted that none of the buckle fractures (nine cases) developed valgus deformity. As for the greenstick fractures, four out of ten developed valgus deformity and four complete fractures (one undisplaced initially and three displaced initially) developed subsequent valgus [16].

**Percentage of valgus deformity**

It is not clear how many of proximal tibial metaphyseal fractures exactly will develop valgus deformity since most of the studies in the literature are either case reports or a series of selected cases that had “already” developed valgus deformity, but will be in the range of 41%. Table 1 shows the number or percentage of fractures that progressed into valgus according to different authors [5,15—20]. Even with linear fractures some percentage will develop valgus deformity if the fracture is complete [15] and it is interesting to note that none of our patients developed valgus deformity despite having a complete linear fracture.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>The percentage or numbers of proximal tibial metaphyseal fracture that progressed into valgus according to different authors.</th>
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<tbody>
<tr>
<td>Author</td>
<td>Number or Percentage of fractures progressing into valgus</td>
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<tr>
<td>---------</td>
<td>-------------------------------------------------------------</td>
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<tr>
<td>Tuten et al. [4]</td>
<td>53%</td>
</tr>
<tr>
<td>Skak et al. [15]</td>
<td>4 out of 40</td>
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<tr>
<td>Robert et al. [16]</td>
<td>1 out of 25</td>
</tr>
<tr>
<td>Ogdon [17]</td>
<td>17 out of 44</td>
</tr>
<tr>
<td>Salter and Best [18]</td>
<td>13 out of 21</td>
</tr>
<tr>
<td>Muller et al. [19]</td>
<td>7 out of 7</td>
</tr>
<tr>
<td>Jordan et al. [20]</td>
<td>7 out of 7</td>
</tr>
</tbody>
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<th>Table 2</th>
<th>The timing of valgus deformity following proximal tibial metaphyseal fracture as reported by different authors.</th>
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<tbody>
<tr>
<td>Author</td>
<td>Timing of reported valgus deformity</td>
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<td>----------------------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>Cozen [2]</td>
<td>Three months later in case no 1, upon cast removal in case no 2, 5 weeks in case no 3 and 7 weeks in case no 4</td>
</tr>
<tr>
<td>Brammer [4]</td>
<td>Less than 6 months</td>
</tr>
<tr>
<td>Tuten et al. [4]</td>
<td>Maximum angulation at 13 months for seven patients</td>
</tr>
<tr>
<td>Zions [11]</td>
<td>After 5 months</td>
</tr>
<tr>
<td>Jackson [12]</td>
<td>After 10 weeks</td>
</tr>
<tr>
<td>Roberts [16]</td>
<td>During or after cast immobilization but within first year</td>
</tr>
<tr>
<td>Ogdon [17]</td>
<td>Angulation may begin within several weeks after the injury</td>
</tr>
<tr>
<td>Muller [19]</td>
<td>After 5 to 7 months in six patients</td>
</tr>
<tr>
<td>Jordan [20]</td>
<td>After 6, 5, 15 and 8 months</td>
</tr>
<tr>
<td>Neil [21]</td>
<td>After 10 weeks</td>
</tr>
<tr>
<td>Balthazar [22]</td>
<td>Within 5 months in nine patients</td>
</tr>
<tr>
<td>Keret [23]</td>
<td>At cast removal</td>
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</tbody>
</table>
Onset of valgus deformity

Although valgus deformity was reported to occur even after one year, it is rather due to lack of timely follow-up rather than the actual time of the "onset" of valgus deformity. Table 2 shows the timing of valgus deformity according to different authors [2,4,5,11,12,16,17,19–23]. None of our cases developed valgus deformity after a reasonable follow-up time.

Conclusion

Children trampolining with other heavier kids are at risk for particular type of fracture to the proximal tibial metaphysis even without falling off the trampoline. This fracture is linear, not displaced and may not lead to valgus deformity of the tibia, an important piece of information for both the treating physician and the parents.

Disclosure of interest

The author declares that he has no conflicts of interest concerning this article.

References