Excessive Tibial Overgrowth Associated Ankle Valgus Deformity After Pediatric Open Mid-Shaft Tibial Fracture: A Case Report

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ABSTRACT

Tibial overgrowth after pediatric tibial fractures has been reported in the literature. Multiple factors can affect the amount of overgrowth, including age and gender of patients, type of fracture (open vs closed), degree of communion, reduction techniques, and fixation method. We describe a 10-year-old boy with a 2-cm overgrowth after sustaining an isolated open tibia fracture with an intact fibula, which is more than what has been previously described in the literature for tibia fractures. This overgrowth was associated with asymmetrical growth of the distal tibial physis, asymmetrical growth between tibia and fibula, and ankle valgus deformity.

Keywords: Tibial Overgrowth, Ankle Valgus, External Fixator, Tibial Fractures, Open Fracture, Pediatric Overgrowth, Pediatric Tibia Fracture

INTRODUCTION

The phenomenon of tibial overgrowth following tibial fractures in pediatric patients has been reported in the literature.[1,2] It has been described following both operatively and nonoperatively treated tibial fractures, including tibial shaft fractures and proximal tibial fractures.[1,3,4] The amount of overgrowth following pediatric tibial fractures can vary depending on whether the fracture is open or closed and the location of the fracture, degree of comminution, primary treatment (casting versus internal fixation versus external fixation), and gender and age of the patient. The average overgrowth following a pediatric tibial fracture is about 5 mm, and it rarely reaches 15 m.[1,5]

We describe the successful treatment of a 10-year-old boy with an open tibia shaft fracture and intact fibula. Treatment resulted in progressive longitudinal overgrowth (more medial than lateral) of the distal tibia with limb length discrepancy of 2 cm and apex medial deformity leading to ankle valgus deformity.

CASE REPORT

A 10-year-old boy was run over by a truck and developed an isolated open fracture of the right tibia classified as a Gustilo type IIIA (Figures 1 and 2). According to Orthopaedic Trauma Association's open fracture classification,[6] the injury had the following classifications: skin=2, muscle=1, arterial=1, contamination=2, and bone loss=1. The fibula was not broken, and there was no apparent direct injury to the distal tibial physis. First-generation IV cephalosporin (Cefazolin) was administered in the emergency department. The wound was covered with a sterile dressing, and the limb was splinted. He was taken emergently to the operating room and treated by irrigation and debridement. Open direct anatomical reduction was obtained using a uniplanar external fixator and loose wound approximation (Figures 3 and 4). At 18 weeks postoperatively, the radiographs showed progressive healing of the fracture with 3° of apex medial angulation at the fracture site (Figure 5). We used "micromotion" at the fracture site to enhance the healing process through dynamization of the frame. To do this, we removed one pin from the proximal cluster of pins and one pin from the distal cluster of pins (Figure 5). The external fixator was removed 22 weeks after its application.

At 17 months after injury (1 year after frame removal), the patient presented to our clinic due to a progressive gait abnormality and the development of a deformity on the affected right side. Anteroposterior and lateral radiographs of the affected leg showed the fracture to be completely healed and remodeled with a minimal

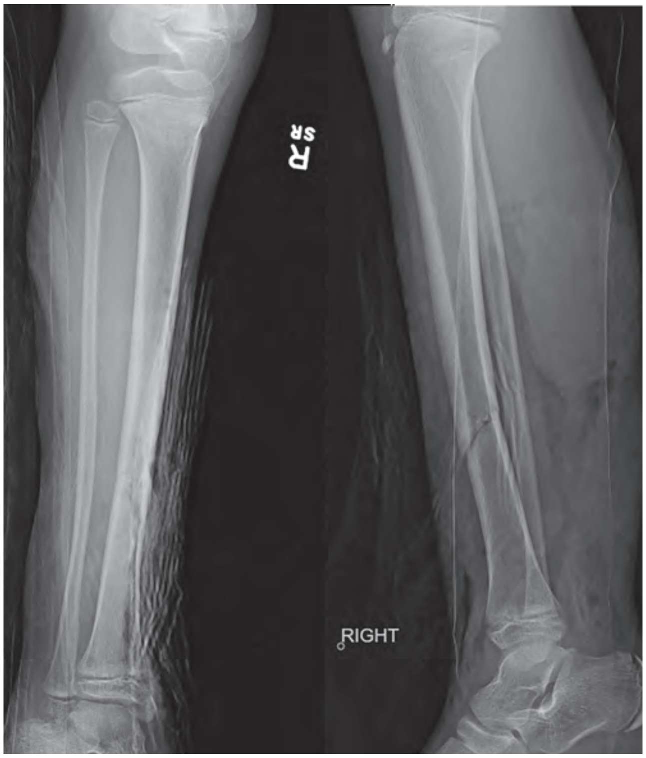

Figure 1. Preoperative radiographs of the open right midshaft tibial fracture (Gustilo type IIIB).

Figure 2. Clinical picture of the open wound and soft-tissue injury.

3° apex medial deformity. Scanogram showed 2 cm of limb length discrepancy with the affected right side longer than the left side and valgus deformity of the ankle (Figure 6). There was 2 cm of overgrowth of the right tibia compared to the left tibia. Both right and left fibulae were at an equal length.

Deformity analysis showed that the center of rotation and angulation (CORA) of the distal deformity was at the right distal tibia physis with a 14° apex medial (Figure 7A) and added 3° of apex medial angulation at the level of the fracture. The CORA with the 14° apex medial angulation reflects both the asymmetrical distal

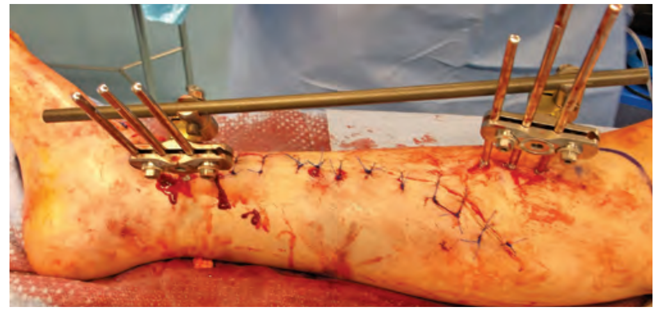

Figure 3. Postoperative clinical picture after the closure of the wound and application of the external fixator.

Figure 4. Postoperative radiographs showing a reduced fracture fixed by the uniplanar external fixator.

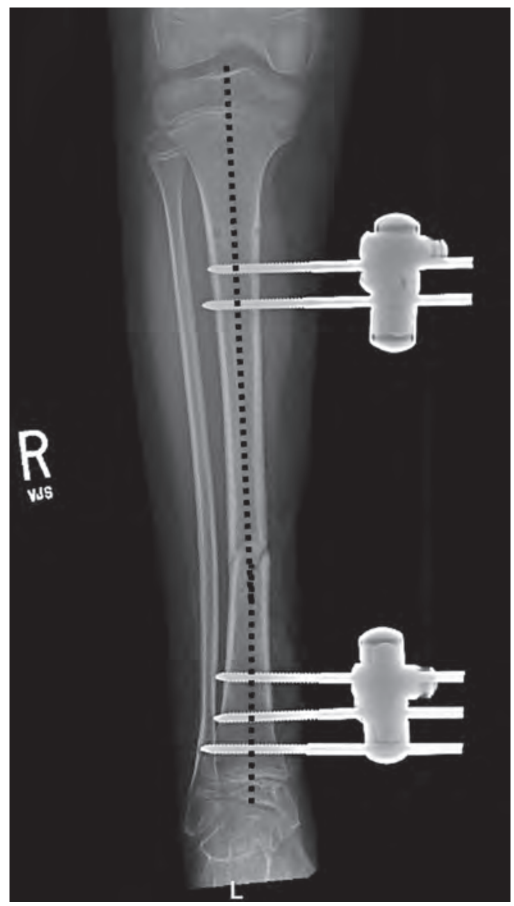

Figure 5. Radiographic image after 4 months postoperatively showing that dynamization by removing pins from construct. Also, there is 3° of apex medial angulation at the level of the fracture.

Figure 6. *Computed tomography scanogram showing 2 cm of limb length discrepancy. Note that the affected right side is longer than the left side and valgus deformity.*

tibial physeal growth (medial more than lateral) and the asymmetrical tibial/fibular growth (tibia growing more than fibula). The overall valgus deformity at the level of the ankle was 17° compared to the left side (Figure 7B).

The patient's gait was greatly affected by the limb length discrepancy and severe ankle deformity. The family and the patient wanted to find a surgical option to correct the gait and ankle deformity. They were not interested in observing the deformity due to the affection of the gait and the relatively fast rate of deformity development. Treatment options for the limb length discrepancy were epiphysiodesis of the right side or lengthening the unaffected left side. For the valgus ankle deformity, the options for treatment were either osteotomy of the distal tibia or hemiepiphysiodesis of the medial side of the distal tibial physis. After discussion with the family and providing them with the options, the decision was to proceed with plate epiphysiodesis (medial and lateral plates) in the proximal right tibia as the treatment for overgrowth of the right tibia. For treatment for the valgus ankle, the decision was to proceed with hemiepiphysiodesis using a distal medial tibial screw. This treatment method was preferred because it was less invasive, did not

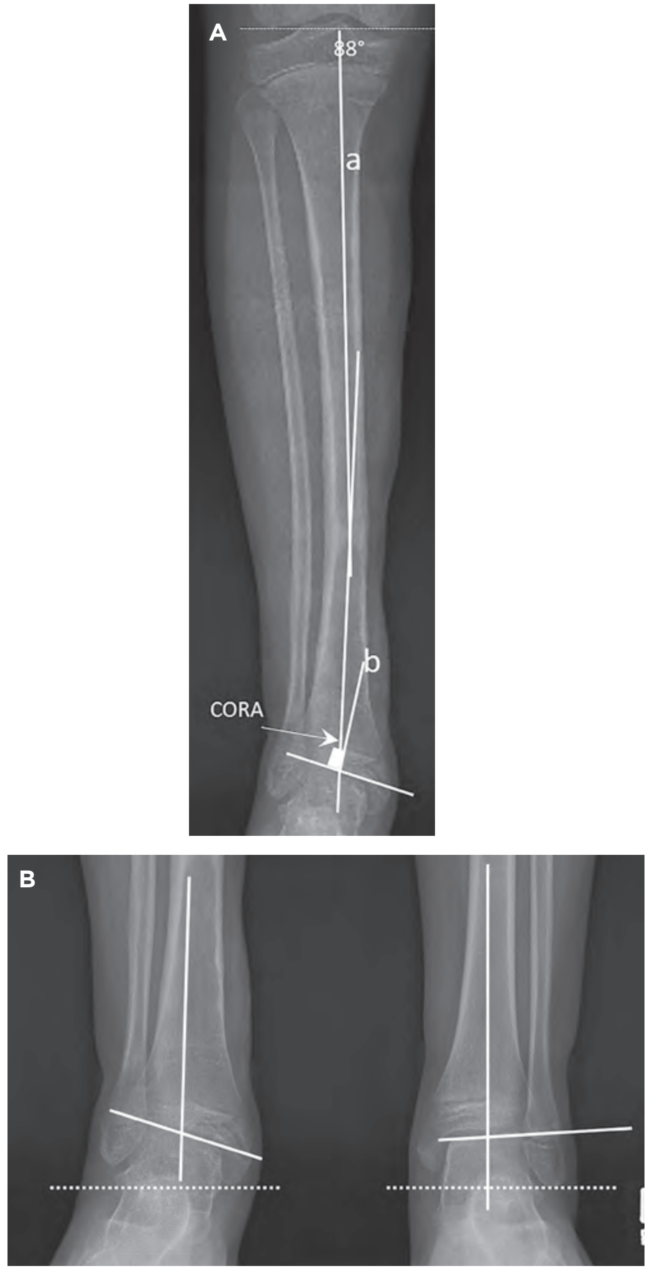

Figure 7. *A) Deformity analysis showing 3° of angulation at the level of the healed fracture. The center of rotation and angulation of the deformity shows a 14° angle between the line perpendicular to the joint and the axis of the distal part for the shaft. B) Tilt of the growth plate in relation to the distal tibial articular line (close up view). On the uninjured left side, the dotted line shows that the distal tip of the fibula is distal to the medial malleolus tip. In contrast, the medial malleolus is further distal than the lateral malleolus on the injured right side.*

involve non-weight bearing, excluded the possible complication compartment syndrome that may occur with tibial osteotomy, and was less effort and stress on the patient and family. Additionally, the distal tibial hemiepiphysiodesis had the advantage of being close to the CORA of the main deformity. Because of the patient's age, the plate epiphysiodesis of the proximal

Figure 8. *Final scanogram showing an equal length of the right and left side and full correction of the ankle valgus deformity.*

tibial alone was enough to correct the overgrowth fully. The hemiepiphysiodesis using a distal medial tibial screw was used to achieve the overcorrection of the distal tibial apex medial deformity to compensate for the 3° tibial shaft apex medial deformity, resulting in full correction of the 17° ankle valgus deformity. Correcting the difference in the tibial and fibular lengths will help restore the neutral ankle alignment. Two years after deformity correction surgery, the tibial overgrowth and valgus deformity at the ankle were corrected. Final scanogram showed an equal length of the right and left sides and full correction of the ankle valgus deformity (Figure 8). The normal relation between the tibia and fibula on the right side was restored. The patient was still not skeletally mature 2 years after the deformity correction surgery, and the implant was removed.

DISCUSSION

In pediatric patients, bone overgrowth following fractures has been well described in the literature, which may be due to the stimulation of growth plates caused by the hyperemia of the affected bone during consolidation and remodeling.[1,2] Overgrowth after pediatric fractures has been studied extensively following femur fractures and, to a lesser extent, after tibia fractures.[7-12] Any time a skeletally immature bone fractures, there is the possibility it may not grow exactly to the same length. Diaphyseal fractures, not involving any physis injury, commonly result in abnormal longitudinal growth and, sometimes, in angular deformity.

In the largest study evaluating the overgrowth after tibial and femur fracture, Stilli et al[1] included 822 cases of pediatric tibial fractures. They found the average overgrowth after tibial fracture to be 5.7 mm, with more overgrowth in patients under 5 years old at the time of injury. The authors found that most of the overgrowth occurs in the first 2 years after fracture. The authors found that when the treatment involved less shortening initially, a greater final overgrowth can be expected. In our case, there was no initial shortening because we were able to obtain direct open reduction; thus, the amount of overgrowth did express itself as a final limb length discrepancy.

Age has been described as a factor of overgrowth following pediatric lower-extremity fractures; however, this has been debated.[1] Generally, overgrowth is a phenomenon of "middle-aged" children. Greiff and Bergmann[3] found that overgrowth after a tibial fracture occurs mainly in boys 3 to 12 years of age and girls 3 to 10 years. Some authors did not find an effect for the skeletal age on the amount of overgrowth.[13] Other studies found that the phenomenon of overgrowth is more pronounced in younger children, mainly boys, under the age of 5 years.[1,3,14,15] In our case, the patient's age at the time of injury was 10 years. Shapiro[7] found that most of the overgrowth will occur in the first 18 months following a fracture. Our patient presented 1 year after healing (17 months after injury).

Spiral, comminuted fractures and fractures resulting from high-energy injuries were found to have more overgrowth than simple transverse fractures.[1,12] This may be related to more disruption of the periosteum in spiral and comminuted fractures than simple transverse fractures.[14,16] Our case was a type IIIA open transverse fracture with major disruption of the periosteum in which a significant amount of the bone was stripped entirely of the periosteum. Gasco noticed that fractures that required prolonged treatment until the fracture is consolidated had developed more overgrowth than those that healed faster.[17] Our case was an open fracture that took 22 weeks to heal. This prolonged time to heal could have contributed to excessive overgrowth. Stilli et al recommended creating intentional shortening of the fracture in anticipation of the overgrowth. With internal fixation and external fixation of tibial fractures becoming more popular for adolescent tibias and less dependent on closed reduction and casting, surgeons aim for as much anatomical reduction as possible. This may be the reason for tibial overgrowth after pediatric fracture becoming more pronounced with modern treatment options than previously reported treatment options.[4,18]

The use of external fixators as treatment of tibial shaft fractures has been associated with more overgrowth than other internal fixation methods.[19,20] This overgrowth is most likely not due to the usage of the external fixator itself, but due to the fact that external fixators are commonly used for comminuted open tibial fractures with a disrupted periosteum.

In the current case, several factors were associated with the excess overgrowth, including the fracture being open, spiral, and high energy; the sex of the patient; the use of an external fixator without initial shortening; and the prolonged time to healing. To our knowledge, this amount of overgrowth has not been reported with pediatric tibial fractures before.

The leg segment is a 2-bone segment that includes the tibia and fibula, and it is different from the thigh segment. If the tibia and fibula do not grow symmetrically, a deformity will develop over the time of differential growth. Some studies have explained this as the intact fibula acting as a cord or a partial tether for the tibial growth, leading to the progressive deviation.[1] Other studies have attributed this phenomenon to the unequal growth of the tibial physis.[21] The case in our current study had an overgrowth of 20 mm, which is more than what is typically described for tibial fractures. This amount of excess overgrowth may explain the large degree of valgus deformity at the ankle joint.

Although coronal deformities after distal tibial physeal fractures are commonly reported, we are not aware of a study describing a case of a more medial than lateral overgrowth at the distal tibial physis after a tibia shaft fracture. A coronal deformity can develop after a direct injury to the physis, resulting in abnormal physis growth.[22] However, we do not believe that the ankle valgus deformity in our case was due to direct injury of the physis because the primary fracture was at the level of the midshaft with no radiographic or clinical extension to the distal tibial physis. In addition, the open wound was medial, making an injury to the lateral physis extremely unlikely. The distal lateral physis also grew more than average when compared to the ipsilateral fibula and contralateral tibia, but not as much as the medial physis. It would be very unusual for a direct injury to cause that.

Treatment of the ankle valgus with guided growth has been well studied in the literature, with consistent results reporting it safe and effective.[23-25] Using a similar technique as the current study, Chang et al[25] found that the medial malleolar screw resulted in an average correction of about 0.37° per month. In our case, the 17° ankle valgus was corrected in only 24 months (0.71° per month), which was twice the average described by Chang et al.[25] We do not think that the ankle valgus correction was entirely due to the medial malleolar screw during medial distal tibial hemiepiphysiodesis because a significant amount of correction was related to stopping the growth of the tibia by proximal medial and lateral plates epiphysiodesis, which allowed the fibula to reach proportionate length. Using the average correction rate described by Chang et al[25] as a reference, it is reasonable to assume that 50.0% of the correction was by distal medial screw hemiepiphysiodesis and the other 50.0% by restoring the correct relation between the length of the tibia and fibula.

In our case, the CORA analysis (Figures 7A and 7B) showed the ankle valgus deformity was mainly related to disturbance of the growth of the distal tibial physis. The medial side of the physis grew at a faster rate than the lateral side of the physis, with the fibula acting as a partial tether for the tibial distal lateral physis. The ankle valgus deformity was also related to the relative lengthening of the tibia in relation to the fibula. Both of these factors contributed to the ankle valgus deformity. Ankle radiographs also showed an obvious tilt in the growth plate in relation to the distal tibial articular line (Figure 7B).

This study is the first description of the valgus ankle associated with tibial overgrowth after an isolated tibia fracture. Our analysis shows that this is related to the distal medial tibia growing faster than the lateral distal tibia, which is tethered by the distal fibula and unequal growth of the tibia and fibula. We hypothesized that the overgrowth of the tibia compared to the fibula could also occur in the distal part of the tibia, resulting in "valgus ankle." Correction of the deformity should be at the level of the CORA either by osteotomy or guided growth modulation (if there is growth potential).

In conclusion, we present a case of the successful treatment of an isolated open tibia fracture that developed a 2-cm overgrowth. This amount of overgrowth is more than what has been previously described in literature before. Certain factors may have contributed to this excessive overgrowth (ie, open fracture, treatment by external fixator with no initial shortening, marked periosteal stripping, prolonged healing time, male patient). This excess overgrowth was associated with the asymmetrical growth of the distal tibial physis and unequal length of the tibia and fibula, resulting in valgus angulation of the ankle.

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