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Triplane Fracture of The Proximal Tibia in A 7-Year-Old Patient: A Case Report

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ABSTRACT

Objective: The aim of this study is to report a rare triplane fracture of the proximal tibia.
Clinical case: a seven-year-old overweight boy suffered a low-speed traffic accident causing an indirect trauma to his left knee. A displaced triplane fracture of the proximal tibia was diagnosed. It was treated with external fixators and an epiphyseal Kirschner wire (KW). After a month, the fixators and KW were removed, and an above-knee cast was applied until two months post-injury. Four years after the lesion, the patient is now 11-years-old, asymptomatic, achieved fracture union, has a medial collateral ligament (MCL) injury, and a proximal tibia angular deformity consisting of varus and recurvatum.
KEYWORDS: "Triplane Fracture" "Proximal Tibia Fracture", "Physeal Fracture", "Fractures in Children", "Growth Disturbance"

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INTRODUCTION

Proximal tibial triplane fractures are extremely rare injuries. They are metaphyseal-physeal-epiphyseal lesions that involve all three planes of the proximal tibia. Only ten case reports are to be found in the available literature, most of which involved adolescents.[1-10]

Epiphyseal fractures of the proximal tibia represent between 0.5% and 3% of all epiphyseal fractures in children[11], while physeal lesions of the proximal tibia constitute less than 1% of physeal fractures. [12,13] They may occur due to high-energy direct trauma (traffic accidents and crush injuries) or after lower-energy indirect trauma, frequently associated with sports. [14]

The first description of a triplane fracture of the proximal tibia was made by Johnson and Fahl et al. in 1957[15], at which time the term 'triplane' was not yet used to describe these particular fracture patterns. These fractures typically occur during peri-adolescence, at which point the physis closure begins. Closure happens asymmetrically, advancing from posterior to anterior and from medial to lateral.

Despite the high frequency of knee injuries in the pediatric population, the low incidence of these fractures is attributed to the anatomy of the knee. While the fibula serves as a lateral buttress, the distal ligamentous insertions of the MCL and lateral collateral ligament (LCL) transmit traumatic forces sustained at the knee to the tibial metaphysis, thus protecting the physis and epiphysis. This also explains the high association of knee ligament injuries when a proximal tibial fracture occurs, the most common being anterior cruciate ligament (ACL) injury, followed by MCL injury. [16,17] The semimembranosus muscle also inserts in the posteromedial region of the distal tibia beyond the physis, providing biomechanical protection.

Vascular and neurological injuries are infrequent but severe. Various series have reported vascular injuries incidence between 3% and 5%. These usually appear in fractures with significant displacement. Popliteal artery is generally affected in posterior displacements, while the anterior tibial artery is endangered in anterior displacements. Strict monitoring is essential in the first 24 to 48 hours. [18,19] Injuries of the common peroneal sciatic nerve are the most frequent neurological injury and usually occur due to distraction, frequently resolving within 4 to 6 months. [14]

Proximal tibia fractures are commonly classified according to Salter and Harris[20] based on the affected bone regions by the fracture pattern. They can be also descriptively classified according to displacement. (fig 1)

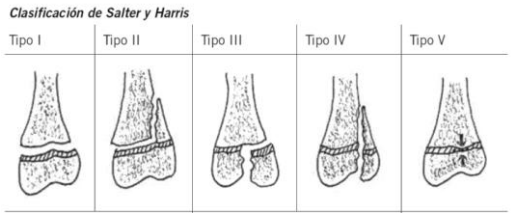


Figure 1: Salter-Harris Classiffication of Physeal Fractures

Fractures involving the anterior tuberosity of the tibia (ATT) are a subgroup of metaphyseal-epiphyseal fractures

of the proximal tibia and are classified using Ogden's classification. [21]

Treatment depends on displacement and associated injuries. If displacement is minimal, conservative treatment with above-knee casting may be applied. When displacement is present at the metaphyseal-physeal level, treatment can be accomplished via closed reduction and immobilization. In cases where fracture reduction is unstable, percutaneous KW pins or screws can be utilized to maintain reduction. As the goal is to achieve a congruent articular surface, open reduction is performed when reduction is impossible by closed methods.[22] Regarding associated ligament injuries, usually, the only one requiring surgical intervention in nearly all cases is that of the ACL. Injuries of the LCL and MCL are generally treated with immobilization, reserving surgical repair for patients who experience instability during the latter recovery process. [23]

When addressing the tibial growth, 60% is attributed to its proximal physis. These injuries compromise this structure at a greater or lesser extent, potentially affecting growth. These injuries can also cause arthrofibrosis, and chronic pain, in addition to the aforementioned neurovascular injuries and the dreaded compartment syndrome. [22,24]

OBJECTIVE

The aim of this study is to report a rare triplane fracture of the proximal tibial fracture, treated at the Centro Hospitalario Pereira Rossell in Uruguay(CHPR).

CLINICAL CASE

A 7-year-old, obese boy, undergoing evaluation for arterial hypertension, suffered a traffic accident after falling off a motorcycle at low speed. The injury assessment highlighted only trauma to the left lower limb. The injury mechanism was indirect, as he steadied his limb to avoid falling, involving a mixed injury mechanism which included forced valgus. The trauma was immediately followed by pain and complete functional impairment of the knee.

On physical examination, he presented abrasions to the anteromedial surface of the distal thigh and proximal leg, a valgus deformity of the knee, swelling, and joint effusion. There were no vascular or neurological compromises. Stability maneuvers were not performed at that time to test the knee's stability.

Anteroposterior and lateral X-rays of the knee diagnosed a triplane fracture of the proximal tibia:

-Anteroposterior view: physeal-epiphyseal fracture line, Salter Harris type III, with an opening in valgus of the proximal tibial physis of approximately 4 mm, with no displacement of the articular fragments.

-Lateral: a metaphyseal-physeal fracture line, Salter Harris type II, starting at the level of the ATT physis, tracking through the proximal tibial physis and exiting at the posterior metaphysis of the tibia, with minimum displacement. (fig 2)

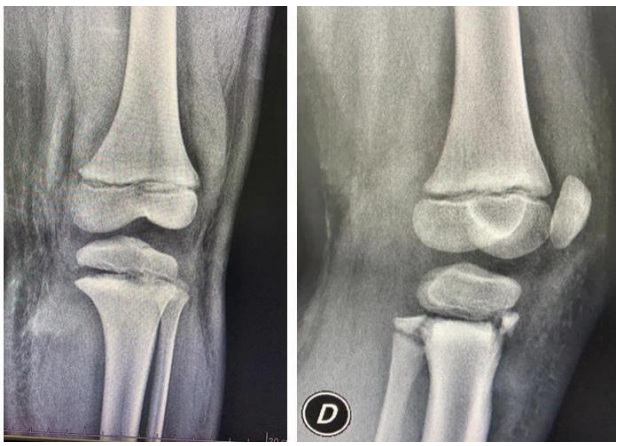


Figure 2: Initial radiographs

A computed tomography scan was requested to confirm these findings. The displacement of the articular fragments was less than 1 mm. (fig 3)

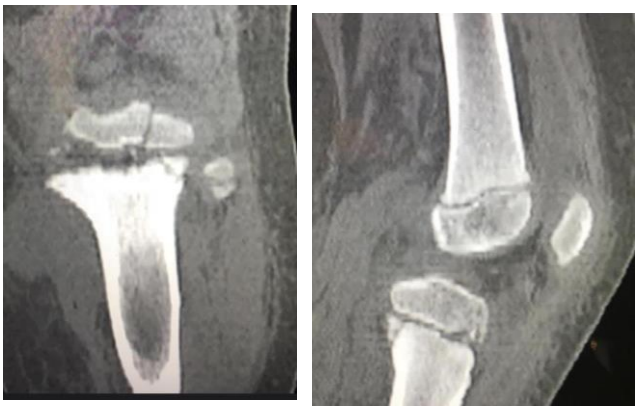


Figure 3: Computed Tomography showing triplane pattern

Due to the minimal displacement of the articular fragments and the extensive but superficial soft tissue damage, the initial plan was to take the patient to the operating room for closed reduction of the valgus displacement and placement of external fixators. The preoperative studies and cardiological assessment requested by pediatrics and anesthetist delayed the surgery, which was performed on the fifth day after the trauma.

During the surgical procedure, the external fixator modules were first placed, followed by closed reduction through traction and varus. This maneuver produced displacement of the epiphyseal fragments. Closed reduction of the articular displacement was then achieved using a KW pin as a joystick, followed by correction of the valgus displacement maneuvering the external fixators modules. (fig 4)

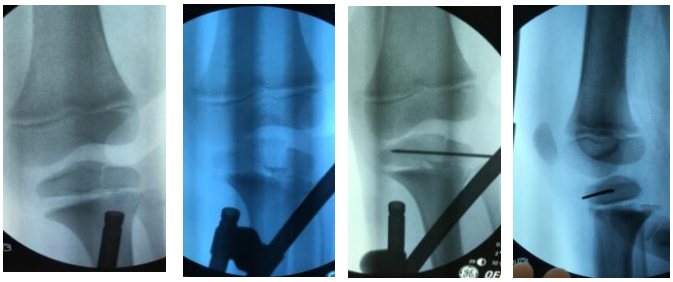


Figure 4: Intraoperative images

The immediate postoperative period was uneventful, and the patient was discharged home 72 hours post-procedure. He was followed weekly during the first month postoperative, then at months two, three, four, six, eight, twelve, eighteen, and forty-eight. 4 weeks into recovery, the KW pin and the external fixators were removed, and an above-knee cast was applied.. After two months of surgical treatment, the cast was removed and physical therapy began with exercises to restore the range of motion. Full weight bearing was not allowed until three months post-surgery, when there was clear fracture union and recovery of knee range of motion and muscle strength.

The patient continued physical therapy for six months. At this point, an asymptomatic medial instability of the knee was noted, indicating an MCL injury. An MRI was requested, revealing a lesion at the MCL's insertion on the tibial metaphysis and a possible ACL strain. (fig 5)

Figure 5: MRI showing MCL injury and LCA distension

Twelve months post-injury, varus and recurvatum of the lower limb was observed. A teleoroentgeneogram assessment showed a lateral deviation of the mechanical axis (MA) at the center of the knee, and a decrease in tibial slope. (fig 6)

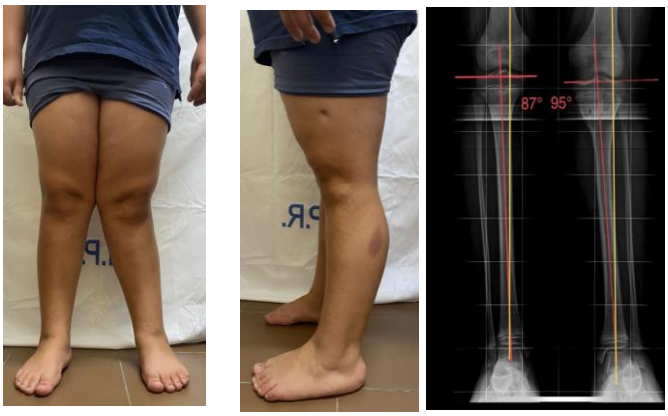
At eighteen months, a new MRI ruled out physeal bars, thus we continued an expectant approach regarding the angular deformity.

Four years after the injury, the patient is asymptomatic, and has fully returned to his usual activities. He denies knee instability or locking. Clinically, the affected limb showed a slight progression of the valgus deformity, with no apparent

Figure 6: Teleoroentgeneogram

changes to the recurvatum. At physical exam, he achieves full range of motion, with a positive valgus stress test, with no other instabilities of the knee. Using the Lysholm score, the patient has a score of 100, which is the maximum score. (25)

The last teleoroentgeneogram at forty-eight months post-injury demonstrated an increase in angular deviation in the coronal plane, with an increase in lateral displacement of the mechanical axis, giving a medial epiphyseal-diaphyseal angle (MEDA) of 95 degrees compared to 87 degrees of the healthy limb. In the sagittal plane, partial correction of the angular deviation is observed, with a posterior-proximal tibial angle (PPTA) of 105 degrees. (fig 7)



Although the patient is asymptomatic, the progression of his angular deviation, combined with medial knee instability and obesity, prompts consideration of an active approach. The patient is awaiting a temporary medial hemiepiphysiodesis of the tibia with an 8-plate.

DISCUSSION

Proximal tibia triplane fractures are extremely rare injuries. The literature search revealed only ten cases[1-10], with the youngest case reported by Nowicki et al. involving an eleven-year-old girl.[10] This case presents a seven-year-old boy at a more immature stage of bone development compared to the cases found, making this case unique.

Regarding fracture patterns, while there is significant variability among reported cases, some similarities are

found with the cases of Aymen and Conroy et al.[1-2] while none of these exhibited the valgus opening at the metaphyseal-epiphyseal level that this patient experienced; instead, those cases suffered a metaphyseal-epiphyseal displacement in the anteroposterior plane. Most published triplane fractures tend to resemble to adult tibial plateau fractures.

The treatments encountered in published cases were always surgical and varied. The majority opted for closed reductions with percutaneous fixations.[1,2,4,5]Every author used KW and/or cannulated screws, except for Hermus et al., who performed arthroscopic reduction of the fracture and fixation with staples.[7] We found no treatments alike the one performed in this case, as it was adapted to the soft tissue damage of the patient. Our treatment departed from the ideal as it could not be performed urgently, compromising the odds of a successful closed reduction.

Regarding associated ligamentous and meniscal injuries from these fractures, most studies make no mention of whether they were investigated. Hermus and Nowicki included arthroscopy in their treatment. Hermus found a partial ACL injury and an external meniscus lesion, while Nowicki found no associated lesions. [7,10]

No work mentions injuries to the lateral and medial ligaments of the knee. Our patient suffered an injury to the distal insertion of the MCL and strain of the ACL, which were diagnosed late and treated with immobilization. While the patient is asymptomatic, he has a uniplanar valgus instability that currently does not necessitate any surgical approach. Although clinically Lachman test was negative, a possible ACL laxity could be masked by the reduced tibial slope, which should be considered in possible future treatments.

All studies report consolidation with a complete return to activities, like our patient. However, it is notable that none used functional scores to objectively measure post-fracture function. We utilized the Lysholm score, which has validated reliability and accuracy in Spanish-speaking populations for adolescents and adults. [26]

No studies reported complications except for Nowicki et al. which presented a compartment syndrome of the leg, requiring a fasciotomy of all four compartments. [10] A year after the injury, this patient exhibited a lateral physeal bar. The authors considered future treatment options to be removal of the physeal bar and/or medial hemiepiphysiodesis during follow-up. Though many works do not express complications, only the follow-up of Singaglia et al.[8] exceeds one year post-injury, which may indicate an underestimation of the actual number of complications and growth disorders experienced by patients suffering these injuries. It is important to note that the presented case has had four years of follow-up, which is the longest to our knowledge to be found in the available literature.

Regarding the angular deviation observed in our patient, we suggest two potential etiological causes. We propose the valgus etiology lies in the traumatic damage suffered to the medial tibial physis, causing medial hypergrowth (a similar phenomenon described by Cozen)[27], resulting in a valgus tibia without shortening. As for the recurvatum, we consider that surgical malreduction of the fracture is the sole cause, as its evolution tended towards correction.

Concerning the valgus deformity, a conservative approach was initially chosen, given that a significant percentage of post-traumatic valgus tibias correct over time.[28] Having now exceeded the time for spontaneus correction taking place, a medial hemiepiphysiodesis using an 8-plate was decided as to guide growth the tibia in the coronal plane. It is worth remarking that follow-up was lost during the COVID-19 pandemic (between 18 and 48 months post-injury), making the proposed intervention a bit delayed. The largest published series on guided growth in valgus tibias is that of Morin et al. [29], who treated 24 Cozen phenomena with temporary medial hemiepiphysiodesis using plates with excellent results and minimal complications. We do not propose correcting the increased PPTA, as the patient is asymptomatic and exhibits no instabilities in the anteroposterior axis, and the angular deviation has tended towards spontaneous correction. If there is a desire to eventually decrease the PPTA, guided treatment with a posterior plate could also be performed, as described by Stevens et al.[30]

Regarding the MCL injury, no surgical approaches are being considered at this time. We will wait to address the angular deviation first and consider treatment if the patient develops symptoms of medial instability.

CONCLUSION

This case represents a unique contribution to documented cases of proximal tibia triplane fractures. The angular deformity produced as a fracture complication is yet to be treated.

CONFIDENTIALITY OF DATA

The authors declare that they have followed institutional protocols regarding the publication of patient data and that all participants in the study have given their written informed consent to participate in this study.

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