Case Series

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Concomitant Tibia Shaft And Triplane Fracture in Adolescents: A Case Series with Comprehensive Review of Literature

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Abstract

Introduction: Concomitant tibia shaft and ipsilateral triplane fracture in the paediatric population is an uncommon presentation. Since the first description in the literature in 2001, approximately 27 cases have been reported. In addition to a literature review, we present our experience with three cases of distal-third spiral tibial fractures with three-part triplane fracture. The average age was 15.3 years. The average body mass index was 31.3 kg/m^2. Two patients underwent rigid intramedullary locking nail for the shaft fracture, and one patient underwent Ender nailing. All triplane fractures were fixed with percutaneous screws. There were no intra or postoperative complications. The average union time was 10.6 weeks. We highlight the patient and injury characteristics in these fractures. A high index of suspicion of an associated ankle fracture is warranted in obese adolescents presenting with distal-third tibia fractures. Tibia fractures require rigid internal fixation whenever possible.

Keywords: Concomitant, Ipsilateral, Triplane, Tibia, Shaft, Ankle Fracture, Obesity

Introduction

Concomitant tibia shaft fracture with ipsilateral ankle fracture is a rare presentation in children. Their occurrence and morphology have been well described in the adult population [1]. Jarvis in 2001 first reported these fractures in six children, of which two were missed on initial diagnosis. All triplane fractures were minimally displaced (< 2mm) and treated successfully with long-leg casting [2]. Following this initial description, anecdotal case reports and small case series have been published [3-6]. Recently, Sheffer et al., in their retrospective analysis, reported an incidence of 36% missed concurrent distal tibia fractures associated with paediatric tibia shaft fractures [7].

The presence of distal tibia physis and its characteristic fusion properties in the adolescent age group leads to an associated triplane fracture. The tibia shaft fractures typically are distal third spiral or oblique type. Whenever a surgeon encounters these patient and injury characteristics, associated ankle injury must be ruled out clinically and radiographically. One should have the least threshold to obtain ankle specific radiographs, especially a mortise view. Identifying a triplane fracture associated with a tibial shaft fracture may alter fixation strategies or lead to morbidity, if missed.

There are few studies in the literature regarding these injuries and management guidelines are lacking. We performed a literature review and report three cases treated successfully with intramedullary nailing for the distal tibia fracture and percutaneous screw fixation for the triplane fracture.

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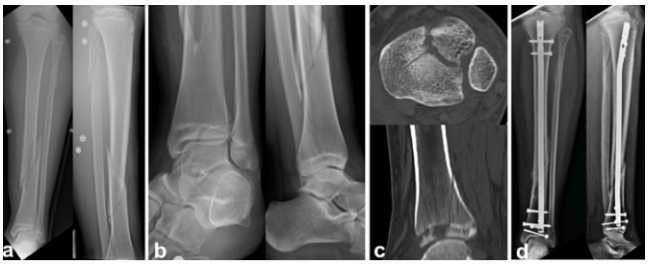

Figure 1: (a) Long-leg AP and lateral radiographs showing distal-third spiral tibia shaft fracture with normal-looking ankle. (b) Dedicated ankle mortise and lateral images show triplane fracture. (c) Axial (upper) and sagittal (lower) CT ankle images showing the extent of displacement of triplane fracture. (d) Final AP and lateral radiographs following rigid IMIN for tibia and percutaneous screw fixation for triplane fracture showing uneventful healing.

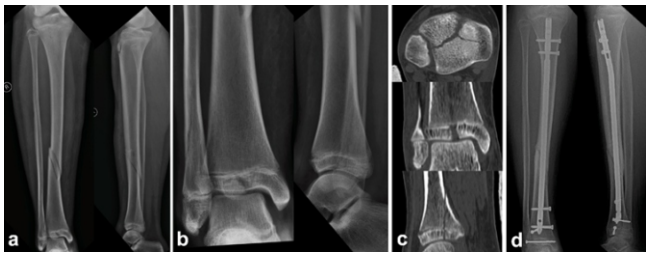

Figure 2: (a) Long-leg AP and lateral radiographs taken on presentation, showing spiral tibia shaft fracture with a distal fibula fracture. (b) Dedicated ankle AP and lateral images show displaced tillaux fracture and medial clear space widening. (c) Axial (upper), coronal (middle) and sagittal (lower) CT ankle images showing the three-part triplane fracture. (d) Final AP and lateral radiographs following rigid IMIN for tibia and percutaneous screw fixation for triplane fracture showing good union.

Clinical experience

Between January 2019 and December-2020, three patients with tibial shaft fractures associated with ipsilateral triplane fractures were treated in our institution (Table-1). The average patient age was 15.3 years (range 14 - 17) and were male. All patients sustained displaced distal-third spiral tibial fractures with three-part triplane fracture of >2 mm displacement. The mechanism of injury was variable. The average BMI was 31.3 kg/m^2, with two patients being obese and one patient in the overweight range. Two patients underwent rigid intramedullary locking nail for tibia shaft fracture, and one patient underwent Ender nailing. All triplane fractures were fixed with percutaneous screws. There were no intraoperative or postoperative complications. The average union time was 10.6 weeks (range 8 - 12).

Surgical Technique

All the patients were obese and required rigid fixation for the distal tibial fracture. If more than 2 years of growth is remaining, damage to the proximal tibia physis from the rigid nails should be avoided. We prefer multiple stainless steel Ender's nails over titanium elastic nails in these cases, as the former provides greater stability. The triplane fracture needs planning akin to that of isolated ones. CT scan ankle is necessary to assess the displacement, type of triplane (number of parts) and plan the trajectory of percutaneous screw placement.

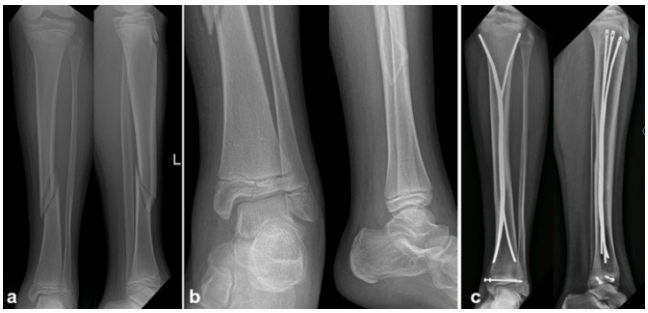

Figure 3: (a) Long-leg AP and lateral radiographs taken on presentation, showing spiral tibia shaft fracture with normal-looking ankle. (b) Dedicated ankle AP and lateral images show undisplaced triplane fracture. (c) Final AP and lateral radiographs following Enders nailing for tibia and percutaneous screw fixation for triplane fracture.

The patient was positioned supine on a radiolucent table. The triplane fracture was stabilized first, in order to prevent further displacement during intramedullary nailing. Following closed reduction, with internal rotation of ankle and direct pressure over the Tillaux fragment, temporary fixation with Kirschner wires was performed. A 4 mm cancellous screw was inserted in an anterolateral to posteromedial direction in the epiphysis. The second screw was used in an anteroposterior direction in the metaphysis, away from the path of the intramedullary nail, to stabilize the posterior metaphyseal fragment. An ankle arthrogram was performed to assess articular reduction. On stabilizing the ankle, the tibial shaft fracture was fixed either with rigid or flexible nails depending on the patient's age. For rigid intramedullary nailing, the leg was positioned on a triangular bolster and standard intramedullary interlocking nailing (IMIN) technique was used. For Ender nailing, the author's technique was used [8].

Case 1:

A 15-year-old obese male presented with a displaced distal third spiral tibia and proximal third fibula fracture of the left leg following a road traffic accident (Figure 1a). Anteroposterior, mortise and lateral views were advised on account of swelling around the ankle joint, which showed a triplane fracture (Figure 1b). The triplane fracture was evaluated with a CT scan (Figure 1c) to assess the displacement and for pre-operative

Table 1: Patient characteristics

	Case-1	Case-2	Case-3
Age	15	17	14
Sex	Male	Male	Male
Mechanism of injury	RTA	Slip and fall from stairs	Twisting injury while playing football
Duration of follow up (Months)	6	6	19
AO/OTA classification of tibia	42D/5.1	42D/5.1	42t-D/5.1
Triplane type	Three-part	Three-part	Three-part
Union time (weeks)	12	12	8
BMI (kg/m^2)	34.1	30.2	29

Table 2: Review of literature

Study	No	Age (years)	Mechanism of injury	Missed injuries	BMI	Shaft fracture type	Ankle triplane type	Intervention for tibia	Intervention for ankle	Follow up (months)	Complications
Roger et al. 2019 [9]	2 (one open, one closed)	15	-Fall from height -Fall from a pedal bike	NA	>100kg	Spiral	NA	Ilizarov fixation	Screws	>12	None
Sheffer et al. 2020 [7]	11	12.7	NA	36%	62.1kg	Middle/distal junction, oblique/spiral	NA	NA	NA	NA	NA
Holland et al. 2018 [3]	5 (one open)	13.7	RTA(1) Slip and fall (4)	NA	NA	Middle/distal third, spiral	NA	Cast in four, Ex-fix in one	Screws	4	CPN palsy due to tight plaster in one case
Sprenger De Rover et al. 2011 [5]	1	14	Slip and fall	NA	NA	Distal third, Oblique	NA	Plating	Screws	3	None
Kasture et al. 2017 [4]	1	14	Fall from height	NA	NA	Distal third, Spiral	Two-part	Plating	Screws	3	None
Jarvis et al. 2001 [2]	6	14.5 for boys, 11.6 for girls	Slip and fall	33.30%	NA	Distal third, Spiral/oblique	Three-part(3), two-part(3)	Casting for all	Cast	22	Varus/valgus of 40 Recurvatum of 4.50 LLD-6.8mm
Rico-Pecero et al. 2009 [10]	1	13	Slip and fall	NA	NA	Distal third, Oblique	Three-part triplane	Plating	Cast	6	None

planning. Considering the age, obesity, unstable shaft fracture and status of proximal tibial physis, a rigid IMIN technique was chosen for stabilising the shaft fracture. The triplane fracture was stabilized with percutaneous 4 mm cancellous screws. He was mobilized non-weight bearing with walker support for 6 weeks and subsequently progressed to weight-bearing as tolerated. At 3 months follow-up, both fractures had united (Figure 1d) and he had returned to his regular activity.

Case 2:

Following a slip and fall from the staircase, a 17-year-old obese male presented with an isolated injury to the Right leg. Radiographs show minimally displaced spiral tibial shaft fracture with displaced triplane fracture (Figure 2a, 2b). CT evaluation of the ankle showed a displaced three-part triplane fracture (Figure 2c). Though shaft fracture could be amenable for non-operative treatment, the triplane fracture required reduction and surgical stabilisation as it was displaced. Hence it was planned for reduction and stabilisation of triplane fracture with screws and IMIN for the tibia. Radiographs at 12 weeks (Figure 2d) demonstrated good healing of the tibia and ankle fracture. He continued to do well at 12 months follow-up.

Case 3:

A 14-year-old male sustained a twisting injury to the left leg and ankle while playing football and presented with inability to weight bear on his left leg. Radiographs of the left leg and ankle series showed an isolated displaced tibial shaft fracture with undisplaced triplane fracture (Figure 3a, 3b). Considering the age and status of the proximal tibial physis, the tibial shaft was stabilized with three antegrade stainless-steel Ender nails and the triplane injury with percutaneous screws (Figure 3c). Postoperatively, the leg was immobilized in an above-knee cast for six weeks. He was mobilized non-weight bearing with a walker for 6 weeks and subsequently progressed to gradual weight bearing as tolerated. At one-year follow-up, he had a full range of knee movements and was able to return to his pre-injury status.

Discussion

Ipsilateral tibial shaft and triplane fractures are very rare but constitute an important clinical problem. The reported incidence is approximately 2.1% [7]. Diagnosis of these types of injuries can be challenging. Most triplane fractures in this combination are nondisplaced and can easily be missed on routine long-leg radiographs. Being intraarticular, missed triplane fractures will lead to secondary displacement and intra-articular incongruence, resulting in ankle arthritis in the long-term. Different fixation methods in the reported cases include casting for both, internal fixation for both or fixation for one fracture and conservative for the other. There are no guidelines on when to look for this type of injuries, how to manage these injuries and the type of implant used. Thus, we aimed to do a comprehensive literature review (Table-2) and present our experience with these rare fractures. All cases in this series were treated with rigid or flexible intramedullary nails with a 100% union rate, without any complications.

The mechanism of injury and primary fracture in this concomitant fracture group is not well described. Kasture et al. speculated that the initial failure would be the spiral or short oblique fracture of the tibia as the twisting force passes longitudinally along the length of the bone [4]. Although most of the energy from the axial and angular force would be dissipated at the tibial fracture, the continued rotational force transmitted distally to the ankle would still be severe enough to fracture the partially fused distal tibial physis causing triplane fracture, especially in the adolescent age group. In all the cases in our series, the triplane fracture was minimally displaced and amenable for percutaneous fixations. This indicates that the primary energy dissipation occurred at the shaft level.

In 2020, Sheffer et al. analysed 517 tibia fractures and found that 4.3% of cases had associated ipsilateral ankle fracture, half

of which were triplane fractures. They reported a high rate (36%) of missed ankle fractures and found that this type of concomitant injury was common in obese children in the adolescent age group. The middle-to-distal third, spiral or oblique fracture pattern of the shaft was most common. However, no significant differences in age, sex, height, weight, or BMI were found between patients who had an isolated shaft fracture and those who had an ankle fracture in addition to a shaft fracture [7]. Also, there was no correlation of low bone mineral density or low vitamin D levels in patients with these fracture patterns.

Jarvis et al. published a series of six cases of concomitant injury in 2001. All patients had sustained minor injuries, usually a fall while running. All fractures were minimally displaced except for one and were amenable for conservative treatment with a long-leg cast, applied without anaesthesia. Two patients had delayed diagnosis at 1 and 3 weeks. Although the authors do not mention the reason for treating the triplane fracture conservatively, the outcome was presumably satisfactory [2]. All fractures with >2 mm articular displacement require anatomical reduction and stable fixation. All our patients were obese and had displaced shaft fracture. Treating this patient group with casts would have been cumbersome with a higher probability of secondary displacement. Hence, we opted for surgical stabilization with intramedullary fixations, especially rigid nails whenever possible.

De Rover et al. reported a case of a similar fracture without fibular involvement. They used plate osteosynthesis for the shaft and percutaneous screw fixation for triplane with good result [5]. Rogers et al. demonstrated successful outcomes in high energy concomitant tibial shaft and ankle injuries in a series of eight patients. Of these, two were triplane fractures. They were treated with an Ilizarov fixator and screw fixation for the physeal component. One patient had a distal tibial physeal growth arrest at follow-up [9]. Rice Pecero et al. reported a 13-year-old boy with Gilbert syndrome who sustained a displaced triplane with shaft fracture after a low energy injury which required open reduction and internal fixation following failed closed reduction [10].

Holland et al. reported good outcomes in a series of five cases. The shaft fractures were managed with a cast and triplane fractures with screws. They found the incidence of these concomitant injuries to be as high as 8.5% [3]. Stuermer et al. suggested the need for a 3-view series of the ankle in adult patients with lower extremity trauma when one of the following three criteria are met: (i) indirect rotational ankle trauma or pronation-eversion injury, (ii) distal-third, spiral shaft fracture and (iii) tibial shaft fracture without concurrent fibular fracture [11]. We believe that the same criteria could be extrapolated for adolescents with tibial fracture (11 to 16 years of age) when they are at highest risk of sustaining transitional fractures. The authors recommend low threshold for open reduction when anatomical reduction is difficult to achieve through closed means. Ertl et al. in their series reported poor functional outcomes in the long-term when the residual gap was greater than 2 mm [12]. The importance of 2 mm cut-off was re-emphasized in a recent publication by Lurie et al. in which they showed significantly worse outcome in patients treated non-operatively who had > 2.5 mm fracture gap on CT scan and [13]. Karef et al in a series of 21 cases managed 2/3rd of cases non-operatively. They reported premature closure of the growth plate in 5 cases, angular deformity in 5 cases (2 varus and 3 valgus) and limb length discrepancy <5 mm in 3 patients and >5 mm in 2 patients [14].

In summary, in an adolescent with distal third tibial shaft fracture due to rotational trauma, one should maintain a high index of suspicion for an associated ankle fracture and should proactively examine the ankle and investigate with ankle radiographs. A CT scan is indicated to assess the displacement and plan treatment. The choice of treatment depends on patient characteristics, displacement of fracture and surgeon's preference.

Conclusion

A high index of suspicion of an associated ankle fracture is needed in obese adolescents presenting with distal third tibia oblique and spiral fractures. CT scan of the ankle facilitates the planning for percutaneous fixation as most triplane fractures are minimally displaced. Tibia fractures warrant rigid internal fixation whenever possible.

References

1. Kempegowda H, Maniar HH, Richard R, et al. (2016) Posterior Malleolar Fractures Associated with Tibial Shaft Fractures and Sequence of Fixation. J Orthop Trauma, 30(10):568-571.

2. Jarvis JG, Miyanji F. (2001) The Complex Triplane Fracture: Ipsilateral Tibial Shaft and Distal Triplane Fracture: The Journal of Trauma: Injury, Infection, and Critical Care, 51(4):714-716.

3. Holland TS, Prior CP, Walton RD. (2018) Distal tibial triplane fracture with ipsilateral tibial shaft fracture: A case series. Surgeon, 16(6):333-338.

4. Kasture S, Azurza K. (2017) Triplane Ankle Fracture with Concomitant Ipsilateral Shaft of Tibia Fracture: Case Report and Review of Literature. Journal of Orthopaedic Case Reports, 7(3):4.

5. Sprenger De Rover WB, Alazzawi S, Hallam PJ, Walton NP. (2011) Ipsilateral tibial shaft fracture and distal tibial triplane fracture with an intact fibula: a case report. J Orthop Surg (Hong Kong), 19(3):364-6.

6. Sferopoulos NK. (2018) Concomitant tibia shaft and triplane fractures. International Journal of Radiology, 5(1):197-201.

7. Sheffer BW, Villarreal ED, Iii MGO, Sawyer JR, Spence DD, Kelly DM. (2019) Concurrent Ipsilateral Tibial Shaft and Distal Tibial Fractures in Pediatric Patients: Risk Factors, Frequency, and Risk of Missed Diagnosis. J Pediatr Orthop., 40(1):5.

8. Durga Prasad V, Sangeet G, Venkatadass K, Rajasekaran S. (2021) Ender's nailing of displaced tibia shaft fractures in children - A nine-year experience. Injury, 52(4):837-843.

9. Rogers GP, Tan HB, Foster P, Harwood P. (2019) Complex Tibial Shaft Fractures in Children Involving the Distal Physis Managed with the Ilizarov Method. Strategies Trauma Limb Reconstr., 14(1):20-24.

10. Rico-Pecero J, Dwyer A. (2009) Triplane fracture of the ankle associated with homolateral tibial fracture in a teenager. A case report. Revista Española de Cirugía Ortopédica y Traumatología (English Edition), 53(4):254-256.

11. Stuermer EK, Stuermer KM. (2008) Tibial shaft fracture and ankle joint injury. J Orthop Trauma, 22(2):107-112.

12. Ertl JP, Barrack RL, Alexander AH, Van Buecken K. Triplane fracture of the distal tibial epiphysis. Long-term follow-up. J Bone Joint Surg Am. 1988 Aug;70(7):967-76. PMID: 3403587.

13. Lurie, B., Van Rysselberghe, N., Pennock, A. T., & Upasani, V. V. (2020). Functional outcomes of tillaux and triplane fractures with 2 to 5 millimetres of intra-articular gap. Journal of Bone and Joint Surgery, 102(8), 679–686.

14. El-Karef E, Sadek HI, Nairn DS, Aldam CH, Allen PW. Triplane fracture of the distal tibia. Injury. 2000 Nov;31(9):729-36. Doi: 10.1016/s0020-1383(00)00086-3. PMID: 11084162.

Declaration of patient consent : The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/her images and other clinical information to be reported in the journal. The patient understands that his/her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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