

Case Report

Image Guided Minimally Invasive Internal Fixation Pilon Fracture with Distraction Arthroplasty

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Abstract

The article explores a case of a 28-year-old woman who sustained a closed comminuted pilon fracture with a segmental fibula fracture after a horse-riding accident. Treatment consisted of Open Reduction and Internal Fixation (ORIF) using a minimally invasive image guided technique with distraction arthroplasty to promote cartilage healing and PRP injections. The patient's initial recovery was complicated by persistent pain and nerve compression. X-rays showed bony union after a year. Within this time the ankle's range of motion had improved from the initial surgery (60% compared to the other ankle). Ultimately, she was able to return to work, although can competitively horse ride again with some limitations. Overall, the combination of ORIF and distraction arthroplasty for this comminuted fracture is a safe and effective treatment with successful outcomes currently. We believe this case highlights principles to be used in joint regenerative surgery.

Keywords: Tibial Pilon Fracture; Open Reduction and Internal Fixation (ORIF); Distraction Arthroplasty; Cartilage Regeneration; Arthrodesis (Fusion); Tarsal Tunnel Syndrome; PRP Injection; Regenerative Technology

Introduction

Tibial pilon fractures are a rare occurrence, accounting for about 3-10% of tibial fractures and less than 1% to fractures in the lower extremities [1]. Pilon fractures can be problematic as they can cause long term quality of life issues including increased rates of walking impairments and ultimately joint fusion of the patient group [2]. The fracture predominantly occurs in males at 57-65 % [3]. This can be attributed to the higher levels of traumatic incidents of males [4]. Due

to the high energy trauma which causes a pilon fracture, there can be severe damage to soft tissues as part of multi-trauma [5, 6]. The fracture configuration can vary according to the position of the foot during the point of impact. When in plantar flexion, the fracture is likely to be in the posterior of the joint, when in dorsiflexion, the fracture is likely to be in the anterior, when neutral, there can be destruction of the whole articular surface [6]. Some of the first trauma surgeons to research pilon fractures extensively were Rüedi and Allgöwer, who created a classification system separating pilon fractures into different categories based on comminution and displacement of the articular surface [7,8]. The categories were separated to type I, II, and III. Type I, intraarticular fracture with a nondisplaced articular surface; Type II, a fracture-dislocation with an incongruous joint; and Type III, a fracture with comminution of the distal tibia articular surface, which can all be seen in Fig. 1 [9].



Figure 1: Type 1, type 2, and type 3 Rüedi-Allgöwer tibial pilon fracture shown respectively. Each (A) being a radiograph and (B) being a drawing [9].

There are a different treatment options for pilon fractures. Careful planning is paramount to achieving successful surgical outcomes [10]. A frequent option for a pilon fracture consists of external fixation and Open Reduction and Internal Fixation (ORIF), with the external fixation used initially then followed by ORIF once soft tissue swelling has reduced [11].

Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore was exempt.

Case Study

A 28-year-old female equestrian had an accident as she fell off a horse and then the horse rolled onto her. This resulted in multiple injuries including a comminuted left ankle fracture, a fractured rib, a left ACL rupture, and soft tissue contusion to the back, hip, ankle, and shoulders. The fractures of the ankle can be seen in the X-Ray in Fig. 2. Stabilisation with an external fixator was applied on the following day of the injury [12]. Following the external fixator, the patient also had Open Reduction and Internal Fixation (ORIF) completed of the fractured fibula and tibia. This technique is shown to be successful using a minimally invasive image guided reduction and fixation of the pilon fracture [13].



Figure 2: X-Rays of the patient's ankle after fractures.

Following ORIF of Pilon Fracture with Distraction Arthroplasty

A hexagonal framing system allowed for distraction of the joint for cartilage regeneration. It also allows for the tibial fracture to be internally fixed minimally invasively adding to the stability of the fracture. Minimally invasive reduction allows the maintenance of the soft tissue envelope and reduces the possibility of wound breakdown. Hence the proximal fibula fracture was internally fixed using a 1/3 semi tubular plate and the distal fibula fracture fixed with 2 screws using an image guided technique [14]. Throughout the literature, distraction arthroplasty is considered an effective, non-invasive option to heal cartilage, especially to avoid more invasive options such as prosthetic arthroplasty or fusion [15-17]. A FrameIt by Integrant (Fig. 3.) has the capability of completing a distraction arthroplasty with less pin site complications due to the pin configuration and use of telescopic arms [18]. An arthroscopy was performed first with the initial fracture reduction and removal of synovitis debris and haemorrhage [19]. Debris was resected using a 4.5 mm chondrotome, clearing the synovitis material. The fibula fracture was reduced secondly to establish the length of the tibia. The tibial fracture was reduced at its medial aspect first then central portion. A structural plug (FuseIt by Integrant) was introduced to the void left in the tibia after fracture reduction which was then impacted further with synthetic graft (GraftIt by Integrant). The fracture was internally fixed with multiple screws [20], hence the fixation being minimally invasive allowing touch weight bearing [21]. A Knee Walker from was used following surgery. An X-Ray 1 week after the frame application demonstrated near anatomic alignment had been achieved from the observed ORIF and external fixation. Stretching of an IP joint contracture of the great toe (also known as a checkrein deformity) started [22,23].



Figure 3: Integrant's FrameIt External Fixator used to complete distraction arthroplasty.

The frame was removed 6 weeks post-surgery, during that time the joint was distracted 8mm. An X-Ray 3-week post-op demonstrated satisfactory alignment and reduction of the fracture. Upon review, the checkrein deformity was still apparent. Physiotherapy commenced to improve range of motion and usage of a cam boot [24]. The patient was advised to avoid wobble board and heel to wall exercises. After 1 month where an MRI and X-Ray were performed. The ATFL was thickened with scar tissue, a common outcome for prior traumatic injuries [25]. Overall improvement was observed from the MRI, with mild synovitis at the ankle joint. X-Ray demonstrated anatomic alignment of the ankle and the multiple fracture lines becoming fainter, consistent with healing. Tightness within the arch of the foot to heel had been noted along with patchy numbness on the sole of the feet with a dysfunctional FHL, which prompted the senior author to request nerve conduction studies [26]. The patient progressed to Partial Weight Bearing (PWB) in the boot with the ankle showing progression and requested hydrotherapy [27]. A review the following month consisted of an MRI scan, nerve conduction study, and X-Ray. The MRI demonstrated an ankle joint effusion and degeneration at the ankle joint with mild synovitis. The extensor hallucis longus and flexor hallucis were intact and normal. Osteophytic ridging in the posteromedial aspect of the distal tibia resulted in extrinsic compression, narrowing the tibial nerve in the distal aspect of the tarsal tunnel. This had led to the tarsal tunnel syndrome which aligned with the results of the nerve conduction study and production of checkrein deformity [28]. The X-Ray in Fig. 4 shows bony union in the fibula with

no complication. Within the distal tibial metaphysis, only partial bony union can be observed. A prominent screw needed to be exchanged. This was performed in conjunction with tarsal tunnel release and removal of the bone spur. Due to the reduced weight bearing of the ankle, disuse osteopenia can be observed in the X-Ray [29,30]. To reduce further osteopenia, the patient would start weight bearing without a boot, however still partially weight bearing with 2 sticks. 3 weeks following weight bearing can be increased with no boot and 1 stick for support.



Figure 4: X-Ray imaging of patient's left foot and ankle.

X-Ray at 9 weeks after the previous imaging which can be seen in Fig. 5. The distal tibia and fibula is healing, with the fibular fracture united and probable incomplete union at the tibia. A PRP injection was performed at the ankle to help shorten healing times and aid cartilage regeneration [31]. One year following the initial fixation, the X-Ray in Fig. 6 the fractures have united. The patient's range of motion is 60% in comparison to the opposite side, along with improving gait which is a satisfactory result during the stage of recovery. The patient had pain in the lateral ankle, peroneal tendons, and fifth metatarsal. To manage the pain experienced by a patient, PRP injections were used to the calcaneal-cuboid joint leading to the resolution of the pain here [32].



Figure 5: X-Ray 9 weeks following Figure 4.

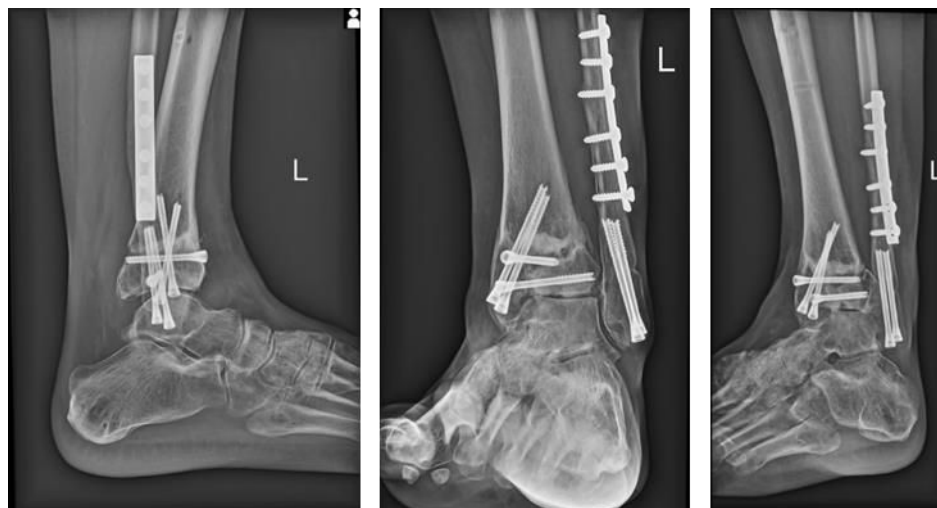


Figure 6: X-Ray 1 year after initial external fixation.

At 6 months the patient was able to return to horse riding. Return to work as a massage therapist 2-3 days per week. Pain killers were still used, which needs to be monitored in extreme trauma patients due to the risk of addiction [33].

Discussion

Tibial pilon fractures are a rare occurrence as it accounts for approximately 5-7% of all tibial fractures and <1% of all fractures to the lower extremity [34]. These fractures pose challenges for treatments which can include comminution, soft tissue damage (to ligaments, tendons, and blood vessels), which can lead to poor blood supply that may hinder bone healing [35]. The treatment of a pilon fracture include ORIF, External Fixation, ankle fusion, and in this case primary distraction arthroplasty [36]. According to the study by Pugh, et al., the external fixation offers the best advantage when soft tissue injuries are associated, however malunion has a higher occurrence [36]. Thus, external fixation is used initially then followed up by internal fixation.

ORIF is a popular treatment for a pilon fracture as it boasts a 98% overall success rate in the study by Zwingmann, et al., [37]. Within a study by Ku, et al., however, the non-union rate is 8.4% [38]. ORIF is the gold standard for Pilon fractures, often augmented by use of external fixation [39]. For pilon fractures ORIF treatments can be either a one stage ORIF treatment, or two stage ORIF treatment preceded by external fixation [40]. ORIF is an invasive treatment including complications such as deep infection, ankle osteoarthritis, and malunion according to Macera, et al., [41]. The study shows in a cohort of 378 patients, there was a 36% complication when applying ORIF on its own. According to a study by Fragomen, ankle distraction arthroplasty is a viable procedure for the complications resulting from ORIF [17]. Hence the two staged ORIF technique aids in avoiding the complications.

External fixation for pilon fractures is considered an excellent temporary procedure for improving alignment and length of the fractures [42]. Definitive treatment with external fixation carries an unacceptable rate of union at 70% and delayed union by 201 ± 79 days [43,44]. The delayed union can hinder a patient's movement for an extended period making it an undesirable option. Ankle fusion is routinely utilised as a late procedure in the management of post-traumatic osteoarthritis but can be controversial for the initial management of complex pilon fractures. Ankle fusion for pilon fractures has a 100% fusion rate according to Nicholas, et al., Sample size of the study consists of 109 patients [45]. Ankle fusions may result in a variety of complications. Such as patients with no subtalar motion and 13 degrees of motion at the chopart joint with degenerative arthritis developing in their joints [46].

Distraction arthroplasty is primarily used to realign, stabilise and create space for joint regeneration. However, ankle distraction arthroplasty alone for a pilon fracture does not achieve satisfactory results in the study of Wang, et al., [49]. This is the first study to our knowledge combining minimally invasive fixation of a complex type III pilon fracture with distraction arthroplasty. Multiple studies have demonstrated the efficacy of distraction arthroplasty in post-traumatic arthritis [50,51].

Joint regeneration was a desirable treatment for this patient due to the age and activities of the patient. The patient wanted to continue riding, requiring ankle mobility hence avoiding ankle fusion. The use of PRP as an adjuvant therapy added to the success of the patient's recovery due to promoting joint function recovery, antagonize anti-inflammatory reactions, therefore improving quality of life [50]. The success of the treatment would give the patient a higher degree of mobility, but the patient noted psychological challenges. The patient had been challenged psychologically with the surgeries due to the rehab and pain management which she is constantly battling with. She added that the recovery process of the treatments is 'exhausting'. The American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score is considered a commonly used instrument to measure the patients' outcomes after sustaining a complex ankle or hindfoot injury [51]. The patient prior to surgery had an ankle-hindfoot score of 17%, showing the severity of the patient's state after her accident. After all the procedures, the patient's ankle-hindfoot score increased substantially to 87%.

Conclusion

Despite that the patient underwent a long and challenging recovery due to the severity of her injuries, the combined use of ORIF surgery, external fixation, PRP injections, and distraction arthroplasty led to a successful outcome. The fracture united with a congruent, well-aligned joint which the patient regained weight-bearing ability, was able to return to work and competitive horse riding. She still experiences some pain and limitations compared to her pre-injury state. This case gives an insight into the versatility of distraction arthroplasty and its ability to be used in conjunction with a minimally invasive, image guided fixation of a complex fracture. These procedures used in conjunction are a unique combination as it is the first study of its kind. In the future, we would require multiple studies to assess the viability of the procedure with different patients, hence further studies are required but the current outcomes are promising. Joint distraction with distraction arthroplasty is an evolving technology with encouraging initial results.

Conflict of Interests

Dr. Gordon Slater has a pecuniary interest in Integrant a biotechnology company and Regen U clinics where he actively advises on treatment protocols and implant design.

Ethical Statement

Not applicable

Acknowledgement

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Authors Contribution

Writing of the paper: Mr Zadane Bachmid / Miss Adelaide Slater

Research on TSF: Miss Adelaide Slater

Research on FrameIt and Clinical studies: Mr Zadane Bachmid

Proofreading/Editing of the paper: Dr Gordon Slater

Data Availability

Data is available for the journal. Informed consents were gained from the patients.

Consent for Publication

Informed consent was obtained from the patient for publication of this case report and is stated in the manuscript.

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