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Original Article

Staged treatment of pilon fractures

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ARTICLE INFO

Article history:

Received 12 January 2015

Accepted 27 January 2015

Available online 27 February 2015

Keywords:

Tibial fractures

Ankle joint

Fibula

Ankle fractures

Soft tissue injuries

ABSTRACT

Aim: To evaluate outcomes following staged anterolateral plating of pilon fractures.**Methods:** Over a 5 year period, patients with pilon fractures received four treatment regimens (staged anterolateral plating, staged medial plating, definitive external fixation, early total care). We defined five outcomes (reduction, soft tissue complications, infection, non-union, malunion) and assessed the outcome of fractures treated by these interventions.**Results:** Staged anterolateral plating or staged medial plating achieved comparable reduction and soft tissue complications. Staged medial plating had higher infection rates, malunion and non-union rates.**Conclusions:** Staged anterolateral plating is superior to staged medial plating in the management of pilon fractures.

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1. Introduction

The distal 8–10 cm of the tibia, including the articular surface, is called the tibial pilon. Pilon fractures usually occur in adults in their thirties or forties caused by a fall from height or a motor vehicle crash.¹ Pilon injury is relatively rare and constitutes approximately 5–7% of all tibial fractures.¹ However, over 30% of pilon fractures are a result of high-energy trauma. These fractures are often associated with severe soft tissue trauma and concomitant polytrauma, making treatment extremely difficult and management challenging for the treating surgeon. Post-operative complications such as wound break down and infection are common and post-traumatic arthritis also occurs in a large number of patients even with adequate joint restoration.² Treatment of pilon fractures

involves a delicate balance between obtaining a strong and stable construct with anatomic articular reduction, while giving careful attention to the delicate soft-tissue envelope. The two-stage procedure protocol viz. the use of the external fixator in the first stage and the internal fixator in the second stage has been applied to successfully treat pilon fractures for many years in different countries around the world.² In general, fixation of the articular surface and tibial shaft is addressed through a variety of anterior incisions (anteromedial, anterior, or anterolateral) or posterior incisions. The classical approach is to use an anteromedial incision to fix the tibial plafond and a postero-lateral approach to fix fibular fractures and to address the posterior fragments. This type of approach mainly depends on the fracture pattern and surgeon preference. Recently, the anterolateral approach to the tibia

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<http://dx.doi.org/10.1016/j.jor.2015.01.028>

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has been popularized. Herscovici et al described this approach, called the Bohler incision and recommended this distal extensile approach for the management of foot and ankle injuries involving the anterior talar dome, talar neck, talonavicular joint, subtalar joint, calcaneo-cuboid joint, and the bases of the third and fourth metatarsals.³ This approach provides excellent visualization of the anterior end of the distal tibia, the distal tibio-fibular joint and the ankle joint helping the surgeon achieve excellent reduction of the articular surface. More importantly, the approach provides better soft tissue envelope to cover the fracture site and the hardware used for the fixation. The drawback of the approach is however limited access to the medial ankle joint making fixation of the fractures of the medial malleoli difficult.

Logical thinking dictates that combining these two methods (staging and using the anterolateral approach) should give us the best outcomes in the management of these difficult fractures. We hypothesized that staged anterolateral plating is superior to all other modes of fixation including medial plating.

2. Methods

We retrospectively collected data from patients who underwent treatment for pilon fractures between September 1, 2007 and September 20, 2012. Institutional review board approval was obtained prior to the start of the study. All patients aged 15–90 years who had been treated with staged anterolateral plating, staged medial plating, early total care, or definitive external fixation were considered for the study. Patients with other means of fixation (such as extreme nailing), with inadequate x-rays, with inadequate follow up of less than 9 months, as well as patients with isolated medial malleolar fractures, were excluded in the study. Out of 217 patients screened, 89 fractures met study inclusion criteria. Fifty seven (57) percent of patients screened were male and 43% were female. The majority (47%) of the patients were in the 40–59 age group followed by 37% of patients in the <40 age group. Thirty one (31) percent of the fractures were documented as open and 69% were closed. Fractures were classified according to the OTA guidelines as Type A (extra articular), type B (partial articular) or type C (intraarticular). Eleven percent (10 of 89) were type A fractures, 24% were type B (21 of 89) and 65% were type C (58 of 89). Fifteen fractures (16.8%) underwent anterolateral (AL) plating, 18 (20.2%) underwent medial plating, 24 (27%) underwent early total care and 32 (36%) had definitive external fixation (Fig. 1). Among patients who received staged treatment, the average time between the first and the second procedure was 12.7 days (range, 1–56 days). The distribution of open and closed fractures among the 4 treatment groups can be seen in Fig. 2.

2.1. Initial management

All patients who were identified with pilon fractures were seen in the ER with a senior consultant and a plan was formulated. Initial splinting was done until we were able to move the patient to the operating room. All patients with open fractures were moved to the operating room as soon as

possible. The wounds were copiously irrigated with 6–9 L of saline. Temporizing external fixators were used. Patients were taken back to the OR in 48–72 h for a repeat irrigation and debridement.

For patients with closed fractures, decision on definitive management depended on the soft tissue condition. Minimally displaced fractures with minimal swelling were treated with definitive fixation during the first OR visit. The rest were staged. Staging typically means temporizing the fractures with a spanning external fixator and coming back to the OR when the soft tissue conditions were more favorable.

2.2. Anterolateral plating

A tourniquet was used in all cases. A longitudinal incision was made from the base of the 4th metatarsal to a point 5 cm superior to the ankle joint. The incision was deepened to the deep fascia. In the distal aspect of the incision subcutaneous dissection was done more carefully to identify and protect the superficial peroneal nerve. All extensor tendons and part of the muscle bellies were swept medially to expose the tibial pilon. Access to Tillaux–Chaupt fragment and anterior distal tibio-fibular joint was immediate and the fragments were reduced under direct vision. Posterior and postero-lateral fragments were fixed with indirect means such as axial traction, making strategic small incisions to manipulate fragments. Final fixation was done with a Synthes anterolateral tibial plate. The proximal aspect of the plate was placed sub muscularily and fixed with screws placed through a separate incision.

2.3. Outcomes measured

We divided outcomes into five categories based on clinical and radiological observations (Table 1). The reduction was classified as satisfactory, based on the immediate post-operative x-ray. A reduction with an articular step off of less than 2 mm and angulation of less than 5° in both sagittal and coronal plane was classified as satisfactory. The second outcome we observed was immediate soft tissue complications; wound necrosis, wound dehiscence and blisters fit into this category. The third outcome was the presence of infection. All superficial and deep infections that required the institution of antibiotics, oral or intravenous (IV), were included. Hospitalization was not necessary to be included in this group. The fourth outcome was non-union. A fracture was classified as non-union when 9 months had passed from the day of the surgery and no evidence of radiological progression has been documented. The fifth and final outcome was a malunion. It was classified as malunion if the ankle healed with more than 5 degrees of angulation in either coronal or sagittal plane with respect to the mechanical axis of the extremity.

3. Results

Both anterolateral plating technique and medial plating achieved comparable satisfactory reduction (Table 1). Satisfactory reduction was best achieved in the early total care cohort and

Fig. 1 – This bar graph illustrates type of treatment for open and closed fractures.

Fig. 2 – This graph indicates treatment by type of fracture.

Table 1 – The early total care group performed well in all outcome measurements and the definitive external fixation performed poorly in all segments.

Type of treatment	Satisfactory reduction	Soft tissue complication	Infection	Non-union	Malunion
Staged AL plating (n = 15)	14 (93%)	4 (27%)	4 (27%)	0	1 (6.5%)
Early total care (n = 24)	24 (100%)	3 (12.5%)	0	0	0
Definitive external fixation (n = 32)	19 (59%)	7 (22%)	6 (18.8%)	8 (25%)	7 (22%)
Staged medial plating (n = 18)	17 (94%)	5 (28%)	6 (33.3%)	4 (22%)	3 (16.7%)
P value	<0.001*	0.61	0.030*	0.012*	0.078

*Indicates statistical significance.

worst in the definitive external fixation group (Table 1). Staged anterolateral plating and staged medial plating had comparable soft tissue complication rates. Both non-union and malunion rates were higher in the staged medial plating group compared to the anterolateral group. Staged medial plating also had higher incidence of deep infections (Table 2).

Type C fractures had the poorest reduction, highest soft tissue complication and infection rates, and also had the highest non-union and malunion rates (Table 3). Open fractures showed statistically significant higher complications, including poorer satisfactory reduction, higher soft tissue complications, higher infection rates and higher rate of non-union. Malunion rates were also higher but did not reach statistical significance (Table 4).

4. Discussion

The treatment of pilon fractures is difficult and marred by high complication rates. Harris et al⁴ observed post-traumatic arthritis in 39% of his cases at a mean follow up of 26 months after surgery. In a retrospective study, Pollak et al⁵ reported on 80 patients who had sustained fractures of the tibial plafond. With an average follow up of 3.2 years, 35% of the patients had substantial ankle stiffness, 29% persistent swelling and 33% ongoing pain. Sixty-eight percent of patients reported that the fracture prevented them from working. He also noted that presence of two or more co-morbidities, treatment by external fixator, in addition to a number of social and demographic variables contributed to poor outcome.

Presence of co-morbidities such as diabetes increased the risk of post-operative complications.⁶ Kline et al in their paper observed that infection rate was 71% in diabetic patients

whereas it was only 19% in non-diabetic patients. In addition, the rate of non-union and delayed union in the diabetic group was 43% and only 16% in the non-diabetic group. The odds ratio for overall risk of complication in diabetic patients versus non-diabetics was 4.69. Wukich et al⁷ compared ankle fracture outcomes in 46 patients with complicated diabetes and 59 patients with uncomplicated diabetes. At a mean follow up of 21.4 months, they reported a 3.8 times increased risk for overall complications and a five times increased risk for revision surgery in patients with complicated diabetes when compared to those with diabetes under tight control. In their large study, Soohoo et al⁸ analyzed short term and intermediate term rates on the basis of readmission. The presence of complicated diabetes was a particularly strong predictor of poor outcome (odds ratio, 2.30; $p < 0.001$), as was peripheral vascular disease (odds ratio, 1.65; $p < 0.001$). Smoking is another variable that can adversely affect the outcome of surgery. A meta-analysis, analyzing 6 randomized trials and 15 observational studies showed decrease in post-operative complications by up to 41%⁹ with prolonged smoking cessation. This included general and wound complications. Our study showed higher (33.3% vs 15.3%) infection rates among smokers when compared to non-smokers ($p > 0.05$).

The timing of the surgery is critical in deciding the outcome of the procedure. Historically, the thought process was that it was safe to operate in the first 6 h of the injury. It has been shown that soft tissue impairment due to inflammatory processes is potentially at its highest for up to 6 days post injury.¹⁰ Hence, it was thought it was best to wait until the inflammatory period has passed. This is clinically assessed by the decrease in swelling and wrinkling of the skin. Despite identifying these two safe window periods, an early period <6 h and a delayed period >7 days, ORIF of tibial plafond fractures continues to have high complication rates and suboptimal clinical results.^{11–13}

Proponents of external fixation have reported better or comparable results. Various forms of external fixation including ring fixators have been tried. Wyrsh et al conducted a prospective randomized study comparing external fixation with ORIF, showing superior results in the external-fixation cohort.¹² However, Liporace et al pointed out that the ORIF cohort was operated on within three to five days, whereas the external fixator cohort with limited open fixation was definitively treated after more than 7 days after injury.¹⁴ Limited internal fixation with definitive external fixation has been touted to achieve comparable results with open reduction and internal fixation.^{15,16} Bacon et al,¹⁷ in his

Table 2 – Comparison of outcome complications for our primary interest groups.

Outcome	Staged anterolateral plating	Staged medial plating
Quality of reduction	14 (93%)	17 (94%)
Soft tissue complication	4 (27%)	5 (28%)
Infection	4 (27%)	6 (33.3%)
Deep Infection	1 (25%)	5 (83%)
Non-union	0	4 (22%)
Malunion	1 (6.5%)	3 (16.7%)

Table 3 – Complications according to fracture type.

Type of fracture	Satisfactory reduction	Soft tissue complication	Injection	Non-union	Malunion
Type A	10 (100%)	2 (20%)	1 (10%)	0	1 (10%)
Type B	20 (95%)	2 (9.5%)	2 (9.5%)	3 (14%)	1 (5%)
Type C	44 (76%)	15 (26%)	13 (22.4%)	9 (15.5%)	10 (17%)
P value	0.036*	>0.05	>0.05	>0.05	>0.05

*indicates statistical significance.

retrospective analysis of ORIF vs Ilizarov fixation found that it took longer for the ORIF group to heal. Rates of non-union, malunion and infection were lower in the Ilizarov group; however, pin-tract infections occurred in patients with long-term external fixation. Our study actually shows the patients treated with definitive external fixation performed poorly. Only 59% of patients in this cohort had satisfactory reduction. They also had higher non-union (25%) and malunion (22%) rates. However, the soft tissue complication rates and infection rates were either similar or even lower compared to other treatment groups. It must be noted that patients in this cohort had a high frequency of Type C fractures (Fig. 2).

More recently, a staged protocol has been found to lower complication rates to more acceptable levels. In this protocol, the first stage is temporizing the fracture using a spanning external fixator. If the fracture is open, irrigation and debridement are done at the same time. The second stage involves the definitive management of the fracture, usually internal fixation. In general, the second stage is completed seven to fourteen days after the first surgery when the soft tissue inflammation and edema has settled down. Sirkin et al¹⁸ employed this technique and reported vastly reduced complication rates than previously reported.^{11–13} Since then several studies have validated this treatment protocol.^{19,20} Despite this proponents of early ORIF still remain. White et al showed good results when early ORIF was performed in the ‘right setting’. He showed only 2.7% complication rate among is cohort of closed fractures. Our study shows excellent results in all measured outcomes. But these are carefully chosen patients based on the severity of the injury and the soft tissue condition. None of the patients in this cohort had open fractures. A majority of patients in this group also had type A or type B fractures.

The approach to a pilon fracture fixation generally depends on the fracture pattern. Careful preoperative planning using computer tomography (CT) is necessary. Tornetta and Gorup²¹ studied the impact of CT on the management of pilon fractures. They observed that CT had changed the management in 64% of the patient cohort. A two-incision workhorse approach gives excellent exposure of the fracture fragments. The lateral incision is for fixation of the fibular fracture and posterolateral corner of tibial plafond. The medial incision,

understandably gives excellent exposure to the anteromedial portion of the tibial plafond. Classically, many surgeons have insisted that at least 7 cm of skin is necessary as a bridge to minimize soft tissue and wound complications. Howard et al²² prospectively analyzed the soft tissue complications in his patient cohort. The mean width of skin bridge in his patient cohort was 5.9 cm. Only 17% of the skin bridges were greater than 7 cm. Even so, the soft tissue complication was unusual.

An anterolateral Bohler incision is an extensile incision that gives direct access of the Tillaux–Chaupt fragment.³ In addition, it provides excellent visualization of the talar dome, distal tibio-fibular joint, lateral talonavicular, subtalar and even calcaneo-cuboid joints. The disadvantage of this approach is that the constant fragment posteriorly cannot be directly visualized. It also provides only limited visualization and access to the medial malleolus. An anterior or anterolateral approach involves “open book” or posterior to anterior reconstruction of the articular surface. In addition, proponents of anterolateral fixation depend on several indirect means of fixation such as traction and manipulation of the foot.¹⁹

The advantage of the anterolateral incision when compared to the anteromedial or the medial incision is the presence of thicker soft tissue envelope. Our study showed comparable reduction of fracture in both staged anterolateral plating and staged medial plating (93% vs 94%). They also showed similar immediate soft tissue complications such as wound dehiscence and necrosis (27% vs 28%). The infection rate was slightly higher in the staged medial plating group (27 vs 33.3%). However of the 4 patients who developed infection of the wound in the anterolateral plating cohort, only 1 went on to develop deep infection. On the other hand in the medial plating cohort, 5 of the 6 patients who developed an infection went on to develop deep infection. This demonstrates the importance of the presence of soft tissue envelope and the ability of the anterolateral approach to salvage superficial infections and minor wound complications. There was comparable distribution of type of fracture and open fractures in these two groups.

Our study suggested that a fracture being open or closed at presentation was prognostically significant. Open fractures had statistically significant poorer outcomes in quality of

Table 4 – Outcomes for closed fractures and open fractures.

Fracture type	Satisfactory reduction	Soft tissue complications	Infection	Non-union	Malunion
Closed	55 (90%)	8 (13%)	6 (9.8%)	3 (4.9%)	6 (9.8%)
Open	19 (68.5%)	11 (39.3%)	10 (35.7%)	9 (32%)	5 (17.9%)
P value	0.009	0.005	0.003	0.001	>0.05

reduction, soft tissue complications infection and non-union. The fact that open fractures tend to be high energy fractures with extensive comminution may have contributed to this observation. Boraiah et al²⁰ in his article observed that 11 patients had complications out of 59 patients (19%). The total number of superficial and deep infections were 5 (8%). In our series 35.7% of patients developed some form of infection, 21.4% developed deep infection requiring the need for IV antibiotics or subsequent debridements.

5. Conclusion

1. Staged anterolateral plating technique is superior to other means of fixation in a comparable setting.
2. Early total care when performed in carefully selected patients gives excellent results.
3. Staged anterolateral plating is superior to staged medial plating in its ability to salvage superficial infections. This in turn is because of better soft tissue coverage in the anterolateral region of the ankle.
4. The most important factor in determining outcome was whether the open fracture or a closed fracture.

Conflicts of interest

All authors have none to declare.

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