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ORIGINAL PAPER

Complications of definitive open reduction and internal fixation of pilon fractures of the distal tibia

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Abstract A series of 49 pilon fractures in a tertiary referral centre treated definitively by open reduction and internal fixation have been assessed and the complications of such injuries examined. A retrospective analysis of case notes, radiographs and computerised tomographs over a seven-year period from 1999–2006 was performed. Infection was the most common postoperative problem. There were seven cases of superficial infection. There was a single case of deep infection requiring intravenous antibiotics and removal of metalwork. Other notable complications were those of secondary osteoarthritis (three cases) and malunion (one case). The key finding of this paper is the 2% incidence of deep infection following the direct operative approach to these fractures. The traditional operative approach to such injuries (initially advocated by Rüedi and Allgöwer in Injury 2:92–99, 1969) consisted of extensive soft tissue dissection to gain access to the distal tibia. Our preferred method is to access the tibia via the "direct approach" which involves direct access to the fracture site with minimal disturbance of the soft tissue envelope. We therefore believe that open reduction and internal fixation of pilon fractures via the direct approach to be a safe technique in the treatment of such devastating injuries.

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Introduction

Fractures of the horizontal surface of the distal tibia are known commonly as pilon or plafond fractures. They represent 1–5% of lower extremity fractures and 7–10% of all tibial fractures [1]. The injury is an intra-articular fracture of the tibiotalar joint with varying degrees of proximal extension into the tibial metaphysis. They are the result of an axial load on the tibia, with or without an accompanying rotational force. The aim of operative treatment is to anatomically reduce the fracture fragments to restore the congruity of the joint surface and promote bony union with minimal disruption of the soft tissue envelope.

Operative fixation of pilon fractures has presented a significant challenge to the orthopaedic surgeon as the extensive soft tissue damage associated with such injuries makes surgical intervention hazardous. The traditional approach advocated by Rüedi and Allgöwer [2, 3] involves an extensive dissection to the distal tibia and has been associated with significant rates of infection and wound dehiscence, ranging from 0–55% [4, 5].

Minimal disturbance of the soft tissue envelope is key to the prevention of the common wound problems of dehiscence and infection. The vascularlity of the soft tissue sleeve surrounding the distal tibia is tenuous [6–10] and aggressive handling with extensive periosteal stripping will disturb the nutrition to the myocutaneous tissue and underlying bone.

In this paper we present a consecutive series of pilon fractures treated by a direct approach onto the fracture line and have found that the avoidance of excessive soft tissue dissection allows definitive open reduction and internal fixation as a viable option for these injuries.

Patients and methods

All adult patients who underwent operative intervention for tibial fractures and ankle fractures were identified retrospectively from operating theatre records from the period 1999–2006 and complied into a primary database (241 patients). Four patients were excluded as their notes were unavailable or they were followed-up elsewhere. All remaining case notes were retrospectively reviewed and those with true pilon injuries treated with open reduction and internal fixation of the tibial plafond were included in this study. Twenty-two patients were treated primarily at our centre whilst the remaining 26 constituted tertiary referrals.

There were 48 patients with unilateral injuries and one with bilateral injuries, giving a total of 49 pilon injuries. Those treated definitively with other methods such as external fixation alone, or a combination of open reduction and internal fixation with external fixation were excluded. Hence this paper aims to elucidate the precise complication rate following the definitive anatomical fixation of pilon fractures.

The plain radiographs were reviewed and analysed according to the Rüedi and Allgöwer [3] and AO [11] classification systems. Coronal and sagittal alignment was also examined. Every patient underwent preoperative assessment with CT scanning. The anatomy of the fracture patterns on CT was also classified in accordance with the recommendations of Topliss et al. [12]. Associated fibular fractures were classified according to Marsh and Salzman [13].

Results

There were 38 males and 11 females. The average age was 36 years (range 16–65). Twenty-nine fractures were a consequence of high energy trauma, the remaining 20 were low energy injuries. Three injuries were open fractures (grades I, IIIa and IIIb).

Of the 49 patients eligible for the study, the preoperative radiographs and CT scans of 48 were available. The fracture patterns are outlined in Table 1.

As regards the coronal alignment on anteroposterior (AP) radiographs there was a virtually equal distribution between varus (21/48) and (20/48) valgus deformity with seven fractures lying in a neutral position. Sagittal alignment as assessed on lateral radiograph again showed an even distribution with the fracture apex anterior in 20/48 cases and posterior in 20/48 cases. Eight fractures did not show any angulation in this plane. There was an associated fracture of the fibula in 32 cases. Weber B was the most common (16), followed by Weber C (14) and then Weber A (1). There was also a single diaphyseal fibular fracture. There were associated bony injuries in nine cases.

Table 1 Fracture anatomy of pilons treated definitively with open reduction and internal fixation

Classification systems	Number
Rüedi and Allgöwer [3]	
I	3
II	26
III	19
AO/OTC [11]	
43.B1	4
43.B2	5
43.B3	4
43.C1	13
43.C2	12
43.C3	6
Topliss et al. [12]	
SS	7
IV	10
T	8
CS	0
AS	2
PS	0
V	3
Y	18

The initial deformity required correction by means of manipulation in 22 cases. Eighteen required temporary stabilisation by means of an external fixator.

The average time to definitive fixation with open reduction and internal fixation was 13.6 days (range 4–31 days). Operative intervention was undertaken only when the soft tissues were deemed to be satisfactory. This was performed under the guidance of the senior author or two other experienced trauma surgeons within the limb reconstruction unit. The majority of the cases (34) were performed by a consultant with the remaining 15 cases by a senior trainee under supervision.

A variety of operative approaches were used in the fixation of the fractures. Each approach was mandated by the fracture anatomy as defined on CT to reduce soft tissue stripping. The fracture line was carefully located intra-operatively with the assistance of the image intensifier and incision targeted to this point.

The incisions used were anterior (12), anterolateral (7), anteromedial (11), posteromedial (5), medial (8) and posterolateral (6). Regardless of the direction of the approach, each incision was minimised to limit disruption of the soft tissue envelope. The relationship between fracture pattern and operative approach is outlined in Tables 2 and 3.

A variety of fixation techniques were used which ranged from cortical lag screws only (23), cortical lag screws with

Table 2 Relationship between AO/OTC fracture pattern and operative approach

Approach	Fracture pattern						Total
	B1	B2	B3	C1	C2	C3	
Anterior	2	1	0	4	2	2	11
Anterolateral	0	0	1	2	3	1	7
Anteromedial	2	2	0	4	2	1	11
Posteromedial	0	1	1	2	1	0	5
Medial	0	1	2	3	2	0	8
Posterolateral	0	0	0	2	2	2	6

a buttress plate (3), cortical lag screws with a locking plate (19) to a locking plate only (4).

Complications were assessed by the lead author from the medical records. Forty-eight cases were followed-up to discharge (range 1.5 months–29 months; mean 9.14 months). We concede that the patient followed-up for six weeks in this series could only be assessed for perioperative and early postoperative complications, but as they did not re-present it is assumed they were asymptomatic. A single case remains under current review. All cases progressed to union within an appropriate time frame. The complications are summarised in Table 4. Complications included malunion (2%), superficial wound dehiscence (2%), deep tissue infection (2%), secondary traumatic osteoarthritis (10%), and superficial wound infection (14%). There were no cases of osteomyelitis.

The most common single complication was that of superficial infection, affecting seven of the 49 cases (14%). This was defined as an infection of the superficial soft tissues only that were responsive to a short course of oral antibiotics (flucloxacillin). Of these seven cases none showed the lateral disruption type of injury that we have previously described [12]. Four cases had an associated fibular fracture. These were all fixed through separate skin incisions to that used to address the tibial fracture. Skin closure was achieved with subcuticular monofilament sutures in six cases and with staples in the remaining two.

The majority of the infected cases had sustained their injuries as the result of low velocity trauma. Only one infected case resulted from a high velocity injury. This contrasts to the non-infected group, the majority of whom sustained their injuries as a result of high energy trauma (68%). None of the infected cases had been open injuries.

As regards soft tissue resuscitation, the average time from injury to surgery was comparable between the groups, 13.4 days in the non-infected and 13.8 days in the infected group.

The patient who suffered the single case of deep infection (defined as infection of the deeper soft tissues surrounding the implanted metalwork) was a type B host, with type 2 diabetes mellitus. Deep tissue samples grew *Staphylococcus aureus*. There is to date no evidence of underlying osteomyelitis.

The relationships between the complication, fracture class and operative approach can be seen in Tables 4 and 5.

Discussion

The French radiologist Destot is credited with first describing the term pilon fracture [14]. He likened the articular surface of the distal tibia to that of a pharmacists pestle (pilon) [15]. Such injuries were traditionally treated in plaster with or without adjunctive skeletal traction [16]. Early attempts at operative fixation of pilon fractures [17–19] were limited by the small number of implants available. The outcome of this injury at that time was so poor that some authors even recommended primary ankle arthrodesis [2].

In an attempt to find a solution to this problem, Rüedi and Allogower, working under the umbrella of the AO group, described a new technique in 1969 for the treatment of pilon fractures [2]. In accordance with the evolving principles of AO they believed that anatomical restoration of the articular surface was paramount to achieving a satisfactory functional outcome. They adhered to four key principles: the restoration of the length and axis of the fibula or tibia; the reconstruction of the distal end of the tibia; the filling of the defect resulting from impaction, using cancellous autografts; and the support of the medial side of the tibia by plating to prevent a late varus deformity. By following these principles they demonstrated a good functional result in 73.7% of their initial series of 84 patients with an average follow-up of 50.3 months. The incidence of soft tissue complication was 12% overall in this series with the deep infection rate at 5%. These impressive results were compounded a decade later, when the authors continued to demonstrate excellent long-term results in their series [3]. It is notable that the majority of fractures in this series (73%) were low-energy skiing injuries.

Table 3 Relationship between Topliss fracture pattern and operative approach

Approach	Topliss et al. [12]						Total
	SS	IV	T	AS	V	Y	
Anterior	1	3	2	2	0	3	11
Anterolateral	1	1	1	0	1	3	7
Anteromedial	2	1	4	0	1	3	11
Posteromedial	0	0	1	0	0	4	5
Medial	1	3	0	0	1	3	8
Posterolateral	2	2	0	0	0	2	6

Table 4 Relationship between complication and fracture pattern

AO/OTC	Complication					Total
	Superficial infection	Deep infection	Superficial dehisence	Malunion	Secondary OA	
B1	0	0	0	0	1	1
B2	1	0	0	0	1	1
B3	1	0	0	0	0	1
C1	3	0	1	0	2	5
C2	2	1	0	0	1	4
C3	0	0	0	1	0	1

This encouraging work led to a dramatic increase in the popularity of open reduction and internal fixation techniques, sparking a fresh enthusiasm for aggressive operative fixation of pilon fractures.

Heim and Naser in 1976 claimed 90% good to excellent results employing the aforementioned principles [20]. Again the patients in this series constituted mainly lower energy injuries. Kellam and Waddell [21] were the first to differentiate between high energy axial loading compressive fracture and low energy rotational injuries in 1979. They were able to demonstrate good outcomes for the former group (84%) but not so for the latter (53%). This difference in outcome was also appreciated by Ovadia and Beals [22]. Bourne et al. [23] reported a 13% infection rate in their higher energy group in a 42 fracture series. Dillin and Slabaugh [5] had an alarming 55% infection rate in their series of 11 high energy compressive pilon fractures, leading them to recommend rigid fixation for the lower energy rotational injuries only. Mc Feran [24] had a 17% rate of deep infection with one patient requiring an amputation in his series of 52 fractures. Teeny and Wiss [25] had a deep infection rate of 37% in a series of 60 fractures (60% high energy injuries).

Helfet et al. [26] demonstrated an impressive superficial infection rate of 3% and deep infection rate of 6% in their series of 32 high energy fractures treated with open reduction and internal fixation (26 cases) or external fixation (six cases). In all cases treatment was delayed until the soft tissues were deemed safe for intervention (average 7.3 days).

A clear idea regarding resuscitation of soft tissue, restoration of alignment, length and rotation and exact reconstruction of the articular surface was emerging. It was evident that by delaying surgery until the soft tissues were capable of dealing with the surgical insult, one could dramatically reduce the complication rates, in particular those associated with infection and wound dehiscence.

Hence, the concept of “staged” reconstruction emerged, with the use of a spanning external fixator to allow resuscitation of the surrounding soft tissue envelope [27] before definitive internal fixation. Sirkin et al. [28] reported 17% partial thickness skin necrosis and 10.5% deep infection rate in his series of 52 C-type fractures treated initially with immediate stabilization with a spanning external fixator followed by definitive open reduction and internal fixation an average of 12.7 days later. In a smaller series of 21 consecutive C type fractures, Patterson and Cole [4] reported an impressive 0% infection rate following fixation after on average 24 days post immediate external fixation. However, this study is limited by its relatively small sample size. Chen et al. [29] showed encouraging results after direct fixation following one to two weeks of traction, quoting 3.9% superficial infection and 5.5% deep infection in a 128 fracture series.

Blauth et al. prospectively compared immediate primary open reduction and internal fixation, minimally invasive

Table 5 Relationship between complication and surgical approach

Approach	Complication					Total
	Superficial infection	Deep infection	Superficial dehisence	Malunion	Secondary OA	
Anterior	0	0	0	0	2	2
Anterolateral	2	0	1	0	0	3
Anteromedial	2	0	0	0	2	4
Posteromedial	0	1	0	0	0	1
Medial	2	0	0	0	1	3
Posterolateral	1	0	0	1	0	2

internal fixation combined with unilateral transarticular external fixation and transarticular external fixation with subsequent definitive internal fixation [30]. The infection rate was 25%, with 10% developing osteomyelitis. This did not differ across treatment groups.

More recent work has shown that despite advances in our understanding of the importance of soft tissue resuscitation and implant technology (with the advent of low profile locking plates), complication rates and infection remain high [31, 32]. Bacon et al. [33] found osteomyelitis rates of 20% and 23% in a series of 42 fractures treated with open reduction and internal fixation and Ilizarov external fixation, respectively. However, promising results have been shown by Leonard et al., who found that early intervention (before 36 hours) prior to the initiation of swelling with minimally invasive techniques can reduce rates of soft tissue complication [34].

Conclusion

It is evident that a great deal of controversy exists as to the optimal management of these injuries. What can be seen clearly from the results of this study is that with meticulous soft tissue resuscitation combined with a direct approach to the fracture line, serious infective complications can be minimised to 2%. CT scanning is fundamental to the modern surgical approach to the pilon fracture [35], as it allows identification of the dominant fracture plane. Surgical reconstruction must be tailored to the personality of each fracture and operative approaches dictated by the quality of the soft tissues. We believe that open reduction and internal fixation of these injuries is a viable management option provided the soft tissue envelope is respected. This is achieved via precise surgical planning and selection of an operative approach that provides maximal access to the dominant fracture plane at a time when the overlying soft tissues are capable of surviving surgical manipulation.

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