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Original article

Analysis of the variables affecting outcome in fractures of the tibial pilon treated by open reduction and internal fixation

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ABSTRACT

Objective: To assess variables that could be related to outcomes in fractures of the tibial pilon treated by open reduction and internal fixation (ORIF).
Design: Retrospective.
Setting: University Hospital.
Patients: A total 92 fractures of the tibial pilon treated by ORIF in a 5-year period. The minimum follow-up was 1 year (mean: 3.3 years; range: 1–5).
Intervention: ORIF with LCP-LISS plate.
Primary outcome measurements: Age, sex, side, type of fracture, energy of the injury, provisional external fixation (EF), time until ORIF, stages of treatment (one or two), surgical approach, type of bone fixation, quality of reduction, bone graft, hardware removal, associated fractures (fibula and others), functional results (AOFAS scale), rates of infection, skin necrosis, flap coverage, non-union, and early posttraumatic ankle osteoarthritis (AOA).
Results: According to AOFAS scale 30.5% of results were excellent, 46.7% good, 13.1% fair and 9.7% poor. Overall, the rate of infection was 13.04%, The rate of non-union was 10.86%. The rate of skin necrosis was 7.6% and the rate of flap coverage was 13.04%. The rate of early posttraumatic AOA was 13.04%. Type 43C3 fractures of the AO classification had a higher rate of skin necrosis and flap coverage. Open fractures were related to a higher prevalence of nonunion and flap coverage. The use of a bone graft was associated with a higher rate of nonunion and poor results. Infection was related to a higher prevalence of fair and poor results. EF was associated with a higher need for flap coverage. A suboptimal anatomic reduction was related to a higher rate of fair and poor results. The anteromedial approach was associated with a higher prevalence of skin necrosis and early posttraumatic AOA than the anterolateral approach. The use of an medial plate was related to a higher rate of nonunion than the use of a lateral plate.
Conclusions: The anteromedial approach was associated with a higher rate of skin necrosis and posttraumatic AOA than the anterolateral approach. Medial plating had a higher prevalence of nonunion than lateral plating.
Level of evidence: IV (case series).

1. Introduction

Pilon fractures are serious injuries affecting the articular surface of the distal tibia. Sometimes they are due to high-energy trauma with an axial load, whereas in other patients, they tend to be the result of low-energy trauma due to a rotational mechanism.[1] Articular involvement and a high degree of comminution are common in metaphyseal fractures.[2] Treatment is primarily surgical. Problems after surgery are common; complications can affect the soft tissues (skin necrosis, requirements for flap coverage and infection) [3–6] or involve the bone (posttraumatic ankle osteoarthritis [AOA], osteomyelitis and nonunion).[7]

To achieve good function, we must restore the articular surface through optimal anatomic reduction and a stable fixation.[1,8] It is also important to appropriately handle the soft tissues.[9] There is some controversy in the literature regarding the variables affecting outcome in fractures of the tibial pilon treated by open reduction and internal fixation (ORIF): One stage (<48 h) [7,10,11] or two stages (staged treatment), placing an external fixator (EF) or a plaster

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splint in the first stage, delaying definitive ORIF until the soft tissues are healed, [8,9,12–14] et cetera.

The aim of this study was to evaluate which variables could be related to functional results and complications after ORIF of tibial pilon fractures.

2. Patients and methods

We analyzed 94 patients with tibial pilon fractures treated by ORIF between January 2011 and December 2015 in one University Hospital. The minimum follow-up was 1 year (mean: 3.3 years; range: 1–5); 2 cases were lost to follow-up. The study was conducted on a sample of 92 patients. Data were collected from the clinical records of the patients.

The trauma energy was defined as high (traffic accidents, falls from heights) or low (domestic accidents, accidental injuries). In all cases, a preoperative CT scan was performed to define the degree of joint and metaphyseal involvement.

ORIF was performed in one stage (<48 h) when there was no edema or blisters; or in two stages, with use of EF or splint in the first stage on arrival to the emergency room, with ORIF delayed until the soft tissue state was adequate (the disappearance of edema and blisters). The choice of surgery in one stage or in two stages was made individually, depending on the soft tissue state of each patient.

All the fractures were classified according to the AO system reported by Muller.[15] Open fractures were classified according to Gustilo-Anderson classification.[16]We also recorded whether there was an associated fibular fracture.

We performed an anteromedial, anterolateral or percutaneous approach, depending on the type of fracture and the state of the skin. As for ORIF, we divided patient groups into those who had bone fixation with a single medial plate, a single anterolateral plate, two plates or cannulated screws. The model of the plates was in all cases the locking compression pale – less invasive stabilization system (LCP-LISS). Fibula was also fixed with LCP-LISS plates (six holes) by means of a direct lateral approach at the same time of external fixation. The goal was to maintain the length of the tibioperoneal complex and the normal rotation of the fibula. The length in days of conversion of external fixation to ORIF was 6.7 days on average (range, 2–21).

Quality of reduction was defined as optimal or suboptimal in terms of the existence of an articular step-off of <2 mm or >2 mm, respectively.[17] The size of step-off was measured in post-operative radiographs. The use of a bone graft in fractures with metaphyseal defect was also recorded. Bone graft was indicated when in the pre-operative radiographs we found a great lack of cancellous bone (lack of contact of cortical bone). Immobilization was performed postoperatively for 1–2 weeks for soft tissue protection and edema control. Partial weight bearing was allowed from the twelve week after ORIF.

To address potential sources of bias we defined all variables in a clear way. The study size was the number of patients treated (94) minus two that were lost to follow-up (92 overall).

We recorded complications affecting the soft tissues (necrosis of the skin, superficial or deep infection and the requirement for flap coverage due to failure of direct closure), and complications affecting the bone (nonunion and early posttraumatic AOA).

Early posttraumatic AOA was evaluated by means of a modification of the Kellgren-Lawrence scale (Table 1).[18]

Function was assessed according to the American Orthopedic Foot and Ankle Society (AOFAS) scale, although we know that this is heavily weighted in the scoring.[19] Therefore these injuries that cause significant stiffness really affect the overall score. We divided the results into excellent (>90 points), good (80–90 points), fair (70–80 points) and poor (<70 points) (Figs. 1 and 2). We assessed whether there was an association between the variables analyzed and the functional outcomes (AOFAS) and the complications encountered. Quantitative variables were handled by means of well-known scales (AOFAS, et cetera). Table 2 shows patient data of this study.

We carried out a statistical analysis of qualitative data (Chi-squared test, Fisher's exact test, Mann-Whitney *U* test and Student's *t*-test) and of quantitative data (ANOVA and Kruskal Wallis test). The variables for the study were analyzed with a Cox multivariable regression analysis. We used a value of $p < 0.05$ for statistically significant differences.

3. Results

A total of 92 fractures of the tibial pilon treated by ORIF in a 5-year period were analyzed. The mean follow-up was 3.3 years (range, 1–5 years).

Among the soft-tissue complications, we found 12 infections (13.04%) (4 superficial [4.34%] and 8 deep [8.69%]), 7 skin necroses (7.6%) and 12 flaps for skin coverage (13.04%) in 8 open and 4 closed fractures. Within these 12, there were 1 infected non-union, 1 injury of the posterior tibial artery and 2 patients with skin necrosis requiring closure by flap (this topic is the subject of another study).

Among the bone complications we found 10 nonunions (10.86%) (3 were infected non-unions [3.25%]) and 12 patients with early posttraumatic AOA (13.04%) (in 5 of whom [5.43%] ankle arthrodesis was performed later, with satisfactory results in terms of pain remission) (Fig. 2).

Other complications included 1 compartment syndrome, 2 complex regional syndromes, 1 sural nerve injury, 1 neuroapraxia of the deep peroneal nerve and 2 injuries of the posterior tibial artery (1 during the approach and 1 during the placement of the EF). No lower limb amputations were required in this series. Twenty-three hardware removals (HRs) (25%) were performed at an average of 1.2 years after ORIF. Implant removal was carried out because of pain. Table 3 shows the correlation or the lack of correlation among the variables studied.

3.1. Skin necrosis

We observed a statistically significant correlation between skin necrosis and the anteromedial approach ($p = 0.021$) (OR 4.2), which

Table 1
Modified Kellgren-Lawrence system of classifying the severity of posttraumatic ankle osteoarthritis (AOA) in nonweight-bearing ankle radiographs.

Grade 0-	no radiographic features of AOA are present
Grade 1-	doubtful joint space narrowing (JSN) and possible osteophytic lipping
Grade 2-	the presence of definite osteophytes and possible JSN on anteroposterior radiograph.
Grade 3-	multiple osteophytes, definite JSN, sclerosis, possible bony deformity
Grade 4-	large osteophytes, marked JSN, severe sclerosis and definitely bony deformity

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