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ORIGINAL STUDY

Complications after plating of articular pilon fractures : a comparison of anteromedial, anterolateral, and medial plating

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The complication rate following tibial pilon surgery continues to be high. Different plating designed has been developed to obtain stability and avoiding bulky implants. Our purpose is to determine differences in complications according to plate type. A retrospective case series of 102 fractures was divided into three groups. Group I : 3.5 mm LCP anterolateral distal tibia plate placed anteromedially(30 fractures), with 73.4% treated with an anteromedial approach and 26.6% with an anterior approach ; Group II :3.5 mm LCP anterolateral distal tibia plate (26 fractures), with 76.9% treated with an anterolateral approach and 23.1% with an anterior approach ; Group III : 3.5 mm LCP low bend medial distal tibia plate (46 fractures) with 100% treated with an anteromedial approach. Nonunion did not occur in group I patients (P=0.038), with statistically significant differences found regarding occurrence of nonunion and open fractures (P=0.022). A greater percentage of group II patients had osteoarthritis (P=0.006). Group I patients had fewer reoperations, though results were not significant. Tibial pilon fractures treated with an anterolateral plate in anteromedial position had a lower complication rate and risk of nonunion.

Keywords : Pilon fractures ; ORIF ; anteromedial plate ; complications.

INTRODUCTION

Open reduction and internal fixation surgery for tibial pilon fractures continues to be a considerable challenge for surgeons due to its complexity and poor soft tissue coverage, which also may be contused by the trauma, in the distal tibia. Soft tissue complications such as suture dehiscence or discomfort related to the prominence of the material are less severe but frequent. Others, such as infection or skin necrosis, may be very severe, leading to surgical failure, arthrodesis, or even amputation. For these reasons, nearly all authors recommend postponing surgery until the condition of the soft tissue improves in addition to meticulous surgical technique in order to guarantee the greatest surgical success.

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The size and shape of the implants have a significant influence on the initial results of surgical treatment of tibial pilon fractures. For example, taking into account their fourth principle (prevent varus deviation in the internal support), Rüedi and Allgower *(19)* used thick, 4.5 mm tibial plates which, just as the 4.5 mm flat buttress plates, frequently caused complications due to implant prominence, dehiscence, and skin necrosis, especially in high-energy fractures. The advent of smaller implants, such as cloverleaf plates, was a great advance in the use of thinner, flat implants with 3.5 mm screws. However, some authors considered them to be weak and unable to prevent varus collapse *(26)* and yet still bulky and able to cause soft tissue problems *(22)*. In regards to the surgery itself, Tornetta et al. advocated for directing the operative approach towards the principal fracture lines and the presence of impaction of articular fragments *(28)*. As a result, dual plating with a dual approach technique is preferentially used as standard treatment for complex articular fractures[22]. This procedure implies greater surgical aggression and more osteosynthesis material (OM), thus increasing possible soft tissue problems.

According to classic works in the literature, following the generalization of surgical treatment of the tibial pilon in the 70's and 80's, major complications occurred in 10% to 55% of patients *(9,19,23,25,31)*. This led to changes in the form and content of surgical treatment. Nevertheless, some current works continue to report similar percentages of major complications, rates which have not decreased significantly in recent years *(2,21)*. To prevent complications, both implants and approaches have changed in recent decades. One example is the anterolateral plate with locking screws, which was developed for the purpose of leaving the plate covered under the lateral musculature and preventing problems with scarce internal skin cover. There are works in the literature which relate different methods of approach *(13,8)* [13,8] and definitive treatment type *(1)* to possible soft tissue complications. However, few works analyze complications related to different plates.

Despite the fact that plates with locking screws lend greater stability to the fracture, many authors have questioned whether the distribution of screws in the plates that are currently on the market manages to stabilize fragments correctly. Therefore, the use of double plating is still recommended *(17)*. To avoid double plating and the use of plates directly in the medial position and so as to achieve a better distribution of screws in the tibial pilon, one study on cadavers and another preliminary clinical study were performed on the use of an anatomical anterolateral locking compression distal tibia plate (anterolateral LCP, DePuy-Synthes USA©) on the contralateral side. It was placed in the anteromedial position in fracture patterns that mainly had articular fragments in the coronal plane (Fig. 1). Very good results were achieved.

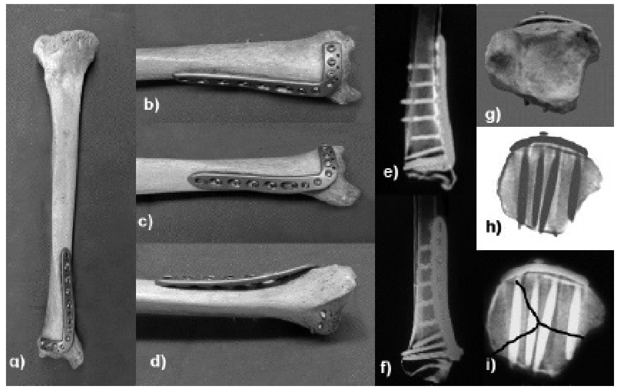

Fig. 1. — Adaptation of the 5 screw LCP plate and screw distribution on the tibia, a) Image of a complete cadaver tibia where we can appreciate that the plate fits well on the medial slope of the tibia for longer plates, b) and c) several planes and d) detail of the plate adaptation in the distal zone with a slight overhang of the plate in the metaphyseal zone. e) and f) Three dimensional distribution of the screws, note that the locked screws (5 and 6) at the beginning of the vertical line are directed to the postero-lateral angle of the pilon. g) Axial vision of the tibia, h) CT scan view of the screw distribution in the epiphysis with a lag screw. i) Screw distribution in the epiphysis according to the most frequent pattern of the fracture lines.

The aim of this work is to evaluate if there are differences in complications with the use of three different types of plates when performing ORIF on tibial pilon fractures. This work will compare a group of patients treated with the aforementioned technique, a group of patients with plates in the anterolateral position, and a retrospective group of ORIF cases with plates in the medial position. Possible predictive fractures related to the occurrence of complications in the three groups will also be analyzed.

MATERIALS AND METHODS

A retrospective cohort study was conducted which included patients who underwent surgery for tibial pilon fractures between January 2002 and December 2017 at our tertiary referral hospital who met the following inclusion criteria : skeletally mature patients with articular fractures of the tibial pilon who underwent ORIF surgery with a plate and who had a minimum follow-up period of 12 months. Patients with open growth plates, type A or extra-articular fractures according to the AO-Müller classification, or grade III open fractures according to the Gustilo-Anderson classification were excluded.

This study analyzes an ORIF case series divided into three different groups : group I included fractures treated with a 3.5 mm LCP anterolateral distal tibia plate (DePuy-Synthes USA©) on the contralateral side in the anteromedial position (Fig. 2) ; group II included fractures which were treated with a 3.5 mm LCP anterolateral distal tibia plate (DePuy-Synthes USA©) on the anterolateral position as per the surgeon's choice (Fig. 3) ; and group III included a retrospective case series of patients with a 3.5 mm LCP low bend medial plate (DePuy-Synthes USA©) (Fig. 4).

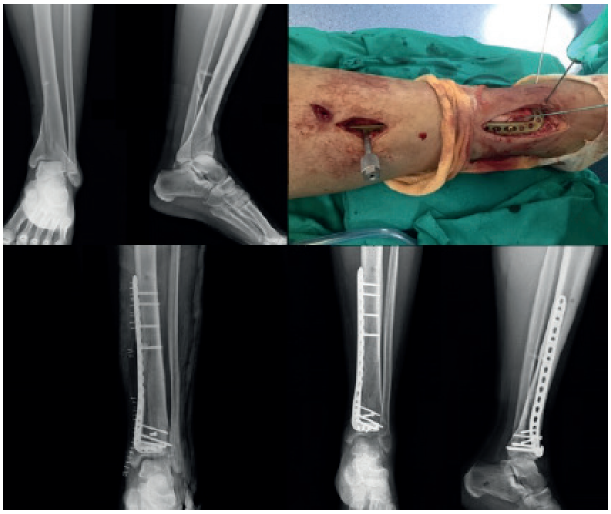

Fig. 2. — Anteromedial plate and MIPPO approach (Group I).

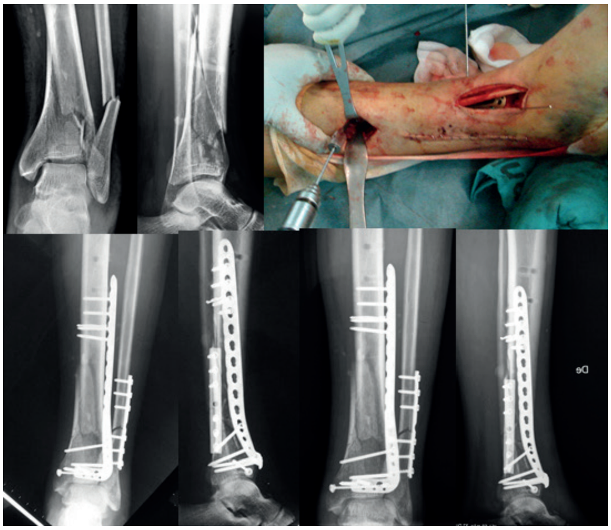

Fig. 3. — Anterolateral plate and MIPPO approach (Group II).

Fig. 4. — Medial Plate (Group III)

General sociodemographic data and specific data related to the treatment received were collected from all patients and analyzed. These data included sex, age, presence of immunosuppression (due to presenting with diabetes (DM), HIV, alcohol use disorder, or drug addiction), whether the patient smokes or not, energy of the trauma : high energy (falls and traffic accidents) and low energy (twisted ankle, low energy sports accidents, falls from low heights, and accidents in the home), type of fracture according to the AO-Müller classification, open fracture grade according to the Gustilo-Anderson classification, and presence of a fibula fracture.

Initial treatment of the fracture was performed according to the condition of the soft tissues, stabilizing the fracture using a splint, a provisional external fixator, and with or without ORIF of the fibula. Open fractures were treated in the Emergency Department with a 2 g bolus of cefazolin IV and 240 mg of gentamicin IV, early debridement, and abundant washing with sterile saline solution. The time between the injury, initial treatment, and definitive surgery was measured in days.

The case series with the plate placed in the anteromedial position was compared with the anterolateral plate case series and the medial plate retrospective case series. Placement of an autologous bone graft in order to fill in subchondral or metaphyseal defects was performed according to the surgeon's decision. MIPPO technique where used when the fractures lines affected the metaphyso-diaphyseal tibia, using an indirect or percutaneous reduction and creating a virtual tunnel by osteotome. The medial plate and anteromedial plate were displaced subcutaneously in the anteromedial face of the tibia. In the anterolateral approach the anterolateral plate was displaced in the sub-muscular lateral plane. In the anterior approach the anteromedial plated crossed under the tibial anterior tendon to be placed in the medial side of the tibia. The anteromedial approach is located medial to extensor retinaculum and lateral to the saphenous vein and nerve. The anterolateral approach is located lateral to extensor digitorus longus tendon on the axis of the fourth metatarsal bone. In this approach it is important to protect the superficial peroneal nerve (Fig. 5). The anterior approach is located lateral to extensor halluces longus, midway between maleolis, sliding the anteromedial plate under the tibial anterior muscle. The selected approach depended of the principal fracture line in CT studies. The fibula was fixated in all fractures, whether initially or in the definitive ORIF. All surgeries were performed by senior surgeons. All patients were administered 2 g of cefazolin IV one hour before the surgery. All patients received low molecular weight heparin as antithrombotic prophylaxis during the first four weeks following surgery. The post-operative protocol consisted of immobilization with a long leg splint at 90º dorsal flexion for two weeks and delaying full loading until 8-12 weeks following surgery, according to signs of complete consolidation.

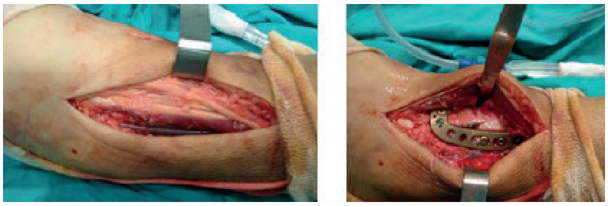

Fig. 5. — Anterolateral plate and peroneal superficial nerve in the anterolateral approach.

Post-surgical complications such as surgical wound infection, secondary displacement, material failure, nonunion, development of osteoarthrosis, and lastly, discomfort related to OM were collected and analyzed. Data on suture dehiscence and delays in wound healing were not collected as they were not sufficiently described in the medial plate retrospective case series and did not have any final consequences. Data on therapeutic measures carried out in order to treat the described complications, including the need for reoperation, were collected. Progression of osteoarthrosis was described as the occurrence of osteoarthrosis that was at least grade III on the Kellgren-Lawrence classification *(14)*. This work was performed pursuant to the ethical principles of the Declaration of Helsinki of 1964, revised in 2000 and it was approved for Institutional review board. All patients signed an informed consent form.

Preliminary cadaveric study

To describe the adaptation and distribution of the screw of the anteroexternal LCP plate (DePuy-Synthes USA©) (right) in a forearm position in the distal tibia 5 Dry left tibiae, without any previous injury or visible deformity, coming from the museum from the Department of Anatomy of the Faculty of Medicine, a CT scan was performed computerized with 3D reconstruction. The distribution of contact between the bone and the plate always followed the same pattern ; the biggest bone-plate contact surface occurred distally on the anterior aspect of the distal tibia as well as in the proximal diaphyseal zone, the zone of least contact was the zone intermediate, immediately superior to the horizontal branch of the plate where the plate It remained a little high. We located a distribution of the 4 screws in the branch horizontal that is fixed from anterior to posterior with some obliqueness in the distal joint peroneo-tibial, in the upper plane the fifth and sixth screws would cross obliquely from the inner side to the post-outer aspect (Volkman Fragment), finally the screws of the vertical zone or line would be on the antero-internal tibial face posterior to the tibial crest (Fig 1). We also measure the means of the shortest distance from the plate to the tip of the malleolus that was 2.74 cm (1.6 to 2.8 cm) and to the lateral side of the tibia was 1.5 cm (0.9 to 2.21 cm).

Statistical analysis

Absolute and relative frequency were calculated for each qualitative variable. In regards to quantitative variables, the mean, mode, and standard deviation were calculated and compared by means

Table 1. — Results by groups

	N = 102	Group I AM (N=30) (29,4%)	Group II AL (N=26) (25,6%)	Group III M (N=46) (45,1%)
Sex				
● Male	79 (77,5%)	22 (73,3%)	21 (80,8%)	36 (78,3%)
● Female	23 (22,5%)	8 (26,7%)	5 (19,2%)	10 (21,7%)
Age	42,45 ± 14,17 (16-80)	44,7 ± 16,3 (17-72)	44,46 ± 12,2 (21-69)	40 ± 13,7 (16-80)
Immunosuppression	15 (14,7%)	6 (20%)	3 (11,5%)	6 (13,4%)
smoker	11 (10,8%)	3 (9,9%)	2 (7.6%)	6 (13%)
Energy of trauma				
● High	64 (63,4%)	19 (63,3%)	16 (61,5%)	30 (65,2%)
● Low	38 (36,6%)	11 (36,7%)	10 (38,5%)	16 (34,8%)
AO Classification type B	45 (44%)	9 (30%)	14 (53,1%)	22 (47,9%)
AO Classification type C	57 (56%)	21 (70%)	12 (46,9%)	24 (52,1%)
AO Classification				
● B1	14 (13,7%)	1 (3,3%)	4 (15,4%)	9 (19,6%)
● B2	23 (22,5%)	6 (20%)	8 (30,8%)	9 (19,6%)
● B3	8 (7,8%)	2 (6,7%)	2 (7,7%)	4 (8,7%)
● C1	14 (13,7%)	7 (23,3%)	3 (11,5%)	4 (8,7%)
● C2	9 (9,5%)	3 (10%)	3 (11,5%)	3 (6,5%)
● C3	34 (33%)	11 (36,7%)	6 (23,1%)	17 (37%)
Gustilo Open Fracture				
● Grade I	6 (5,8%)	1 (3,3%)	2 (7,7%)	3 (6,5%)
● Grade II	3 (3,1%)	0 (0%)	2 (7,7%)	1 (2,2%)
Fibula Fracture	47 (47%)	16 (53,3%)	12 (46,2%)	19 (41,3%)
Initial Treatment				
● Splint	49 (48%)	2 (40%)	13 (50%)	24 (52,2%)
● External Fixation	38 (37,25%)	13 (43,3%)	8 (30,8%)	17 (37%)
● External Fixation + ORIF fibula	15 (14,7%)	5 (16,6%)	5 (19,2%)	5 (10,9%)
Time to definitive surgery	10,17 (0-29 ± 6,3)	12,17 ± 4,7 (7-25)	11,2 ± 7,4 (1-29)	8,34 ± 5,9 (1-24)
Anteromedial approach	68 (66,6%)	22 (73,4%)	0 (0%)	46 (100%)
Anterolateral approach	20 (19,6%)	0 (0%)	20 (76,9%)	0 (0%)
Anterior approach	14 (13,7%)	8 (26,6%)	6 (23,1%)	0 (0%)
Radiological follow-up	55,4 ± 50,6 (12-108)	18,81 ± 9,7 (12-53)	50,57 ± 41,7 (12-108)	56,6 ± 16 (12-96)

AM = Anteromedial, AL = Anterolateral, M= Medial, Age = Years, Time beetwen injury and definitive surgery = Days, Radiological follow-up = months.

of the Chi-squared test, Student's t-test, or Mann-Whitney U test, according to whether they met the Kolmogorov-Smirnov normality criteria. A multivariate regression analysis was performed and the odds ratio was calculated for notable significant results. Statistical significance was considered to be a bilateral value of P<0.05. All data were analyzed using the SPSS v23.0 (SPSS Inc., Chicago, IL, USA) statistical program.

RESULTS

After analyzing the results, out of a total of 112 patients, ten were excluded for meeting the aforementioned exclusion criteria (two in group I, three in group II, and five in group III). A total of 102 patients met the inclusion criteria. Demographic results for all participants and by groups are summarized in table 1.

Sample homogeneity was compared in the three groups. Similar relative frequencies were found in regards to sex, personal medical history, energy of the trauma, number of open fractures, and initial treatment. Similar mean values among the groups were found in regards to age, days from the injury until surgery, and whether an autologous bone graft was added or not. There were variations in the proportion of type C fractures. Group I had 70% of this type (21/30), group II had 46.9% (12/26), and group III had 52.1% (24/46) (Fig. 6). Another variation among the three groups was mean time of radiological follow-up, which was 55.4 ± 50.6 (12-108) months overall. Group I had the shortest radiological follow-up time, 18.81 ± 9.7 (12-53) months, group II had a radiological follow-up time of 50.57 ± 41.7 (12-108) months, and group III had a radiological follow-up time of 56.6 ± 16 (12-96) months.

A total of 12.3% of patients (13/102) developed an infection. In group I, 6.6% of patients (2/30) ; in both cases were skin fistulas. One of those patients was treated with surgical debridement, removal of OM, and antibiotic treatment. The other patient rejected treatment because it was an intermittent fistula. In group II, 11.5% of patients (3/26) developed infection. One was treated with antibiotic treatment alone ; one with surgical debridement along with IV antibiotic treatment ; and one with surgical debridement, removal of OM, and antibiotic treatment. In group III, 15.2% of patients (7/46) developed infection. Five were treated with surgical debridement along with antibiotic treatment. Two of the infections (4.3%) were cases of skin necrosis with extensive exposure of the osteosynthesis material. They were treated with surgical debridement and removal of the OM as well as stabilization via external fixators along with antibiotic treatment to resolve the infection. In one patient bone and articular resection was done due to osteomyelitis, and was treated with an ankle arthrodesis following bone transport that was performed once the infection was resolved. Although no statistically significant differences were found between the type of plate used and incidence of surgical wound infection (P=0.925), greater clinical severity was noted in group III patients' infections. Additionally, there were no statistically significant differences between the approach used and the appearance of surgical wound infection (P=0.886).

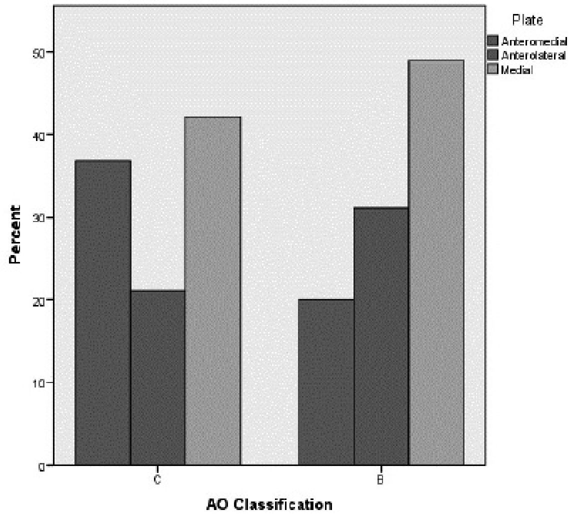

Fig. 6. — Percent of C-Type and B-Type fractures in the anteromedial,anterolateral and medial plates.

There was nonunion of the pilon fracture in 8.8% of cases (9/102). No fractures in group I had nonunion whereas 11.5% of fractures in group II (3/26) and 13% of fractures in group III (6/46) did have nonunion. In group II, there were two OM

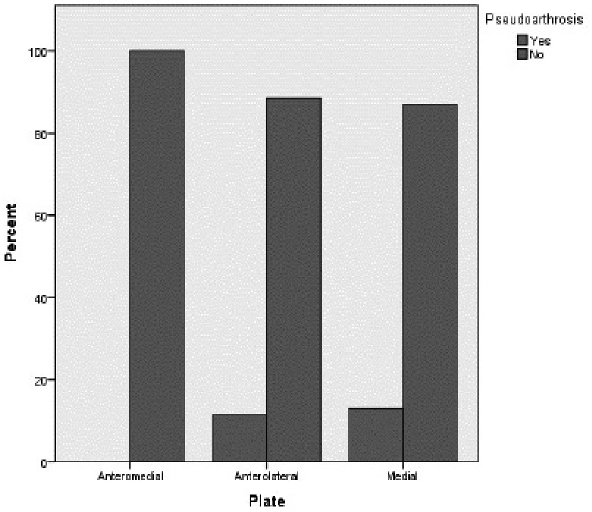

Fig. 7. — Relationship beetween pseudoarthrosis and type of plate.

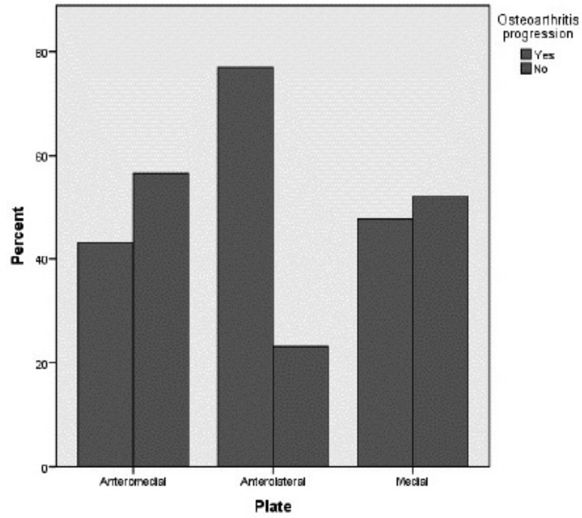

Fig. 8. — Relationship beetween osteoarthritis progression and type of plate.

failures : one early case of plate breakage (3.8%) at three months after definitive surgery (not counted as nonunion as it was before six months had passed since the fracture) and another later failure (1/3), which was classified as nonunion, in which the plate had varus bending with breakage of the fibula plate. This case was treated by exchanging the anterolateral plate for another, additional stabilization with a medial plate, and an autologous bone graft. Another nonunion (1/3) was treated with a bone graft and stabilization with an additional medial plate. The last case of nonunion in this group (1/3) was treated by removing the anterolateral plate, performing a bone graft, and stabilizing it again with a longer anterolateral plate. In group III, there was mechanical failure of the plate in 16.6% of nonunion cases (1/6). It was treated with ankle arthrodesis due to the comminution of the fracture. Another case of nonunion was treated with an autologous bone graft. The remaining four nonunion cases were treated by removing the medial plate, performing a bone graft, and stabilizing the fracture again with a medial plate. Statistically significant differences were found when comparing the number of nonunion cases in group I with those in group II and group III combined (P=0.038) (Fig. 7).

In 53.9% of patients (55/102), there was radiological progression of osteoarthrosis. Progression occurred in 43.3% of patients in group I (13/30), 76.9% of patients in group II (20/26), and 47.8% of patients in group III (22/46). We found statistically significant differences in regards to radiological progression of the osteoarthrosis and the type of plate used (P=0.023), with a higher incidence of radiological progression of osteoarthrosis found in group II (76.9%) compared to group I (43.3%) and group III (47.8%) (P=0.006) (Fig. 8).

A total of 5.9% of patients (6/102) received ankle arthrodesis as treatment for advanced osteoarthrosis : 3.3% of patients in group I (1/30), 7.7% of patients in group II (2/26), and 6.5% of patients in group III (3/46). Although there was more osteoarthrotic progression in group II and it was statistically significant, we did not find statistically significant differences between the type of plate used and the number of ankle arthrodeses performed (P=0.763).

A total of 17.6% of patients (18/102) reported discomfort due to OM. Removal of OM was performed in 94.4% of these cases (17/18). In group I, 16.7% of patients (5/30) reported discomfort due to OM and it was removed in 13.3% of patients in this group (4/30). In group II, 15.4% of patients had discomfort (4/26) and OM was removed in all these cases. In group III, 19.6% of patients (9/46) reported discomfort due to OM and it was removed in all these cases. No statistically significant differences were found between the type of plate used and discomfort due to OM (P=0.892).

Other complications

One 72-year-old patient in group I (3.3%) with a homolateral calcaneal fracture had another fall that caused a grade II open peri-implant fracture in the proximal part of the plate. It was treated with definitive external fixation with removal of the OM. The previous fracture had already consolidated. One patient in group I (3.3%) had an infection following ORIF of the fibula, later developing a fistula and osteomyelitis. It was necessary to remove the OM – a fibula plate – and resect the affected fragment without removing the tibial plate. One of the patients in group II developed neuropathic pain in the anterior face of the ankle (3.8%), which was treated medically. Another patient in this group (3.8%) did not achieve optimal surgical reduction and needed another surgery to resolve this complication.

A total of 43.1% of patients (44/102) were re-operated on due to any of the aforementioned causes. In group I, 26.6% of patients were reoperated on (8/30). Both in group II (13/26) and in group III (23/46), 50% of patients were reoperated on. Although we did not find statistically significant differences between the number of reoperations and the type of plate used (P=0.337), the lower percentage of reoperations in group I patients was clinically relevant.

Results on complications are summarized in table 2.

Statistically significant differences were not found between the patient's age when the tibial pilon fracture occurred and surgical wound infection (P=0.087). Statistically significant differences were also not found from when the injury occurred to

Table 2. — Complications by groups. Group I Anteromedial Plate. Group II Anterolateral Plate. Group III Medial plate.

Complications	**N =102**	**Group I (N=30) (29,4%)**	**Group II (N=26) (25,6%)**	**Group III (N=46) (45,1%)**
Septic complications	13 (12,3%)	**2 (6.6%)**	3 (11,5%)	7 (15,2%)
Material failure and nonunion	9 (8,8%)	0 (0%)	**3 (11,5%)** **1 broken plate**	6 (13%) **(1 Faillure)**
Progression of Osteoarthrosis ● **Ankle Arthrodesis**	55 (53,9%) 6 (5,9%)	13 (43,3%) 1 (3,3%)	20 (76,9%) 2 (7,7%)	22 (47,8%) 3 (6,5%)
Disconfort Osteosintesis Material ● Remove osteosintesis Material	18 (17,6%) 17 (16,6%)	5 (16,7%) 4 (13,3%)	4 (15,4%) 4 (15,4%)	9 (19,6%) 9 (19,6%)
Other complications	3 (2,94%)	**2 (6,6%)**	2 (7,69%)	0 (0%)
Reoperations	43 (42,15%)	8 (26,6%)	12 (46,15%)	23 (50%)

Table 3. — Correlation between study variables

	Séptic complications	Nonunion	Progression of Osteoarthrosis	Disconfort Osteosintesis Material	Reoperations
Age	NS	NS	NS	NS	NS
Energy (High/Low)	NS	NS	NS	NS	NS
C-Type (AO classification)	NS	NS	NS	NS	NS
Type fracture (Open/close)	NS	**0.022**	NS	NS	NS
Fibula Fracture	NS	NS	NS	NS	NS
Time beetwen injury and definitive surgery	NS	NS	**0,005**	NS	NS
Approach (anteromedial/anterolateral/anterior)	NS	NS	NS	NS	NS
Anteromedial Plate	NS	**0,038.**	NS	NS	NS
Anterolateral Plate	NS	NS	**0,006**	NS	NS
Medial Plate	NS	NS	NS	NS	NS

when definitive surgery was performed and the occurrence of surgical wound infection (P=0.139). On the other hand, we found statistically significant differences (P=0.022) in instances of nonunion and open fractures, with nonunion occurring in 33.3% of open fractures (3/9) (Fig. 5). Despite being described in the literature, statistically significant differences were not found in regards to the aforementioned complications and the energy of the trauma (P=0.430) or the type of fracture according to AO classification (P=0.801).

The correlation between study variables can be observed in table 3.

DISCUSSION

The best articular reduction quality is achieved with ORIF surgical treatment of tibial pilon fractures *(6)*. However, in the most recent works, rates of complications and infections continue to be relatively high *(4,29)*, despite advances in understanding the importance of soft tissue healing and in implant technology (with the advantages of low-profile locking plates). It has been demonstrated that the type and number of implants and their placement in the tibial pilon play a decisive role in treatment and incidence of complications in these fractures *(15)*.

In regards to the cause of complications, published works report contradictory results : some defend the idea that the emergence of complications depends more on the mechanism of injury and the energy of the trauma whereas others believe the type of approach or plate used have more influence. In a comparative study, Encinas-Ullán C.A. et al. *(10)* prospectively studied 40 patients treated with open reduction and internal fixation with medial versus lateral places. They found a soft tissue complication rate of 12.5%, with no statistical differences found between the two approaches with regards to consolidation time, delayed consolidation rate, or infection rate. The authors concluded that complications are more related to the severity of the injury itself. Likewise, Chen et al. *(3)* reported a wound complication rate of 8% when using a medial or lateral approach. Unlike these studies, in our series, we found no statistically significant differences between the mechanism of injury (P=0.430) or the type of fracture according to the AO classification (P=0.801) and the overall number of complications. Therefore, we cannot consider these variables to be predictors of the emergence of these complications, perhaps because other factors can influence their occurrence.

Other works *(1,18)* highlight the importance of the type of approach in the emergence of complications. In a review of 137 fractures (33 open), Rubio-Suárez JC et al. *(18)* found 12 infections (8.7%), 21 cases of skin necrosis (15.2%), 22 nonunions (16.03%) (four aseptic and 18 septic), and 16 patients with post-traumatic AOA (13.01%) (five ankle arthrodeses). They found a greater number of soft tissue complications as well as progression of osteoarthrosis with the anteromedial approach versus the lateral approach. In our work, 12.3% of patients (13/102) developed a deep infection. Although statistically significant differences were not found between the three groups, the medial approach along with the medial plate (group III) had the highest percentage of infection of the three groups (15.2%) in addition to two cases of skin necrosis with exposure of OM (4.3%). We did not find any cases of skin necrosis with the anteromedial plate, possibly because it does not go on the medial malleolus and therefore the distal part is placed like an anterior plate.

Logically, the medial plate should be more problematic in regards to soft tissues, but it entails a biomechanical advantage as it bears varus loads. Despite this, various articles have reported a greater number of cases of nonunion. Deivaraju et al. *(7)* used either a medial plate or anterolateral plate and had similar results in terms of quality of reduction and soft tissue complications. However, they found a greater prevalence of infection and nonunion with medial plates. Greater severity of complications in the use of a medial plate and approach was also described by Carbonell et al[2], who found statistically significant differences in regards to occurrence of nonunion when using a medial plate and incidence of skin necrosis when performing an anterolateral approach. Penny et al. *(17)* recently published their finding that anterolateral plates are superior for stabilization of the fracture line in the coronal plane through the anterior area of the tibial pilon and for providing support to the area of comminution. What's more, Collinge et al. *(5)* published a finding of secondary displacement in 7% of cases with locking plates that supposedly provide good axial stability. In our work, we had more complications than expected in group II. They included 11.5% of patients with nonunion and two plate failures (7.69%) : one early failure, breakage of the implant, and another late failure, bending of the plate, with varus displacement of the two plates in the latter case, possibly due to lack of medial support. The case of medial plate failure (2.1%) occurred because of the inability of the locking screw to secure anterior and lateral comminution from the medial side. In our results, we did not have any material failure or nonunion in group I, a statistically significant difference (P=0.038) with respect to groups II and III combined (11.5% and 13%, respectively). One possible explanation could be that the plate is placed on the anterior apex as anterior support, medially stabilizing the fracture without a need for a second plate. Additionally, we found a statistically significant difference (P=0.022) between the occurrence of nonunion (present in groups II and III) and an open fracture.

In contrast to the work by Rubio-Suarez et al. *(18)*, which found that the anteromedial approach and medial plate had a higher rate of post-traumatic osteoarthrosis, we found greater progression of osteoarthrosis in patients in group II with respect to those in group I and III ; this difference was statistically significant (P=0.006). Therefore, our results seem to suggest that fractures on the antero-lateral margin are arthrogenic, despite being the group which had the lowest percentage of type C fractures (46.9% compared to 70% in group I and 52.1% in group III). Nevertheless, to date, this degree of osteoarthrosis has not translated into a greater number of arthrodeses with respect to other groups, given that we did not find statistically significant differences between the type of plate used and the percentage of ankle arthrodesis as treatment for the sequelae of advanced post-traumatic osteoarthrosis (P=0.763).

Despite not finding statistically significant differences in regards to the type of plate and the number of reoperations (P=0.337), our findings were clinically relevant, given that patients in group I had the lowest overall number of complications and reoperations.

Although there are a multitude of works in the literature *(3,9,27)* that suggest the need for two-step treatment in order to minimize the risk of soft tissue complications, other authors, such as White TO et al. *(30)*, suggest the possibility of one-step ORIF for tibial pilon fractures, including for high-energy mechanisms. They found a complication rate similar to that of two-step fracture treatment. Lomax A et al. *(16)* found similar results in selected patients who underwent early surgery (within the first 48 hours following the trauma) and in patients who underwent two-step treatment surgery. Tang X et al. *(24)* compared patients who had early surgery (<36 hours following the injury) with patients who underwent surgery later (1-2 weeks following the injury). They found similar results in terms of the occurrence of complications in the two groups provided that the soft tissue was in good condition for performing early surgery. Furthermore, there is no consensus on the exact amount of time it is necessary to wait in order to perform the definitive surgery. Tomás-Hernández, J[27] defends the idea of waiting until the initial healing of soft tissues takes place, though the number of days to wait before performing the definitive surgery is not indicated. Liporace FA et al. *(15)* recommend delaying definitive surgery for up to 14 days from the initial injury in order to minimize complications. In our series, we did not observe statistically significant differences between delaying surgery and the occurrence of surgical wound infection (P=0.139). Therefore, we can suggest that this complication arises independently of the time between the injury and definitive surgery.

Lastly, few authors directly relate age and the occurrence of complications, but many do relate the occurrence of complications to patients' comorbidities. These include anesthesia risk >2, according to the American Society of Anesthesiologists (ASA) ; being older than 60 years of age ; chronic lung disease ; neuropathies ; uncooperative patients ; heavy smokers ; patients with a body mass index greater than 40 ; and medications that compromise wounds, such as corticosteroids *(12)*. In our study, we found a greater risk of surgical wound infection in patients over 42 years of age – a younger age than expected – independently of the type of plate used and the mechanism of injury. However, these results were not statistically significant if we take into account an error of $\alpha=0.05$ (P=0.087). This finding is probably due to worse soft tissue quality in patients who are older than that age.

The limitations of our work include those that are inherent to retrospective designs –including the fact that follow-up on the wound for patients in group III was not able to be collected – together with the small sample size, the slight heterogeneity of the groups, differences in follow-up, differences in technique among surgeons, etc.

In conclusion, the overall presence of complications was not able to be correlated with the mechanism of injury, surely due to the involvement of other factors in the emergence of complications. We can suggest that tibial pilon fractures treated with an anterolateral plate in the anteromedial position have a lower percentage of complications compared to fractures treated with anterolateral and medial plates, though this result was not statistically significant, and that they have a decreased risk of nonunion. The most severe soft tissue complication in the two cases of infection in group III was the full-depth skin necrosis with exposure whereas in group I, the two infections manifested as fistulas. Additionally, placing anterolateral plates without medial support must be avoided in type C fractures due to the risk of material failure or nonunion. According to what is observed in our results, it seems that an anterolateral margin fracture is arthrogenic. Lastly, age is another factor to take into account in the occurrence of soft tissue complications, with an increased risk of complications when the patient is older than 42 years of age.

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