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New minimally invasive view of tibial pilon fractures: Experience of the A4 orthopaedic traumatology department at CHU Ibn Rochd in Casablanca

Y. EL QADIRI *, O. EL ADAOUI, Y. SBIHI, Y. EL ANDALOUSSI, AR. HADDOUN, D. BENNOUNA and M. FADILI.

Department of Orthopaedic Traumatology Wing 4 CHU Ibn Rochd Casablanca Morocco.

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Abstract

Tibial pilon fractures are rare and serious fractures, given their complexity and therapeutic difficulty. Closed-focus osteosynthesis is an interesting alternative for treating these fractures. In order to assess the clinical and radiological results of treating tibial pilon fractures with closed-focus osteosynthesis, we conducted a retrospective descriptive study of a series of 80 tibial pilon fractures treated at the Traumatology-Orthopedics Department A4 of CHU Ibn Rochd in Casablanca, over a period from January 2017 to December 2022. The mean age in our study was 42.5 years, with a M/F sex ratio equal to 3. Etiological circumstances were dominated by high-energy mechanisms, including falls from a high place in 43% and MVAs in 42% of cases. Clinical diagnosis was guided in 100% of cases by functional impotence, pain and localized swelling. We performed an ankle radiograph in front and side views, complemented by a CT scan, in all our patients to confirm the diagnosis and classify the different fracture types. Surgical treatment with closed-focus osteosynthesis was performed by combined treatment in 50% of cases; external fixator in 20% of cases; and minimally invasive treatment under arthroscopy in 30% of cases. According to CAFFINIERE criteria, functional and radiological results were good and satisfactory in 80.57% of cases, and poor in 19.43%. Complications included algodystrophy in 28.75% of cases, infection in 10%, joint stiffness in 13.75%, pseudarthrosis in 11.25%, arthrosis in 11.25% and callus in 7.5%. Finally, analysis of our results showed that the majority of our patients treated with closed-focus osteosynthesis had good functional, clinical and radiological results, demonstrating the effectiveness of this surgical method in tibial pilon fractures.

Keywords: Tibial Pilon Fracture; Minimally invasive; Surgical treatment; Closed focus osteosynthesis; Arthroscopy

1. Introduction

Tibial pilon fractures are metaphyseal-epiphyseal articular fractures, affecting the load-bearing surface of the tibiofibular mortise ceiling, with a high potential for sagittal instability [1].

These fractures are rare, accounting for 3 to 10% of all tibial fractures, and are serious in view of their complexity and therapeutic difficulties [2].

Their treatment is not unequivocal, and must take into account not only the bony aspect requiring initial stabilization, but also the soft-tissue environment, a source of frequent cutaneous or infectious complications [3].

In order to avoid arthrosis, which is often poorly tolerated and has a significant socio-professional impact, the only therapeutic option is an open approach that reconstitutes a congruent joint surface, the only guarantee of improved functional recovery.

* Corresponding author: Y. ELQADIRI

Nevertheless, iatrogenic complications must temper this attitude, imposing great caution made necessary by the initial soft tissue lesions due to precarious vascularization [4].

The therapeutic choice of external fixation and the advent of percutaneous internal fixators have offered surgeons a good alternative for treating these serious injuries [5].

The aim of our work is to present the various epidemiological, clinical and paraclinical characteristics of our patients, and in particular to highlight the following points:

- Evaluate the clinical and radiological results of closed-focus osteosynthesis treatment of tibial pilon fractures as an attractive alternative.
- Compare the data obtained with the literature, through a retrospective study of 40 cases.

2. Material and methods

This is a retrospective descriptive study of 80 cases of tibial pilon fractures, treated by closed-focus osteosynthesis in the Traumatology-Orthopedics Department A4 of the Ibn Rochd University Hospital in Casablanca. All cases were collected over a 6-year period, from January 01, 2017 to December 31, 2022. Inclusion criteria: age greater than or equal to 18 years, tibial pilon fractures treated by closed-focus osteosynthesis.

3. Results

The mean age in our study was 39.3 years, with extremes ranging from 18 to 73 years. Peak frequency was between the ages of 23 and 39. We therefore found that tibial pilon fractures generally affect young adults.

There was a clear male predominance, with 63 men (78.75% of cases) and 17 women (21.25% of cases), with a sex ratio of 3.

Left-sided involvement was predominant in 49 cases (61.25%), and right-sided involvement in 31 cases (38.75%).

In our series, 39 patients, i.e. 48.75% of cases, had no particular pathological history, whereas 41 patients, i.e. 51.25% of cases, had associated defects, the most frequent of which were: toxic habits: 21 cases (26.25%), diabetes: 9 cases (11.25%), hypertension: 6 cases (7.5%). Surgical history: 9 cases (11.25%).

The primary etiology of tibial pilon fractures in our series was falls, noted in 35 patients, i.e. 43.75% of cases, with 20 cases of fall from a high place (57.14%), and 9 cases of fall due to carelessness (25.71%). MVA was the second most common etiology in 33 patients (41.25%). Aggression was found in 12 patients, or 15% of cases.

It was difficult to pinpoint the mechanism of these fractures. In most cases, they followed a fall from a high place or an MVA, so the mechanisms were combined and complex.

Clinical examination showed total functional impotence on the affected side, with permanent and intense ankle pain, edema and ankle deformity in all patients (100% of cases).

9 patients (11.25%) had abrasions, 23 patients (28.75%) had bruises, 22 patients (27.5%) had phlyctenes, we found 13 open tibial pilon fractures (16.25%), including 9 type I and 4 type II according to the Cauchoix Duparc classification, and 23 patients (28.75%) had grade I skin contusions according to Tscherne and Gotzen. There were no cases of associated vascular or neural lesions.

In our study, there were 9 cases of polytrauma (11.25%), with 5 cases of head trauma (6.25%), 3 cases of spinal fracture (3.75%) and 2 cases of pelvic fracture (2.5%). and 40 cases of polyfracture (100% of cases), with 8 cases of fracture of the upper limb (10%), 4 cases of fracture of the lower end of the femur and 72 cases (90%) of homolateral ankle fractures, including 54 cases (67.5%) of fracture of the lateral malleolus and 18 cases (22.5%) of fracture of the medial malleolus.

A total of 80 patients (100%) underwent radiological assessment, with X-rays of the ankle in front and in profile, to establish the diagnosis and classify the fractures.

Figure 1 Ankle X-ray, app and profile, showing tibial pilon fracture type A2 according to AO

80 patients (100%) underwent a CT scan with three-dimensional reconstruction to support the diagnosis and search for osteochondral lesions of the talus dome (LODA).

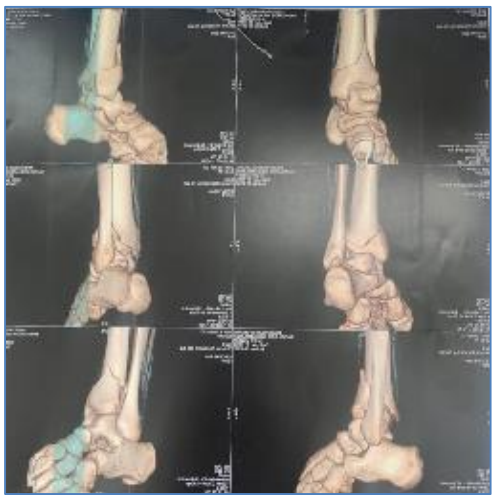

Figure 2 3D CT scan showing AO tibial pilon fracture tibial pilon type A2 according to AO

Some conditions require immediate treatment to avoid life-threatening injuries, and are often associated with violent falls and MVAs.

In our study, we adopted 3 classifications to analyze the different tibial pilon fractures:

- VIVES classification: Type 1: 10 cases (12.5%), Type 2: 7 cases (8.75%), Type 3: 7 cases (8.75%), Type 4: 56 cases (70%). We found that type 4 was the most frequent, noted in 65% of cases.
- SOFCOT classification: Complete articular fractures predominated in 64 patients (80%), followed by incomplete fractures in 10 patients (25%).
- AO classification: Type A: 18 cases (22.5%) of extra-articular fractures, Type B: 22 cases of partial fractures (37.5%), the most frequent. Type C: 40 cases of complex fractures (50%).

Pending surgical treatment, patients were conditioned:

- Reduction by boot-pulling maneuver for dislocated ankle fractures, then immobilization with a plaster cast to reduce pain and relieve soft tissue.
- Elevation and icing of the limb.
- Surgical decontamination of the traumatic wound, tetanus vaccination and prophylactic antibiotic therapy.
- Medication: LMWH, NSAIDs, TCA.

In our study, all patients had undergone surgical treatment, which would involve reconstituting the anatomy of the tibio-tarsal joint, protecting or restoring the skin covering, and restoring good ankle function.

The average delay between trauma and surgical management was estimated at 4 days, with extremes ranging from 1 day to 17 days, and was a function of several parameters such as delayed consultation, unfavorable skin condition, equipment availability problems and transfer from another department. In our study, patients underwent locoregional anesthesia, with a sciatic nerve block to ensure postoperative analgesia in 62 cases (77.5%), and general anesthesia in 18 cases (22.5%).

The patient was positioned in dorsal recumbency, with the foot overhanging the operating table, supported under the buttock on the side to be operated on, the contralateral leg lowered to avoid interfering with fluoroscopic control, and a pneumatic tourniquet placed at the thigh root.

All cases in our series were treated with closed-focus osteosynthesis, either by :

- External fixator osteosynthesis in 16 patients, i.e. 30% of cases.
- Minimally invasive screw fixation under arthroscopic control in 24 patients (30% of cases) for simple fractures.
- External fixator osteosynthesis combined with minimally invasive osteosynthesis (combined surgical treatment) in 40 patients (50% of cases).

In our series, the 1st surgical step was osteosynthesis of the lateral malleolus, which consisted in restoring the limb's initial length in 54 patients (67.5%), using 1/3-tube plates in 46 patients (85.18% of cases), externally, centered on the fibula, and by ascending centromedullary pinning in 8 patients (14.81% of cases).

In our series, three types of external fixator were used:

- Hoffmann-type external fixator in 52 patients, 65% of cases; the number of sets of Hoffmann external fixator used was as follows: 1 set of external fixator in 36 cases, a percentage of 69.24%, and double sets of external fixator in 16 cases, a percentage of 30.76%.
- Orthofix-type external fixator in 2 patients, 2.5% of cases.
- Hybrid external fixator in 6 patients (7.5% of cases).

Minimally invasive arthroscopically-assisted osteosynthesis was performed in 20 patients (25% of cases), using arthroscopically-assisted screw fixation. This technique is intended for simple, minimally displaced fractures.

In our series, combined treatment using an external fixator with minimal osteosynthesis was performed in 40 patients (50%), screw fixation in 32 patients through mini-incisions (80%), and percutaneous pinning in 8 patients (20%), combined with a Hoffmann-type external fixator in 100% of cases.

In our series, plaster cast immobilization with a posterior splint was mainly used for analgesic purposes, and to protect the fixture in unruly or agitated patients. Removal on D3 postoperatively.

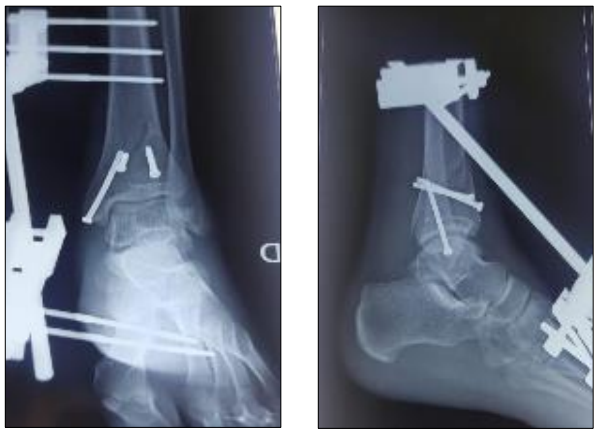

Figure 3 Control radiograph of the ankle app and profile, post-op after combined osteosynthesis with malleolar cancellous bone screws and a set of anti-equin tibio-metatarsal external fixators

In our study, we performed secondary ankle arthrodesis in one patient, representing 1.25% of cases.

All our patients had received post-operative care, analgesic treatment, antibiotic prophylaxis, with prophylactic anticoagulation for 3 weeks, and a control radiograph of the ankle face and profile. All patients received a discharge letter detailing their rehabilitation protocol. Partial weight-bearing was allowed on average at 7 weeks, while full weight-bearing was allowed on average at 14 weeks.

The average follow-up in our series was 40 months. Among 80 patients, 9 were lost to follow-up, 11.25% of cases. In our series, consolidation was achieved in an average of 4 months, with extremes ranging from 2 to 6 months.

In our study, 8 cases of superficial infection (10%) were found and treated with antibiotics and local care. 4 cases of deep soft-tissue and osteosynthesis infections (5%) were treated surgically by debridement, drainage and curettage, combined with effective antibiotic therapy. There were no cases of vascular injury, secondary displacement or thromboembolic events. In our study, 20.75% of cases presented with algodystrophy secondary to external fixation, but only 5 patients had retained chronic pain.

In our study, 11 patients (13.5%) had joint stiffness, 9 patients (11.25%) had pseudarthrosis, 9 patients (11.25%) had tibio-astragalar osteoarthritis, and 6 patients (7.5%) had callus.

Figure 4 Control X-ray of the ankle, app and side, showing good consolidation of the fracture site

To assess the quality of these results, we adopted the De la Caffinière criteria. 80.57% of patients regained satisfactory ankle function. However, in 19.43% of cases, the functional result was poor. Radiological results were good and satisfactory in 83.75% of cases, 67 patients. Poor radiological results accounted for 16.25% of cases. There was no correlation between good and average clinical and radiological results. However, poor clinical and radiological results were concordant.

Figure 5 Clinical image after removal of the external fixator, showing a normal ankle axis with healing of the mini-abutments

In our study, tibial pilon fractures classified as Vives type I and II had good clinical results in 100% of cases. Vives type III tibial pilon fractures had good clinical results in 50% and fair results in 50%. Complete and complex type IV fractures had poor clinical results in 30% of cases.

4. Discussion

The mean age in the various series ranged from 37.7 to 45.3 years. In our series, it was 39.3 years. On the whole, these averages correspond to the working-age population, most probably reflecting their young age and the predominance of accidents on public roads. The frequent involvement of this age group is serious, as it can have a serious impact on socio-economic activity. [1, 6, 7, 8, 9, 10, 11, 12, 13, 14].

All publications [1,5,6,7,8,9,10, 11,12,13,14,15] report a predominance of males, and in ours, this particularity is due to the nature of the male population's activity.

High-energy traumas, represented by falls from high places and MVAs, are the most implicated in the occurrence of tibial pilon fractures according to the series studied, as well as in our own. The causal trauma was represented by: falls in 43.75% followed by MVAs in 41.25%. Falls are due to carelessness and underestimation of danger. MVAs are due to the failure of the road network and non-compliance with traffic regulations [6, 9, 11, 16, 17, 18, 19].

In series reported in the literature [5, 8, 9, 11, 14, 16], right-sided involvement is the most frequent. In our series, we found a predominance of left-sided involvement (61.25%) compared with right-sided involvement (45%). The predominance of left-sided involvement may be explained by the predominance of left-handed subjects in our study.

HECKEL's [15] retrospective study of 692 observations at the SOFCOT's 66th annual meeting (1992) found a high rate of associated defects, of the order of 40%, while VIVES [16] reported a rate of 12%. In our series, we found a high rate of associated history estimated at 51.25%.

Pilon fractures result from two main mechanisms that can either act individually or concomitantly [17, 18], axial compression, resulting in the talus sinking into the tibial plafond, and torsion, which produces varying degrees of joint shear and displacement of the fracture fragments [19, 20].

Diagnostic orientation based on clinical examination alone poses few problems. Functional impotence, pain, swelling, ecchymosis and the notion of high-energy trauma point to a fracture of the lower end of the tibia.

Comparing data from different studies, we note that results vary from one study to another. We found a predominance of closed fractures (83.75%), compared with open fractures (16.25%). These figures are in line with the literature [6, 8, 11, 13, 15, 25]. On the other hand, several other authors report a predominance of open fractures [9, 17]. Fractures of the tibial pilon frequently occur following high-energy trauma, which explains the frequency of associated lesions [9, 23]. In our study, we had 54 cases with associated external malleolus fractures (67.5%), and this lesion played a role in the hierarchy of intervention. Osteosynthesis of the fibula restored the length of the lower limb. These figures are consistent with those in the literature by Bari et Al [2], G.C. Babis [22], and Lim et Al [23].

The positive diagnosis of tibial pilon fracture is purely radiographic. Standard anteroposterior, profile and mortise radiographs of the ankle, front and side radiographs of the whole leg and radiographs of the foot are required. For preoperative planning purposes, a CT scan of the ankle is required to better study the fracture [26, 39, 40, 45]. This examination provides information on the direction of the fracture line and the presence of subchondral bone impingement at the articular surface. All patients in our series underwent a standard radiographic work-up, including a CT scan [37].

Fractures of the tibial pilon have always presented a classification problem [6], with some authors basing their classification on the degree of displacement and comminution like RUEDI and ALLGOWER [17], according to the mechanism of the lesion like BRUMBACK and MCGARVEY [51], on the complete or partial nature of the fractures like the SOFCOT classification [26, 28, 29], or on the solution of metaphyseal continuity and the complexity of the epiphyseal line like VIVES and HOURLIER [16]. In our study, we adopted 3 classifications: VIVES, AO and SOFCOT, which enabled us to analyze tibial pilon fractures and compare them with data in the literature. We noted the high frequency of complex and complete fractures in all classifications, reflecting the violence of the trauma. Like RAFAOUI et AL [45], they noted the predominance of complete and complex fractures according to VIVES in 65% of cases.

The choice of treatment depends on clinical and radiological parameters. Surgical restoration of tibio-astragalar joint congruence remains the only guarantee of good functional recovery of the ankle [1, 6, 30, 45]. According to several series [9, 24], the operating time should not exceed 8 to 12 hours, otherwise it is preferable to postpone the operation for 7 to 10 days until the skin condition has improved [1, 12, 16, 30, 32, 44].

Surgical treatment involves a number of different methods:

Open surgical treatment:

- Primary osteosynthesis of the fibula: This is an essential step, restoring the exact initial length. Synthesis is performed using a 1/3-tube plate or a pre-molded Vives-type plate (3.5 screw), pinning, screwing or a small external fixator [4]. In our series, fibular fixation was achieved by screw plate in 85.18% of cases, and by pinning in the remainder.
- Anatomical reduction of the fracture site: Reconstruction of the tibial epiphysis is always difficult. To ensure proper reduction, the individual fragments must be held together with pins, and a cancellous bone graft may be used if reduction has revealed significant metaphyseal loss (iliac or tibial autograft) [4, 44, 47]. Stabilization by application of an internal osteosynthesis plate; the ideal material for this type of synthesis is the thin Heim cloverleaf plate fixed with cortical 3.5 and cancellous 4 screws. This is followed by immobilization with a posterior plaster splint for analgesic purposes for a few days.

Because of the complexity of fractures in our patients, and the fear of skin problems, we did not opt for treatment by open-focus surgery. Instead, we opted for closed-focus osteosynthesis.

Closed surgical treatment :

External fixation: External fixation treatment of tibial pilon fractures is an improvement on continuous extension orthopedic treatment. It provides more rigid immobilization and bridging of the tibio-tarsal joint, while allowing early mobilization of the patient [13]. In our study, the external fixator alone was used as a definitive treatment for tibial pilon fractures in 30% of cases; this option was the choice of Mazzitelli [14] in 35.7% of cases, and Lim [23] in 80% of cases.

Combined treatment: External fixator relayed by internal osteosynthesis is currently an increasingly advocated approach, when skin condition is compromised and does not allow immediate direct approach according to Galante [54]. According to Patterson [52] and Mandracchia [53], combined treatment is capable of reducing the risk of infection. The external fixator combined with minimally invasive osteosynthesis improves anatomical results, by improving joint congruency and correcting residual displacement. We used combined treatment in 40 patients, i.e. 50% of cases. Lim et al [23], after failure of exclusive external fixator treatment, had to switch to combined treatment in 20% of cases.

Arthroscopy: This is a simple, minimally invasive technique with numerous benefits, using conventional equipment [43, 44]. Its advantage is that it allows anatomical reduction without an extensive approach, and enables assessment and treatment of possible associated lesions (osteochondral, capsuloligamentary, musculotendinous or foreign-body lesions, etc.). this technique may be indicated for comminuted fractures and certain complete fractures of the tibial pilon, but is not indicated for the treatment of complicated fractures. In our study, arthroscopy was used for minimally invasive fracture reduction in 30% of cases.

Minimally invasive surgery and screw osteosynthesis: This technique is designed for minimally displaced fractures, with no joint or metaphyseal comminution. Traction is not necessary in this type of fracture. For better stabilitý of the construct, fibular synthesis is preferable and can be performed minimally invasively if the fracture permits. In our series, we adopted this surgical technique in 30% of cases, reduction was arthroscopically assisted and fixation was achieved by percutaneous screw fixation.

Arthrodesis: Arthrodesis is sometimes indicated immediately in complex fractures with extensive joint damage making reconstruction impossible, taking into account factors such as the patient's age, occupation, extent of bone damage, soft tissue involvement and infectious context, and also in patients with severe post-traumatic osteoarthritis, or in cases of skin necrosis secondary to osteosynthesis. In our study, late arthrodesis was performed in 1.25% of cases.

In our series, indolence was controlled by intraoperative locoregional anaesthesia and postoperative per os relay, while antibiotic prophylaxis was provided by protected amoxicillin. Nevertheless, Lassen et al [37] recommend the administration of low-molecular-weight heparin at a dose of 4000 IU/day to prevent thromboembolic risks until support has been authorized, as was the case in all our patients.

As experimentally demonstrated by Salter [38], mobilization of the joint in articular fractures guides cartilage healing, In our study, we undertook progressive rehabilitation and allowed the resumption of weight-bearing on average at week 7, while full weight-bearing was postponed on average to week 14. According to several authors [9, 34], the date of resumption of weight-bearing of the fractured limb depends on the experience and choice of the practitioner. The

average time to consolidation in our patients was 4 months. This time is around 4 to 5 months [68], and depends on the type of fracture, skin lesions, quality of reduction and stability of the fixture used [6, 38, 45].

In our series, we found 8 cases (10%) of superficial infection treated with antibiotics, and 4 cases of deep infection treated surgically with debridement, drainage and curettage, combined with antibiotics. The rate of infection reported in published series is variable: Mc DonaldMG [31] and Craig and Arkady [21] reported no cases of deep infection in their series using external fixator treatment, while Sirken [40] reported a 10.5% rate of deep infection. Comparing our results with those reported in the literature, it appears that closed-focus treatment of tibial pilon fractures reduces the rate of infectious complications, since it avoids aggravation of the skin damage caused by the surgical wound during open-focus surgery. In our series, we found no cases of skin necrosis, whereas Sirken [40] reported 17% of skin necrosis in his series.

The rate of algodystrophies was 20.75% of cases, whereas Lahrach [6] reported a rate of 16% of cases, and Havet [49] reported a rate of 12% of cases, whereas Lahrach [6] reported a rate of 16% of cases, and Havet [49] reported a rate of 12% of cases. No cases of secondary displacement were noted. Whereas 11 of our patients (13.5%) had stiffness that was recovered by rehabilitation.

In our study, we recorded 6 cases (7.5%) of malunion, while several authors [6,41,48] have reported a rate of over 8% in the literature. We also observed 9 cases (11.25%) of pseudarthrosis, 7 cases of pseudarthrosis of the medial malleolus and 2 cases of the lateral malleolus. McDonald MG [31] reported 8.3%, while Arlettaz [9] reported a rate of 2% of pseudarthrosis in his series. 4 cases of talocrural osteoarthritis (10%) were found in our study, of which only one required arthroscopic talocrural arthrodesis. Marsh [50] reported an osteoarthritis rate of 2%, while Yildiz and Cemil [39] found no osteoarthritis in their series.

Our study, and that of Cetik et al [33], showed that arthroscopic-assisted surgery combined with the use of an external fixator and minimally invasive internal fixation is the optimal treatment for tibial pilon fractures, as external fixation can improve fracture alignment, arthroscopy can help restore the articular surface and minimally invasive screws ensure fragment stability. In his study, Luo [43] emphasized the advantages of this surgical method.

5. Conclusion

Our retrospective study has confirmed the seriousness of tibial pilon fractures, which affect patients' long-term functional prognosis.

The literature and our own experience show that tibial pilon fractures are still a challenge today, and the overall improvement in the long-term future of these lesions depends on good initial reduction, restoration of joint congruence, satisfactory stabilization allowing early mobilization of the ankle, and respect for the soft tissues.

Closed osteosynthesis respects these imperatives, and delivers functional results equal to those of open surgery, with a lower rate of infectious complications, giving closed osteosynthesis the edge in the treatment of complex tibial pilon fractures.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest in relation to the writing of this this article.

Statement of ethical approval

Ethical approval for this study was obtained from the Institutional Ethics Committee

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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