BALNEO RESEARCH Balneo and PRM Research Journal English Edition
e ISSN 2734 - 8458 p ISSN 2734 - 844X ROMANIAN ASSOCIATION OF BALNEOLOGY

Research article

Late functional and radiological outcomes in recovery of patients with staged osteosynthesis for the tibial pilon fractures

Bogdan Obada [1,2], Vlad-Alexandru Georgeanu [3], Ion-Andrei Popescu [4], Madalina-Gabriela Iliescu [2,5]*, Liliana-Elena Stanciu [2,5]* and Bogdan Marian Caraban [2,6]

1. Orthopaedic Traumatology Department, Emergency Clinical County Hospital, Constanta, Romania;
2. Ovidius University of Constanta, Faculty of Medicine, 1 University Alley, Campus – Corp B, Constanta, Romania
3. Clinic of Orthopaedics and Trauma Surgery, "St. Pantelimon" Hospital, Bucharest, Romania
4. Romanian Shoulder Institute, Ortopedicum – Orthopaedic Surgery & Sports Clinic, Bucharest, Romania
5. Balneal and Rehabilitation Sanatorium Techirghiol, Romania
6. Plastic Surgery Department, Emergency Clinical County Hospital, Constanta, Romania

* Correspondence: lilianastanciu77@yahoo.com; iliescumadalina@gmail.com
All the authors contributed equally to this work

Citation: Obada B., Georgeanu V.A., Popescu I.A., Iliescu M.G., Stanciu L.E. and Caraban B.M. - Late functional and radiological outcomes in recovery of patients with staged osteosynthesis for the tibial pilon fractures
Balneo and PRM Research Journal ***2023****, 14(3): 593*

Academic Editor(s):
Gabriela Dogaru

Reviewer Officer:
Viorela Bembea

Production Officer:
Camil Filimon

Received: 05.08.2023
Accepted: 15.08.2023
Published: 01.09.2023

Reviewers:
Condurache Mihaela - Iustina
Ilie Onu

Publisher's Note: Balneo and PRM Research Journal stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract: Postraumatic rehabilitation represent a dynamic field, with specific protocols and technics. Our prospective study targets the tibial pilon fractures admitted in our clinic, to which a new treatment protocol was applied, consisting of two surgical steps, assesing in the end the results achieved at the discharge of the patient and later follow up. The study group consist of 196 patients (198 fractures), in the period 2019-2022. The average evaluation time was of 16 months. The most frequently applied osteosynthesis principle was staged osteosynthesis which consisted of first stage fibula plate osteosynthesis and external fixator tibia pilon, followed by minimally invasive or limited approach locked plate tibia pilon fixation. (64.14%) Olerud and Molander clinical score at more than one year after the last surgical intervention highlights good results: excellent results in the amount of 37% to 15% in the first lot, good results 52% to 29%, moderate success 7% to 39% and poor 4% to 17%. Two stage surgery protocol with external fixation in emergency and minimally invasive internal fixation with locked plate performed after the dissappearance of the local edema, as the second surgical step, allows anatomically correct articular reconstruction without skin complications, with decrease of arthitic late complications.

Keywords: tibial pilon; fractures; staged osteosynthesis, recovery

1. Introduction

Tibio-tarsal arthrosis is a frequent complication after articular fractures of the tibial pilon and lead to incongruency, deviation of the biomechanical axis, stiffness, and pain. Late mobility disfunction is corelated with the type of fracture, quality, and possibilities of osteosynthesis. The optimal timing for definitive osteosynthesis, especially for the fracture which associates ischemic lesions of the soft tissues, was a debate theme in the literature. The aim of the damage control surgery is to avoid the complications which can appear after the surgical incision on a suffering tegument. Starting from these considerations, appeared the need of staged osteosynthesis, which respect the soft tissues healing after the occurring of the fracture [1,2,3].

The prospective study targets the tibial pilon fractures admitted in our clinic, to which a new treatment protocol was applied, consisting of two surgical steps, assessing

in the end the results achieved at the discharge of the patient and later follow up. This therapeutical algorithm follows a better preservation of soft tissue, allowing subsequent approach of joint fractures for an anatomical reconstruction and a stable osteosynthesis.

2. Results

Demographic profile of the patients related with age, number of male versus female, type of trauma or fractures are shown in Table 1.

Table 1. Demographic profile of the patients

AO – Arbeitsgemeinschaft Osteosynthesefragen = german fracture classification system	
Medium age	46.5 (19-83)
Gender (male/female)	156/40
Low energy trauma / high energy trauma	57/139
Type 43 B (AO) / type 43 C (AO)	119 / 79
Open fractures type I / II/ IIIA / III B	17 / 14 / 11 / 6

The evaluation of joint fractures necessarily requires Xray and classical CT and, where possible, the use of three-dimensional reconstruction, which helped both to accurately diagnose and to achieve an appropriate and personalized therapeutic plan for each fractured type [4,5,6].

The therapeutic protocol applied in emergency aims to stabilize the bone, but especially the soft parts, its purpose being to limit the risk of local skin complications. The principles of treatment of soft parts will be differentiated according to the initial traumatic energy (Table 1), but especially according to the condition of the skin, in the case of open fractures applying the classical principles of therapeutic approach: mechanical, chemical, and surgical toilet [7,8,9].

Table 2. Bone stabilization in emergency

AO classification	Plaster cast	External fixator	External fixator + plate osteosynthesis of peroneus
B – 119 cases	46	2	71
C – 79 cases	0	5	74
Definitive osteosynthesis			
Single stage osteosynthesis		46	23.24 %
Two stage osteosynthesis		127	64.14 %
External fixator		25	12.62 %

The preferred emergency bone stabilization method consists of osteosynthesis of fibula fracture with plate and screws, followed by external osteosynthesis of the tibia (130 cases). Subsequently, when the local condition allows, sequential osteosynthesis of the tibia is performed (after extraction of the external fixator) (Table 2).

Two types of approaches were used to achieve locking plate osteosynthesis: the Assal modified antero-medial approach and the anterolateral approach. The decision between the two approaches depends on the typology of the fracture, and minimizing or

extending the approach depends on the quality of the initial fracture reduction, achieved in the first stage [10,11,12].

The antero-medial approach modified by Assal allows a good visualization of the anterior and medial aspects of the tibial pilon, but also sufficiently good of the lateral distal tibial metaphysis and even of the lateral articular surface. The visualization of the articular surface is excellent and the approach allows easy fixation of the "L" shaped plate [13,14].

We notice and monithorize the complications in the postoperative recovery, and the centralized clinical situation are shown in Table 3.

Table 3 Late complications	Number	%
Stiffness	42	21.21
Neuroalgodistrophy	18	9.1
Chronic oedema	8	4
Delay of consolidation	6	3
Vicious callus	7	3.5
Pseudarthrosis	2	1
Arthrosis	25	12.6
Refracture	2	1

At least 1-year, clinical evaluation based on Olerud and Molander score, Ovadia and Beals score and radiological evaluation of osteoarthritis changes based on Kellgren and Lawrence score were performed (Table 4).

Table 4 Olerud and Molander clinical score by fractured type AO

Results	Excellent	Good	Moderate	Poor	Total
Fr. type B	50 (42%)	65 (55%)	3 (2%)	1 (1%)	119
Fr. type C	24 (30%)	38 (48%)	11 (14%)	6 (8%)	79
Casuistry	74 (37%)	103 (52%)	14 (7%)	7 (4%)	198

Late results according to Ovadia and Beals criterion at 1 year postsurgery

Results	Objective		Subjective	
Excellent	105	53%	73	37%
Good	76	38%	87	44%
Satisfactory	11	6%	31	16%
Poor	6	3%	7	3%

Kellgren and Lawrence radiologic score for arthrosis evaluation according AO fracture after 1 year

Grade	1	2	3	4	Total
Type B	65	47	6	1	119
Type C	30	25	19	5	79
Cazuisttry	95	72	25	6	198

Evolution of representative cases are represented in Figures 1, 2 and 3.

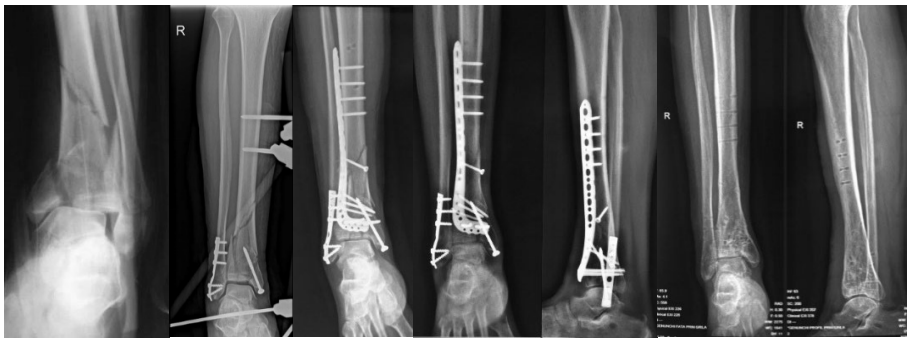

Figure 1. Staged osteosynthesis type C fracture

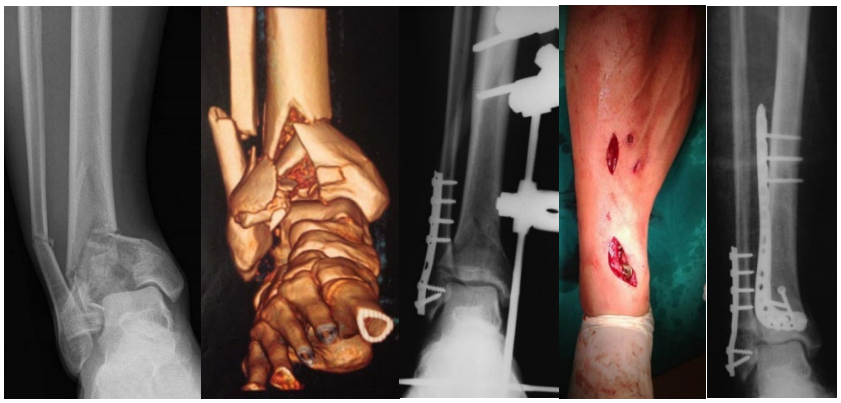

Figure 2 Staged osteosynthesis type C fracture, minimal invasive plate osteosynthesis in second surgical time

Figure 3. Bilateral fractures type C, staged osteosynthesis right tibial pilon, arthrodesis left tibial pilon.

3. Discussion

The most frequently applied principle of osteosynthesis was staged osteosynthesis which consisted of the first stage of osteosynthesis of the fibula with plate and osteosynthesis of the tibial pilon with external fixator, followed by minimally invasive osteosynthesis or limited open approach with locking plate of the tibial pilon (64.14%).

The therapeutic protocol aims in the first stage the osteosynthesis of the peroneal fracture, with the restoration of the length of the fibula, when it is fractured and the stabilization of the tibial pilon fracture with an external delta fixator, followed in the second operative time, moment chosen depending on the condition of the soft parts, the osteosynthesis of the pilon by minimally invasive approach or by the limited approach of the fracture site and stabilization with locking plate. During the second stage, the location of the surgical approach and the type of implant used were dictated by the location of the skin lesions, which was predominant on the medial slope, which led to the avoidance of this area [15,16].

The goal of osteosynthesis by minimally invasive approach or limited open approach in the treatment of tibial pilon fractures is to reduce the rate of infections and increase bone healing capacity. This technique prioritizes bone biology over classical mechanical principles of wide opening and solid rigid fixation. Using this method, the fractured area is not exposed or is minimally exposed, and periosteal vascularization of bone fragments is not additionally injured during osteosynthesis [17].

Because we avoided applying plate on the antero-internal slope due to the high risk of subsequent skin lesions, the preferred plate in our study was the "L" shape. Except that the locking plates provide superior stability to simple plates and are already anatomically shaped facilitating the insertion and reducing the fracture site, another major advantage is the "biology" favorable to bone consolidation of these implants, by preserving periosteal vascularization [18,19,20,21].

In one case of fracture type III Gustilo, due to severe comminution, the possibilities of joint reconstruction were overcome, which required ankle arthrodesis with retrograde nail. Primary ankle arthrodesis is a therapeutic option to be considered for tibial pilon fractures where joint reconstruction seems impossible, type 43 C3 AO. The criteria underlying this decision are: the surface area and amount of missing joint bone, the severity and quantity of the comminution and the degree and surface of clogged bone [22,23,24].

The average consolidation period, radiologically objectified by the appearance of bridged callus, the disappearance of fracture lines and clinically by the lack of movements in the focus or pain when loading the limb, was 3.6 months. The loading on the operated limb was started progressively, not earlier than 6 weeks postoperatively, being complete only after radiological consolidation of the fracture. All patients were referred to the functional recoveries and balneophysiotherapy clinic to follow a specialized program of functional joint rehabilitation and socioprofessional reintegration.

All cases of pseudartrosis were reported after open fractures type III. The delay in consolidation was reported in 8.3% of the open fracture group versus 1.4% of the closed fracture group.

The percentage of late complications increases in direct proportion to the degree of comminution joint involvement according to AO fracture classifications. In the case of type B AO fractures, stiffness is encountered in 7.5% of cases, chronic edema in 1.6%, and neuroalgodystrophy in 1.6% of cases, while in the case of type C AO fractures these percentages are practically much higher, most complications being encountered in this category: stiffness 41.7%, neuroalgodystrophy 20.2%, chronic edema 7.6%. The causes are those already mentioned: increasing the complexity of the fractured site, limiting the possibilities of reconstruction and prolonging the period of immobilization of the joint. Consolidation delay, vicious callus and pseudarthrosis are absent in type B fractures but occur in type C fractures in proportions of 7.6%, 8.8% and 2.5%, respectively. Arthrosis

occurs in a small percentage of 3.3% in type B fractures, due to the real possibilities of anatomical reconstruction, but we notice it in a significant percentage of 26.6% in type C fractures, where severe joint cominution makes joint reconstruction difficult, with subsequent unfavorable prognosis.

From the evaluation of late complications from the point of view of the chosen osteosynthesis method, we note that minimally invasive internal osteosynthesis was associated with the lowest rate of complications: stiffness 8.65%, consolidation delay 1.2% and refraction with implant rupture 1.2%.

The Olerud and Molander clinical score more than 1 year after the last surgery highlights: excellent results in proportion of 37%, good results 52%, moderate results 7% and poor results 4%. These results are also reflected in the favorable average values of the plantar / dorsal flexion interval of the ankle for the group, obtained by goniometric measurement of the ankle, when we have radiological image of consolidation and it is possible to fully load the operated limb: 46^0 / 18^0 for type B fractures and 33^0 / 13^0 for type C fractures.

The Ovadia and Beals criteria highlight excellent and good objective results in 91% of cases, satisfactory and poor objective results were in 9% of casuistry, and excellent and good subjective results were 81%, while satisfactory and poor results were in 19% of cases. Once again, favorable results are inversely proportional to fractured injury graduality according to the two classifications, as with the Olerud and Molander score, with the percentage of poor outcomes increasing with the fractured graduated type. The Ovadia and Beals criteria, both objective and subjective, highlight the efficiency of the applied therapeutic protocol, noting excellent and good results obtained in high percentages, including in the case of type C AO fractures [25].

Patients who performed excellent or good on objective assessment invariably also show excellent or good results in clinical evaluation of results according to the Olerud and Molander score. In contrast, patients who performed moderately or poorly on objective assessment may have satisfactory clinical outcomes. Thus, a moderate functional limitation and minimal axial deviation of the limb with shortening, do not exclude the possibility of a good clinical outcome. The most important factors affecting the final clinical outcomes are the fractured type, the method of osteosynthesis applied and the quality of reduction.

Comparing the results of our study with the results of 6 other studies in the literature on tibial pilon fractures, we can appreciate that the results obtained after evaluating the group are very good, approximately equal to those obtained by Heim's study, which had the fewest complications. It is important to note that the favorable results obtained by Heim through his study were disputed because fractures were mostly caused by low and medium energy trauma, without significant soft injuries or severe open fractures, which implicitly led to an uncomplicated evolution. This makes our prospective study more valuable because it included a significant number of cases. A significant part of the casuistry were fractures produced by high energy, open fractures type III Gustilo-Anderson, type C AO which are difficult to treat in terms of immediate and late local complications. Among the studies in the literature that had series of open fractures of the tibial pilon and reported percentage late infection, we mention: Ovadia and Beals 7%, Teeny and Wiss 37%, Sands et al. 5%. It should be noted that these studies also had closed fractures in the group, so the proportion reported is not correct in terms of the number of open fractures. The only study that makes a strict reference to the number of open fractures type IIIB is that of Conroy et al. who report a percentage of 6% of the group, an important study to appreciate being about 32 serious open fractures [26,27,28,29].

The principles of "damage control surgery" must necessarily underpin the therapeutic management of tibial pilon fractures. Two-stage osteosynthesis led to a decrease in the rate of use of soft tissue plasty, especially in type III fractures.

Anatomical reconstruction of the joint surface and rapid mobilization of the ankle are the key factors for a successful evolution, while fracture severity, high comminution and inability to achieve anatomical reduction are the causes of unfavorable results.

Functional outcomes are directly influenced by the severity of fracture joint and severity of skin opening. The severity of radiological arthrosis in the case of tibial pilon fractures does not always correspond to objective or subjective clinical results, being a well-tolerated arthrosis clinically and functionally, this drawing attention once again to the fact that the decision to choose arthrodesis as the definitive primary method of treatment must be very well appreciated.

Patients who have had moderate or poor results on objective assessment may have satisfactory clinical outcomes. Thus, a moderate functional limitation and minimal axial deviation of the limb with shortening, do not exclude the possibility of a good clinical outcome. The most important factors affecting the final clinical results are the fracture type, the method of osteosynthesis applied and the quality of joint fracture reconstruction.

4. Materials and Methods

This study comprises all the tibial pilon fractures admitted and treated in the Orthopaedics and Traumatology Clinic of Clinical Emergency Hospital of Constanta, in 4 year's time. The study group was a prospective batch of 196 patients (198 fractures), in the period 2019-2022.

Inclusion criteria – distal tibia intra-articular fractures

Exclusion criteria - non-intra-articular distal tibia fractures
- tibial malleolus fractures

1. The statistical analysis of the batch was performed on the following criteria: sex, age, etiology, fracture site aspect in AO-Muller classification, soft tissue quality in Cauchoix-Gustilo-Anderson classification.
2. Analysis of immediate complications compared to the traumatic energy
3. Evaluation of the emergency and final therapeutical protocol.
4. Analysis of the long-run results: Olerud and Molander clinical score.

5. Conclusions

Staged osteosynthesis of tibial pilon fractures allows optimisitation of soft tissue management and joint anatomical reconstruction during the second surgical stage. Minimally invasive internal osteosynthesis or limited open approach with locking plate, performed after the disappearance of local edema, in the second surgical stage, allows joint anatomical reconstruction without skin complications, with the decrease of osteoarthritis-type complications, definitive stable osteosynthesis with prevention of consolidation delay and pseudarthrosis, and finally, avoiding of late infection. The therapeutical protocol we applied leaded to a good functional recovery.

Author Contributions: All the authors had equal contribution. Conceptualization, B.O. and V.A.G; methodology, L.E.S., I.A.P. and B.O.; software, B.O.; validation, B.O., M.G.I. and P.B.; formal analysis, B.M.C.; investigation, B.O.; resources, B.O., V.A.G. and I.A.P.; data curation, L.E.S.; writing—original draft preparation, B.O.; writing—review and editing, B.M.C.; visualization, M.G.I.; supervision, B.O. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study was approved by the ethical committee of Emergency Clinical County Hospital "St Apostle Andrei" of Constanta, Romania and written informed consent was obtained from all the patients.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: All the data and materials are available upon requests from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Wyrsch B, McFerran MA, McAndrew M, et al. Operative treatment of fractures of the tibial plafond. A randomized, prospective study. J Bone Joint Surg Am 1996; 78(11): 1646-57
2. Patterson MJ, Cole J. Two-staged delayed open reduction and internal fixation of severe pilon fractures. J. Orthop Trauma 1999; 13(2): 85-91
3. Crist BD, Fergusson T, Murtha YM, Lee AM. Surgical timing of treating injured extremities. J Bone Joint Surg Am 2012; 94(A):16, 1515-24
4. Tornetta P 3rd, Gorup J. Axial computed tomography of pilon fractures, Clin Orthop Relat Res 1996; (323): 273-6
5. Hindman BW, Ross SD, Sowerby MR. Fractures of the talus and calcaneus: evaluation by computed tomography. J Comput Tomogr 1986; 10(2): 191-196
6. Jia B, Zhang Y, Li ZL, et al. Classification of pilon fractures by computed tomography and its guide to clinical treatment, Zhongguo Gu Shang. 2011; 24(6): 470-3
7. Liporace FA, Mehta S, Rhorer AS, et al. Staged treatment and associated complications of pilon fractures. Instr Course Lect 2012; 61: 53-70
8. Sedlár M, Chrz K. Pilon fractures of the tibia - a short summary of problems and case reports. Rozhl Chir 2012; 91(5): 271-5
9. He X, Hu Y, Ye P, er al. The operative treatment of complex tibial pilon fractures: a strategy of soft tissue control. Indian J Orthop 2013; 47(5): 487-92
10. Chen L, O'Shea K, Early JS. The use of medial and lateral surgical approaches for the treatment of tibial plafond fractures, J Orthop Trauma 2007; 21(3): 207-11
11. Bastian L, Blauth M, Thermann H, Tscherne H. Various therapy concepts in severe fractures of the tibial pilon (type C injuries). A comparative study, Unfallchirurg 1995; 98(11): 551-8
12. Jacob N, Amin A, Giotakis N, Narayan B, Nayagam S, Trompeter AJ. Management of high-energy tibial pilon fractures. Strategies Trauma Limb Reconstr 2015; 10(3): 137-47
13. Assal M, Ray A, Stern R. The extensile approach for the operative treatment of high-energy pilon fractures: surgical technique and soft tissue healing. J Orthop Trauma 2007; 21(3): 198-206
14. Bucholz RW, Court-Brown CM, Heckman JD, Tornetta P. Pilon fractures in Rockwood and Green's Fractures in Adults, 7th edition, Lippincott Williams & Wilkins 2010
15. Marsh JL, Lavini F. Distal tibial and pilon fractures. Operative technique. Orthofix Operative Technique Manual n.7. In: www.orthofix.com
16. Marin LE, Wukich DK, Zgonis T. The surgical management of high- and low-energy tibial plafond fractures: A combination of internal and external fixation devices. Clin Podiatr Med Surg 2006; 23(2): 423-44
17. McCann PA, Jackson M, Mitchell T, Atkins R.M. Complications of definitive open reduction and internal fixation of pilon fractures of the distal tibia. International Orthopedics (SICOT) 2011; 35:413-418
18. Sirkin M, Sanders R, Di Pasquale T, Herscovici D Jr. A staged protocol for soft tissue management in the treatment of complex pilon fractures. J Orthop Trauma 1999; 13(2): 78-84
19. Tong D, Ji F, Zhang H, et al. Two-stage procedure protocol for minimally invasive plate osteosynthesis technique in the treatment of the complex pilon fractures. International Orthopedics (SICOT) 2012; 36: 833-37
20. Leonard M, Magill P, Khayyat G. Minimally-invasive treatment of high velocity intra-articular fractures of the distal tibia. International Orthopedics (SICOT) 2009; 33: 1149-53
21. Scolaro J, Ahn J. Pilon fractures. Clin Orthop Relat Res 2011; 469: 621-23
22. Bozic V, Thordarson DB, Hertz J. Ankle fusion for definitive management of non-reconstructable pilon fractures. Foot Ankle Int 2008; 29(9): 914-8
23. Zelle BA, Gruen GS, McMillen RL, Dahl JD. Primary arthrodesis of the tibiotalar joint in severely comminuted high-energy pilon fractures. J Bone Joint Surg Am 2014; 96(A): 11, 911-6
24. Morgan SJ, Thordarson DB, Shepherd LE. Salvage of tibial pilon fractures using fusion of the ankle with a 90 degrees cannulated blade-plate: a preliminary report. Foot Ankle Int 1999; 20(6): 375-8
25. Jansen H, Fenwick Annabel, Doht Stefanie, et al. Clinical outcome and changes in gait pattern after pilon fractures. International Orthopedics (SICOT) 2013; 37: 51-58
26. Ovadia D, Beals RK. Fractures of tibial plafond. J Bone Surg Am 1986; 68(4): 543-551
27. Sands A, Byck DC, Angel J et al. Clinical and functional outcomes of internal fixation of displaced pilon fractures. Clin Orthop 1998; 347: 131-137
28. Teeny SM, Wiss DA. Open reduction and internal fixation of tibial plafond fractures. Clin Orthop 1993; 292: 108-117
29. Conroy J, Agarwal M, Giannoudis PV, Matthews SJE. Early internal fixation and soft tissue cover of severe open tibial pilon fractures. International Orthopedics (SICOT) 2003; 27: 343-347