RESEARCH ARTICLE

Factors that Influence Soft-tissue Injury in Fractures of the Distal Tibia

Monica Rubio-Yanchuck, MD[1]; Juan C. Rubio-Suarez, MD[2]; E. Carlos Rodriguez-Merchan, MD, PhD[3]

Research performed at Departments of Plastic and Reconstructive Surgery, and Orthopaedic Surgery, La Paz University Hospital-IdiPaz, Madrid, Spain

Received: 08 July 2019 *Accepted: 23 March 2020*

Abstract

Background: Soft tissue injury associated with fractures of the distal tibia is a predictive factor for a poor prognosis. The purpose of this study was to investigate factors associated with the need for a flap coverage after distal tibial fracture, and whether there was a difference in functional outcomes between patients with flap coverage or no flap coverage for a distal tibial fracture.

Methods: All fractures of the distal tibia treated in our department between 2010 and 2017 were reviewed. The functional result was assessed using the SF-36 Quality of Life Questionnaire, the Visual Analog Scale (VAS) when walking and the AOFAS scale (American Orthopedic Foot and Ankle Society).

Results: 132 distal tibia fractures were reviewed, of which 51 required soft tissue flap reconstruction, which was associated with open fractures (*P<0.001*, OR 5.25), high energy trauma (*P<0.001*, OR 1.7)), the use of external fixation (*P<0.001*, OR 12.5) and the presence of vascular alterations on the Angio-CT scan (*P<0.001*). No significant differences were found in any of the scales that assessed the functional results between the group of patients who required soft tissue flap reconstruction and the group of patients who did not.

Conclusion: We found that the need for a soft tissue flap was associated with the following parameters: open fracture, high energy of trauma, presence of skin necrosis, the use of external fixation and the existence of vascular injury. In relation to functional results, differences were not found between the group that needed coverage with a flap and the one that did not.

Level of evidence: III

Keywords: Distal tibia, Fractures, Soft-tissue flap coverage, Soft tissue injury

Introduction

According to Zelle et al, high-energy tibial pilon fractures continue to represent a significant challenge to the treating orthopedic surgeon (1). Soft tissue injuries associated with fractures of the distal third of the tibia are a predictor of poor prognosis (2). The distal region of the leg has limited biological potential, due to the poor muscle coverage. In fact, one third of the circumference of the distal tibia is located subcutaneously (3, 4). When an injury occurs at this level the quality of the coverage is further compromised and this, together with the fact that many of these fractures are the result of high-energy trauma, can lead to irreversible soft tissue damage, aggravated even more by the surgical procedures required to treat most of these fractures. All of these factors may cause the fracture not to heal, which occurs in more than 5% of cases according to some studies (5, 6). Although it is indisputable that the intrinsic of the fracture and the choice of an adequate method of osteosynthesis are important for a good prognosis, the key factors for success probably include an adequate initial debridement and the surgeon's expertise in treating the soft tissues (7).

A recent systematic review and meta-analysis (grade

Corresponding Author: E. Carlos Rodriguez-Merchan, Osteoarticular Surgery Research, Hospital La Paz Institute for Health Research – IdiPAZ (La Paz University Hospital – Autonomous University of Madrid), Madrid, Spain
Email: ecrmerchan@hotmail.com

1 of evidence) reported by Erichsen et al on distal intra-articular tibial fractures surgery has shown a decreased physical function (8). The meta-analysis showed lower incidence of superficial wound infection and malunion rates in the ORIF (open reduction and internal fixation) group than in the external EF (external fixation) group. This review reported lower complication rates following ORIF for distal intra-articular tibial fractures. Taking into account that the overall evidence was limited, Erichsen et al could not recommend ORIF to be superior to EF treatment for distal intra-articular tibial fractures. More multi-center studies with larger sample sizes are needed to assess long-term physical function and complications following distal intra-articular tibial fractures surgery (8).

The purpose of this study was to investigate factors associated with the need for a flap coverage after distal tibial fracture, and whether there was a difference in functional outcomes between patients with flap coverage or no flap coverage for a distal tibial fracture.

Materials and Methods

In a retrospective cohort study, we analyzed all patients older than 18 years of age (inclusion criteria) who were treated for a distal tibia fracture (fracture that involves the distal part of both tibia and fibula) in our department (referral center), between 2010 and 2017. One hundred and thirty-two distal tibia fractures were reviewed, of which 51 required soft tissue flap reconstruction.

Twenty-eight flaps were muscular: 18 latissimus dorsi, 7 gracilis and 3 serratus anterior; 23 flaps were perforating (anterolateral thigh flap with segmental vastus lateralis) [Figure 1]. The flaps were done by the members of the

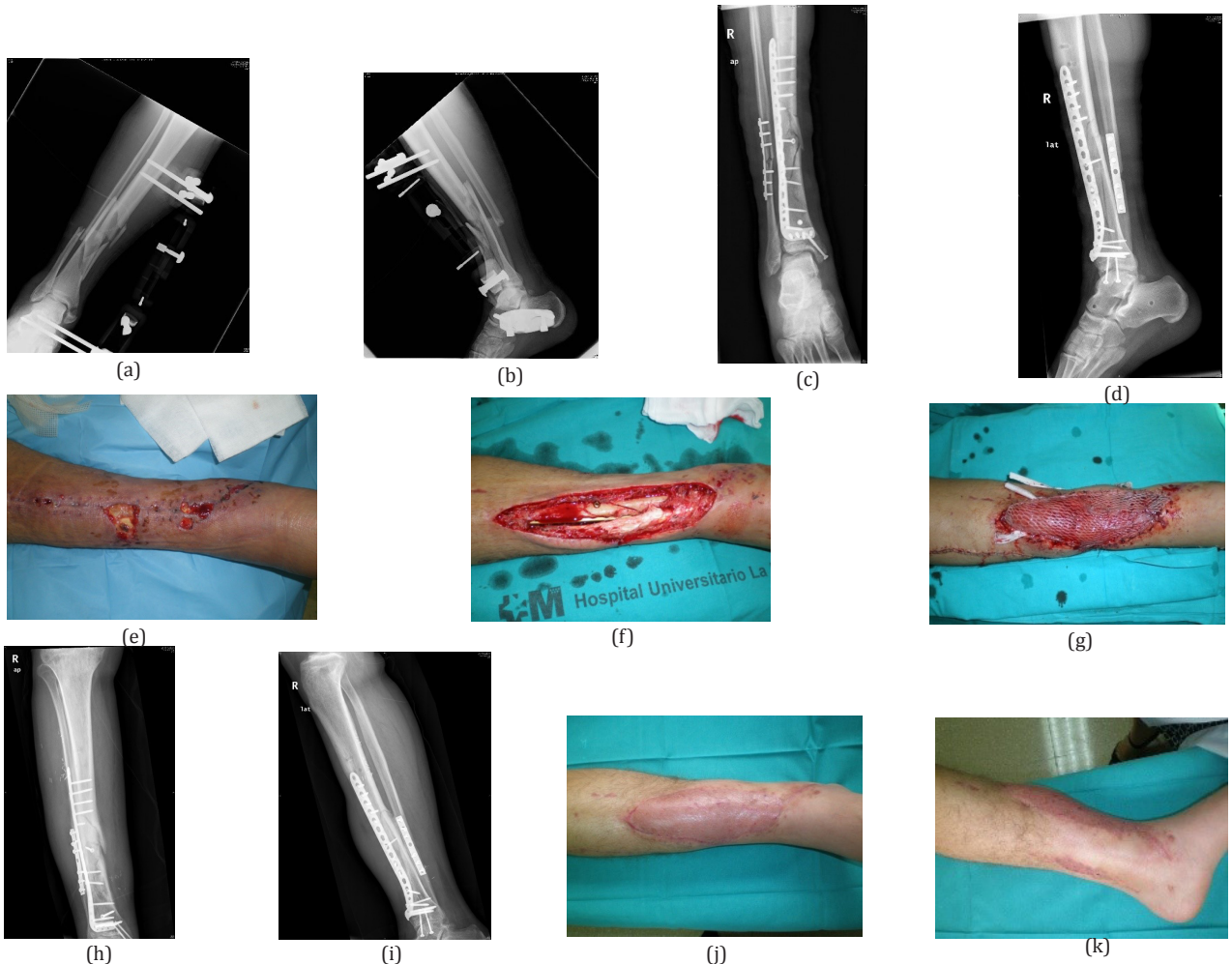

Figure. 1. Fracture of the distal tibia with joint involvement, initially treated with an external fixation device: (A) Anteroposterior (AP) radiograph of the fracture; (B) Lateral image of the fracture. Radiographs of fracture (C) and (D) after definitive treatment by means of open reduction and internal fixation (ORIF) with a 3.5mm fibular plate and an locking compression plate (LCP) 3.5mm anterolateral distal tibia plate, together with two 3.5mm screws in the medial malleolus. (E) Image showing the evolution of the soft tissues one week later, evidencing cutaneous necrosis and suture dehiscence. Intraoperative images showing extensive debridement performed in the area of cutaneous necrosis and devitalized tissues (F) and coverage carried out using a latissimus dorsal flap and meshed epidermal graft (G). Radiographic images showing the evolution at 6 months: (H) AP radiograph showing the consolidated fracture in good position; (I) Image in lateral projection showing the aforementioned bone healing. Images (J) (K) in which the clinical appearance of the covering flap can be seen.

Department of Plastic and Reconstructive Surgery of our Hospital.

In general, perforating flaps were preferred because of lower morbidity in the donor area. However, the choice of one or another type of flap was decided on the basis of the extension of the soft tissue defect and the absence of periosteum on the underlying bone. Thus, in lesions with significant soft tissue defect and wide desperiostization on the tibial diaphysis, muscle flaps were chosen (N=28), being the latissimus dorsi flap the most used in larger defects (N=18), followed by the gracilis (N=7) and the serratus anterior (N=3). On the other hand, in defects closer to the metaphyseal area, with less or no loss of periosteum, and taking into account that it is a more mobile area, fasciocutaneous flaps were chosen (anterolateral thigh flap, N=23) [Figure 1].

The average time for flap reconstruction surgery was 279.17 minutes (SD 50.20). Of the 51 patients who received coverage, 14 suffered complications after surgery: 7 flap failures (13.72%), 2 nonunions (3.92%) and 6 cases of infection (11.76%). Analyzing the possible factors that could influence the occurrence of complications, such as the time between fracture and flap coverage, the type of flap (muscular versus fasciocutaneous), the use of external fixator, the type of definitive osteosynthesis, the existence of associated fractures, the type of fracture or the energy of the trauma, we found no significant differences in any of these variables.

The average number of surgeries in patients who had needed coverage was 2.01 (SD 0.57) while in those who did not need it, the number was 1.46 (SD 0.615) (*P<0.001*)

Patient age under 18 years of age was the only exclusion criteria. The follow-up period was 12 months. The study was approved by the Ethical Committee of our center. Data collection included the use of medical records of the patients and interviews with patients. Such interviews were performed by one of the authors (JC R-S) at 12 months follow-up. We had no patient loss in this study. Functional scores were taken at final follow-up (12 months). Flap coverage was performed by plastic surgeons. No flap failures were found in our series. The fact of performing or not performing an angio-CT (computed tomography) scan depended on the preferences of the surgeon in charge of the patient.

The parameters evaluated were the need for soft tissue flap coverage and the functional outcome of the limb. The need for flap coverage was determined by the existence of a loss of substance secondary to necrosis or suffering of soft tissues whose extension or depth did not allow closure by second intention, direct closure or skin graft.

The parameters analyzed were: age, sex, laterality, the existence of associated fractures, the time to definitive osteosynthesis surgery, surgery in one or two times (use of external fixator), the energy of the trauma, the type of fracture and the complexity of it, the type of approach, the type of definitive osteosynthesis, the presence of alterations in some vascular axis of the leg in the angio-CT scan and the presence of complications.

The energy of the trauma was defined as high (traffic accidents, falls of height) or low (domestic accidents, casual injuries). Surgeries were performed at one time (definitive surgery, ORIF at <48h) if there was no edema or blisters, and two-stage surgeries, opting firstly for the use of external fixation on arrival to the Emergency Department, definitive osteosynthesis being deferred until the state of soft tissues was adequate (disappearance of edema and blisters). The fractures were classified as closed or open. In turn, closed fractures were classified according to the AO/OTA (AO-Müller/Orthopaedic Trauma Association) classification of distal tibial fractures, and open fractures according to the Gustilo-Anderson classification. Depending on the type of fracture, an anteromedial, anterolateral, anterior, medial, lateral, posteromedial, posterolateral, or percutaneous approach was performed.

Complications were defined as cutaneous suffering, skin necrosis, nonunion and infection. The infection was determined by the result of 2 positive cultures on different days.

The functional outcome was assessed using the SF-36 quality of life questionnaire, the visual analogue scale (VAS) when walking and the AOFAS scale (American Orthopedic Foot and Ankle Society), dividing the results into excellent (> 90 points), good (80-90 points), fair (70-80 points) and poor (<70 points).

We analyzed whether there was an association between the variables studied and the need for flap coverage and the functional result comparing those with distal tibial fractures that needed flap coverage and those that did not need coverage.

We have mentioned above that "the fact of performing an angio-CT scan or not depended on the preferences of the surgeon in charge of the patient". This could be a potential source of bi-as in our study. A multivariate analysis was performed.

Results

Table 1 shows main data and results of this study, as

Table 1. Analysis of variables potentially associated with the need for flap reconstruction (N=51) in fractures of distal tibia (N=132)

	With flap (N=51)	Without flap (N=81)	*P value*
Age	49.9±18.51	45.5±13.32	0.165
Female/Male	15 / 36	31 / 50	0.457
Trauma energy			
High	46	15	
Low	5	66	< 0.001*

Table 1. Continued

Open fracture (Gustilo-Anderson classification)	34	15	< 0.001*
Complexity (AO/OTA Classification)			
A	7	22	0.137
B	10	15	0.821
C	34	44	0.279
External fixation	38	25	< 0.001*
Associated fractures	11	14	0.653
Time to definitive osteosynthesis (days)	9.47±5.17	5.35±4.94	0.003
Approach			
Anterior	5	7	1
Anteromedial	12	26	0.325
Anterolateral	17	32	0.463
Lateral	1	5	0.402
Medial	3	6	1
Posterior	5	1	0.738
Percutaneous	8	4	0.370
Definitive osteosynthesis			
Plate	47	77	0.379
Nail	2	1	0.389
Cannulated screw	2	3	0.253
Vascular alterations on angio-CT scan (occlusion or subocclusion)	28	1	< 0.001*
Skin necrosis	44	0	< 0.001*
Nonunion	2	2	0.005
Infection	8	5	0.131
AOFAS (American Orthopedic Foot and Ankle Society)	83 (74-86)	84 (79.5-92)	0.391
VAS (Visual Analog Scale)	4 (3-5)	4 (2-5)	0.432
SF-36 quality of life questionnaire, physical sphere	51.3 (46.80-55.2)	51.9 (49.2-55.3)	0.571
SF-36 quality of life questionnaire, mental sphere	46.8 (44.7-47.7)	47.3 (45.1-48.1)	0.536

well as the variables associated with the need for flap coverage. We found statistically significant differences between the need for flap coverage and high-energy trauma, the use of external fixation as a step prior to definitive osteosynthesis surgery and vascular alterations on angio-CT scan. Differences were also found regarding the time to definitive osteosynthesis.

In relation to functional results, we found average results above 80, which is interpreted as good results (score 80-90), without finding differences between the group that needed coverage with a flap and the one that did not (*P = 0.391*).

Discussion

In the last three decades, the advent and refinement of microsurgical techniques has led to a revolution in the treatment of distal lower extremity trauma (8-17). Coinciding with other studies, most of these injuries are caused by high-energy trauma. These are responsible for a greater incidence of flap coverage, due to the fact that they cause a soft tissue defect in a territory already compromised (8-11). The fact of being open fracture increases up to 5 times the risk of requiring flap coverage (*P < 0.001*) (11 - 18). The role of soft tissue reconstruction in open fractures is not limited to covering the wound to prevent desiccation and infection. The soft tissues also contribute to the repair of the fracture being a source of osteoprogenitor cells, growth factors and, of course, vascular supply (18).

Sequential management in 2 stages of the treatment of these lesions is widely accepted. First an external fixation is carried out, which allows the control of the edema and the resuscitation of the soft tissues previous to the definitive treatment (19). Coinciding with the study of Krettek et al, in our series the need for external fixation and therefore, the delay in surgery until definitive osteosynthesis involves an increase of up to 12 times of risk of needing coverage with flap (20). This can be attributed to the worse initial state of soft tissue in the fractures that require external fixation and that

irrevocably will present cutaneous suffering.

Coinciding with the study by Lebus et al, we found an association between the need for flap coverage and the existence of alterations in the vascular imaging test (angio-CT scan) (21). The most frequently affected vessel was the anterior tibial artery (82.4%). Angiosome of the anterior tibial artery supplies the anterior part of the leg and ankle and, under normal circumstances, the three main arteries communicate with each other, providing the vascular supply to the skin through collateral circulation. Attinger et al stipulated that when there are abnormalities in blood flow in this area, collateral flow can maintain vascularized angiosome, and incisions should be planned so that collateral flow is not disturbed (22). Like the Carbonell et al study, we found no association between the need for soft tissue reconstruction and the approach used for definitive osteosynthesis (23). This is attributed to a good preoperative planning as well as a 2-stage reconstruction, which would favor the reduction of edema as well as the development of collateral circulation.

This study has some limitations. It is a retrospective study. Secondly, the definitive osteosynthesis surgery, although it was planned in consensus by the same surgical group, it was performed by different surgeons of the same group, which could influence the soft tissue management. Finally, not all the patients underwent a preoperative study with angio-CT scan, the majority of whom had a worse condition of soft tissue and performed it in the context of a preoperative flap coverage planning. Therefore, prospective studies are necessary to perform imaging tests on all cases of fractures of the distal tibia to assess the need and importance of this test in the management of this type of fracture, provided that the cost is permissible.

In conclusion, in this study we found an association between the type of fracture (open), the energy of the trauma (high energy), the use of an external fixator, the existence of skin necrosis and vascular lesions, with the need for soft tissue coverage. However, the need for coverage by itself, was not an indicator of poor functional prognosis. Within the vascular lesions, the lesion of the anterior tibial artery was the most frequent.

Conflicts of Interest: The authors have declared that they have no conflicts of interest.

Monica Rubio-Yanchuck MD[1]
Juan C. Rubio-Suarez MD[2]
E. Carlos Rodriguez-Merchan MD PhD[2]
1 Department of Plastic and Reconstructive Surgery,
2 Department of Orthopaedic Surgery, La Paz University Hospital-IdiPaz, Madrid, Spain
3 Osteoarticular Surgery Research, Hospital La Paz Institute for Health Research, IdiPAZ (La Paz University Hospital- Autonomous University of Madrid), Madrid, Spain

References

1. Zelle BA, Dang KH, Ornell SS. High-energy tibial pilon fractures: an instructional review. Int Orthop. 2019:1-2.
2. Rb G. Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. J Bone Joint Surg Am. 1976; 58(4):453-8.
3. Dickson KF, Katzman S, Paiement G. The importance of the blood supply in the healing of tibial fractures. Contemp Orthop. 1995; 30(6):489.
4. Menck J, Bertram C, Lierse W. Sectorial angioarchitecture of the human tibia. Cells Tissues Organs. 1992; 143(1):67-73.
5. Tarkin IS, Sop A, Pape HC. High-energy foot and ankle trauma: principles for formulating an individualized care plan. Foot Ankle Clin. 2008; 13(4):705-23.
6. Zelle BA, Bhandari M, Espiritu M, Koval KJ, Zlowodzki M, Evidence-Based Orthopaedic Trauma Working Group. Treatment of distal tibia fractures without articular involvement: a systematic review of 1125 fractures. J Orthop Trauma. 2006; 20(1):76-9.
7. Tarkin IS, Siska PA, Zelle BA. Soft tissue and biomechanical challenges encountered with the management of distal tibia nonunions. Orthop Clin North Am. 2010; 41(1):119-26.
8. Crist BD, Khazzam M, Murtha YM, Della Rocca GJ. Pilon fractures: advances in surgical management. J Am Acad Orthop Surg. 2011; 19(10):612-22.
9. Erichsen JL, Andersen PI, Viberg B, Jensen C, Damborg F, Froberg L. A systematic review and meta-analysis of functional outcomes and complications following external fixation or open reduction internal fixation for distal intra-articular tibial fractures: an update. Eur J Orthop Surg Traumatol. 2019; 29(4):907-17.
10. Bear J, Rollick N, Helfet D. Evolution in management of tibial pilon fractures. Curr Rev Musculoskelet Med. 2018; 11(4):537-45.
11. Molepo M, Barnard AC, Birkholtz F, Tetsworth K, Glatt V, Hohmann E. Functional outcomes of the failed plate fixation in distal tibial fractures salvaged by hexapod external fixator. Eur J Orthop Surg Traumatol. 2018; 28(8):1617-24.
12. Scaglione M, Celli F, Casella F, Fabbri L. Tibial pilon fractures treated with hybrid external fixator: analysis of 75 cases. Musculoskelet Surg. 2019; 103(1):83-9.
13. Vaienti E, Schiavi P, Ceccarelli F, Pogliacomi F. Treatment of distal tibial fractures: prospective comparative study evaluating two surgical procedures with investigation for predictive factors of unfavourable outcome. Int Orthop. 2019; 43(1): 201-7.

14. Dang KH, Ornell SS, Huynh RA, DeLeon JC, Pesek R, Karia RA. Early clinical and radiographic outcomes of a mini-fragment, low profile plating system in tibial plafond fractures. Injury. 2019; 50(10):1773-80.
15. Silluzio N, De Santis V, Marzetti E, Piccioli A, Rosa MA, Maccauro G. Clinical and radiographic outcomes in patients operated for complex open tibial pilon fractures. Injury. 2019; 50:S24-8.
16. Malige A, Yeazell S, Nwachuku C. Surgical fixation of pilon injuries: a comparison of the anterolateral and posterolateral approach. Arch Orthop Trauma Surg. 2019; 139(9):1179-85.
17. Misir A, Kizkapan TB, Yildiz KI, Uzun E, Ozcamdalli M. Traction radiographs versus CT in the evaluation of fracture morphology and consecutive treatment decisions in OTA/AO 43C3 fractures. Injury. 2019; 50(2):332-6.
18. Gates CB, Karthikeyan T, Fu F, Huard J. Regenerative medicine for the musculoskeletal system based on muscle-derived stem cells. J Am Acad Orthop Surg. 2008; 16(2):68-76.
19. Sirkin M, Sanders R, DiPasquale T, Herscovici Jr D. A staged protocol for soft tissue management in the treatment of complex pilon fractures. J Orthop Trauma. 2004; 18(8):S32-8.
20. Krettek C, Bachmann S Pilon fractures. Part 2: Repositioning and stabilization technique and complication management Chirurg. 2015; 86(2):187-201.
21. LeBus GF, Collinge C. Vascular abnormalities as assessed with CT angiography in high-energy tibial plafond fractures. J Orthop Trauma. 2008; 22(1):16-22.
22. Attinger CE, Evans KK, Bulan E, Blume P, Cooper P. Angiosomes of the foot and ankle and clinical implications for limb salvage: reconstruction, incisions, and revascularization. Plast Reconstr Surg. 2006; 117(7S):261S-93S.
23. Carbonell-Escobar R, Rubio-Suarez JC, Ibarzabal-Gil A, Rodriguez-Merchan EC. Analysis of the variables affecting outcome in fractures of the tibial pilon treated by open reduction and internal fixation. J Clin Orthop Trauma. 2017; 8(4):332-8.