The Journal of Foot & Ankle Surgery 58 (2019) 497–501

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

# Efficacy of Pie-Crusting Technique on Soft Tissues in Distal Tibia and Fibula Fractures

Ulas Akgun, MD[1], Umut Canbek, MD[1], Cem Yalin Kilinc, MD[1], Ahmet Emrah Acan, MD[2], Nazim Karalezli, MD[3], Nevres Hurriyet Aydogan, MD[3]

[1] *Assistant Professor, Department of Orthopaedics and Traumatology, Faculty of Medicine, Mugla Sitki Kocman University, Mugla, Turkey*
[2] *Orthopedic Surgeon, Department of Orthopaedics and Traumatology, Mugla Sitki Kocman University Training and Research Hospital, Mugla, Turkey*
[3] *Professor, Department of Orthopaedics and Traumatology, Faculty of Medicine, Mugla Sitki Kocman University, Mugla, Turkey*

ARTICLE INFO

*Level of Clinical Evidence:* 4

*Keywords:*
pilon fractures
postoperative complications
surgical wound dehiscence
surgical wound infection
wound closure techniques

ABSTRACT

Distal tibia and fibula fractures are challenging injuries to treat as evidenced by the high rates of wound complications because of vulnerable soft tissue coverage. The aim of this study was to examine the effect on soft tissue complications of the pie-crusting technique when applied between 2 incisions in distal tibia and fibula fractures treated with open reduction and internal fixation. We reviewed 34 patients with distal tibia and fibula fractures treated between September 2014 and March 2017. The pie-crusting technique was performed during wound closure in 16 (47.06%) fractures (group 1) and classic wound closure was done in 18 (52.94%) fractures (group 2). The primary outcome was evaluated as the presence or absence of soft tissue complications such as superficial skin necrosis, deep skin necrosis, and deep infection. The mean age was 50.44 ± 13.51 (range 23 to 65) years in group 1 and 51.67 ± 14.49 (range 18 to 68) years in group 2. The mean follow-up time was 27.35 ± 9.02 (range 16 to 46) months. The mean surgery time after injury was 5.88 ± 3.5 (range 1 to 14) days in group 1 and 7.32 ± 4.25 (range 1 to 16) days in group 2. No soft tissue complications were seen in any patient in group 1. Five (27.77%) occurrences of superficial skin necrosis were observed in group 2. In 2 (11.11%) patients in group 2, deep necrosis and wound dehiscence occurred, and subsequent deep infection developed in 1 (5.55%) of these patients. The overall complication rate was higher in group 2 ($p = .005$). We believe that the pie-crusting technique is beneficial for wound closure in distal tibia and fibula fractures, because it reduces the tension of the skin and allows leakage of subcutaneous fluids.



Distal tibial fractures are infrequently seen and constitute approximately 0.7% of all fractures (1). In 80% to 90% of these fractures, there is a concomitant fibula fracture (2,3). Because there is limited muscle coverage between the skin and the bone, the soft tissues around the distal tibial region are vulnerable (4). Closure of the surgical incisions may be difficult, especially after surgical procedures on injuries around the ankle caused by high-energy trauma, which can lead to complications such as wound dehiscence and infection (5,6).

Although there is no ideal single method suitable for all patients to avoid soft tissue complications after distal tibia fracture surgery, a 2-stage approach with temporary external fixation and definitive internal fixation after improvement in the condition of the soft tissue is generally preferred (7,8). Furthermore, gentle retraction, a short tourniquet time, a 7- to 10-cm skin bridge between 2 incisions, fixation with low-profile implants, tension-free closure, delayed closure of the fibular incision (if required), and postoperative vacuum sealing drainage are recommended to prevent wound dehiscence (9,10). Despite advancements in modern treatment strategies for distal tibia fractures, soft tissue complications are still encountered (6,11,12).

The pie-crusting technique was first described in the English-language literature by Hasenhuttl (13). There are various synonyms for this technique, such as “dermal fenestration,” “fish-mouthing,” “multiple relaxing skin incisions,” and “tissue meshing” (14–17). In the pie-crusting technique, small transdermal incisions perpendicular to the line of tension are made to facilitate wound closure and to enable subcutaneous wound drainage (18,19).

To the best of our knowledge, there has not been any previous study that compares the efficacy of the pie-crusting technique against classic wound closure in distal tibial fractures. We hypothesized that the pie-crusting technique would provide better wound healing in the early

**Financial Disclosure:** None reported.
**Conflict of Interest:** None reported.

Address correspondence to: Ulas Akgun, MD, Faculty of Medicine, Department of Orthopaedics and Traumatology, Orhaniye Mh. Haluk Ozsoy Cd. Mugla Sitki Kocman University, 48000 Mugla, Turkey.
*E-mail address:* ulasakgun@mu.edu.tr (U. Akgun).

1067-2516/$ - see front matter © 2018 by the American College of Foot and Ankle Surgeons. All rights reserved.
https://doi.org/10.1053/j.jfas.2018.09.027

postoperative period. The aim of this study was to compare the soft tissue complications between the classic wound closure technique and the pie-crusting technique applied between 2 incisions in distal tibia and fibula fractures treated with open reduction and internal fixation.

## Patients and Methods

Approval for the study was granted by the local ethics committee of the institutional review board. The study included 49 consecutive patients who underwent surgery in our clinic with open reduction and internal fixation for isolated Arbeitsgemeinschaft Osteosynthese/Orthopaedic Trauma Association (AO/OTA) type 43 distal tibia and fibula fractures between September 2014 and March 2017 (20). The inclusion criteria were patients with simultaneous internal fixation with plates and screws for distal tibia and fibula fractures. The exclusion criteria were patients treated with staged surgeries (first-stage external fixation and fibula fixation, second-stage definitive tibia fixation), open fractures, concomitant ipsilateral lower extremity fractures, physeal injuries, a period $>6$ weeks since the injury, and a follow-up period $<12$ months. According to these criteria, 34 patients attending a final follow-up examination were included in the study and retrospectively examined. Informed consent was obtained from all participants.

There were 22 (64.7%) males and 12 (35.3%) females in the study, with a mean age of 51.09 ± 13.84 (range 18 to 68) years. The mean time from injury to operation was 6.65 ± 3.93 (range 1 to 16) days. The mean follow-up time was 27.35 ± 9.02 (range 16 to 46) months.

In our clinic, 6 surgeons are interested in orthopedic trauma; 3 surgeons (A.U., C.U., K.C.Y.) apply the pie-crusting technique routinely during wound closure for distal tibia and fibula fractures, while the other 3 perform classic wound closure. Two of these 3 surgeons are unfamiliar with the pie-crusting technique, and the other surgeon prefers not to apply this technique due to cosmetic concerns. The patients were separated into 2 groups according to the wound closure technique used. Group 1 consisted of 16 (47.06%) fractures in which the pie-crusting technique was used, and group 2 consisted 18 of (52.94%) fractures treated with classic wound closure.

Subtypes of the fractures according to AO/OTA classification, the time from injury to surgery, the number of plates used for fixation of distal tibia fracture, and the narrowest distance between the 2 incisions (usually 3 to 5 cm above the ankle mortise level) were recorded. The presence or absence of diabetes mellitus, peripheral arterial disease, and smoking history was also noted. Primary outcomes were evaluated as the absence of soft tissue complications such as superficial skin necrosis, deep skin necrosis, and deep infection.

### *Surgical Technique*

Routine preoperative plain radiographs and computed tomography scans were used for all the patients (Fig. 1). The adequacy for surgery of the soft tissues was evaluated with use of the daily applied wrinkle test. The test is performed via visual assessment and direct palpation of the anterior skin 3 to 5 cm above the ankle mortise level. The test is assumed positive if skin wrinkling is seen. In all patients, the surgical intervention was made under spinal anesthesia and with the use of a tourniquet. The fibula was stabilized first by using a posterolateral approach in all cases. According to the level of the fracture, fixation was provided with a distal precontoured plate or a one-third tubular plate. In most cases, an anteromedial approach was used for the distal tibia. After reduction of the fracture fragments and provision of temporary fixation, the reduction was checked with C-arm fluoroscopy. Depending on the type of fracture, a precontoured medial or anterolateral plate was used for permanent fixation. In some cases, the 2 plates were used together (Fig. 2). No K-wires were left permanently in any of the cases.

After the surgical procedure, the incision used for the distal tibia was closed first, followed by the incision for the fibula. In the group 1 patients, multiple parallel mini-incisions were made longitudinally with a no. 15 scalpel between the 2 incisions. The incisions were 0.5 to 1 cm in length and as deep as the skin thickness (Fig. 3). The required amount of pie-crusting was defined by the bleeding and color of the skin at the edges of the incision after the tourniquet release. Pie-crusting was performed until the skin pallor resolved; the skin color turns pink and bleeding starts from the wound edges. The wound was covered with a sterile gauze, and no other nonadherent-type dressings were used. A short leg posterior splint was applied to the ankle.

Postoperatively, rest, elevation, and ice compresses were applied, and the neurovascular status of the distal extremity was monitored. After recovery from edema and swelling, early joint movements were started. Weightbearing was not permitted until the fracture was healed.

### *Statistical Analysis*

The statistical comparisons of both groups were made with use of the Pearson $\chi^2$ test and the Mann-Whitney $U$ test. A value of $p \leq .05$ was accepted as statistically significant, as calculated by using IBM SPSS Statistics™ (version 22; IBM Corp., Armonk, NY, USA).


**Fig. 1.** (*A*) Plain radiographic anteroposterior and (*B*) lateral views and (*C*) coronal section of computed tomography scan of intra-articular distal tibia fracture.

## Results

The data for both groups related to age, sex, follow-up period, time from injury to surgery, AO/OTA fracture type, number of plates used for distal tibia fracture, distance between the 2 incisions, number of diabetic patients, number of patients with peripheral artery disease, and number of patients with smoking history are shown in Table 1.

No soft tissue complications were seen in any patient in group 1 (Fig. 4). All pie-crusting incisions were healed within 2 weeks.

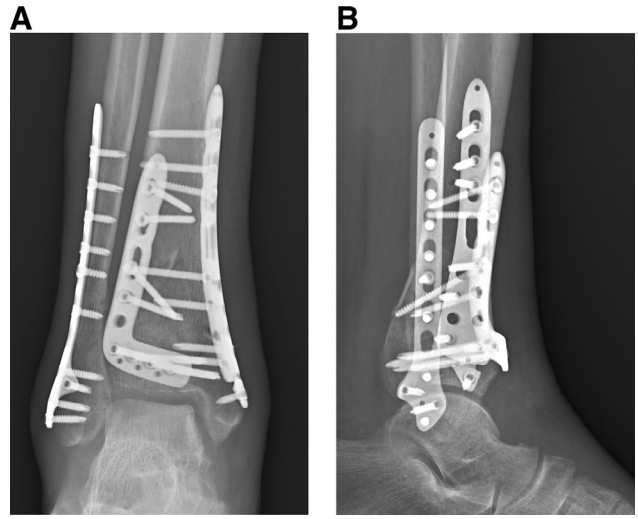


**Fig. 2.** Postoperative plain anteroposterior (*A*) and lateral (*B*) views of patient shown in Fig. 1.

**Fig. 3.** Pie-crusting technique between 2 incisions.

Superficial skin necrosis occurred at the edges of the incision in 5 (27.77%) patients of group 2, and all recovered without the need for additional surgery. In 2 (11.11%) patients in group 2, deep necrosis developed around the anteromedial incision and wound dehiscence (Fig. 5), and subsequent deep infection developed in 1 (5.55%) of these patients. In both patients with deep necrosis, 2 plates were used for distal tibia fracture fixation. These 2 patients were not diabetic and had no peripheral arterial disease and no smoking history. Following antibiotherapy, repeated debridements, and negative pressure wound care, the tissue defects that had formed in these 2 patients were reconstructed with a reverse sural artery flap (Fig. 6). At least 1 complication was observed in 7 (38.88%) patients in group 2, and the overall complication rate was higher in group 2 ($p = .005$). The data on the complications are shown in Table 2.

## Discussion

The treatment of distal tibia fractures is challenging because of thin surrounding soft tissue coverage. After the recommendation of open reduction and internal fixation approaches for distal tibia fractures by Ruedi and Allgower (21), the alarming high rate of complications, such as wound dehiscence and deep infection, led to the search for new treatment strategies (22,23). The current preferred treatment for distal tibial fractures, especially those caused by high-energy trauma, is temporary bridging external fixation and subsequent definitive surgery after a waiting period for soft tissue recovery (24).

However, there are some obvious disadvantages to applying a joint spanning external fixator around the ankle. With this method, early joint movement cannot be made, there is an increased risk of the development of reflex sympathetic dystrophy, and external fixators may be a source of pin site infection (4). Although with lower rates compared with early surgery, soft tissue complications may still be seen with this method even after surgery (11,12).

In recent years, a few studies have been published about an early surgical approach for distal tibia fractures (25). White et al treated 95 consecutive pilon fractures with early open reduction and internal fixation and encountered a 6% soft tissue complication rate (26). Tang et al retrospectively compared results of early and delayed open reduction and internal fixation for pilon fractures and found similar rates (1.3% and 2.6%, respectively) of soft tissue complications (27). Although these results are impressive, they are conflicting with well-known historical data about soft tissue complications after early surgery of pilon fractures and should be very critically analyzed (28).

In the current study, the mean time from injury to surgery was 5.88 ± 3.5 (range 1 to 14) days in group 1 and 7.32 ± 4.25 (range 1 to 16) days in group 2. We believe that the early admission to surgery of patients with extra-articular fractures (AO/OTA 43A) may have lowered the mean time to surgery. We do not suggest early open reduction and internal fixation for all distal tibia and fibula fractures; yet, some of our patients are treated with staged surgeries and excluded from this study. Instead, in patients with distal tibia and fibula fractures, a personalized approach should be taken according to the severity of the soft tissue injury and the fracture type.

Two separate incisions for the distal tibia and the fibula, prolonged operating time, and demanding fracture reduction attempts increase edema and result in tight closure of incisions. This tension starts a process that advances to necrosis of the skin near the wound edges, wound dehiscence, and deep infection (8,9). Leone et al recommended primary closure of the medial wound, followed by delayed primary closure, or primary or delayed split-thickness skin grafting of the fibular wound in the presence of skin tension (29). Wang et al left the incisions open and applied vacuum sealing drainage after pilon fracture surgery, and incisions were gradually closed after the swelling had subsided with pre-prepared sutures. No soft tissue complications were reported with the use of this method (10).

**Table 1**
Patient data (N = 34)

| Variable | Pie-Crust Technique (n = 16) | Classic Wound Closure (n = 18) | *p* Value |
|---|---|---|---|
| Age, y (range) | 50.44 ± 13.51 (23 to 65) | 51.67 ± 14.49 (18 to 68) | .666 |
| Sex, n (%) | | | .057 |
| Male | 13 (81) | 9 (50) | |
| Female | 3 (19) | 9 (50) | |
| Follow-up time, months (range) | 24.69 ± 8.55 (16 to 43) | 29.72 ± 8.98 (19 to 46) | .107 |
| Time from injury to surgery, days (range) | 5.88 ± 3.5 (1 to 14) | 7.32 ± 4.25 (1 to 16) | .299 |
| AO/OTA fracture type, n (%) | | | .868 |
| 43 A | 8 (50) | 8 (44.4) | |
| 43 B | 1 (6.3) | 2 (11.2) | |
| 43 C | 7 (43.7) | 8 (44.4) | |
| Plates used for distal tibia fixation, n (%) | | | .897 |
| 1 | 11 (68.7) | 12 (66.7) | |
| 2 | 5 (31.3) | 6 (33.3) | |
| Diabetes mellitus, n (%) | 3 (18.8) | 5 (27.8) | .536 |
| Peripheral artery disease, n (%) | 0 (0) | 1 (5.6) | .339 |
| Smoking history, n (%) | 5 (31.3) | 4 (22.2) | .551 |
| Distance between 2 incisions (cm) | 8.15 ± 0.79 (range 7 to 9.5) | 8.22 ± 0.94 (range 7 to 10) | .929 |

Abbreviation: AO/OTA, (Arbeitsgemeinschaft Osteosynthese/Orthopaedic Trauma Association).

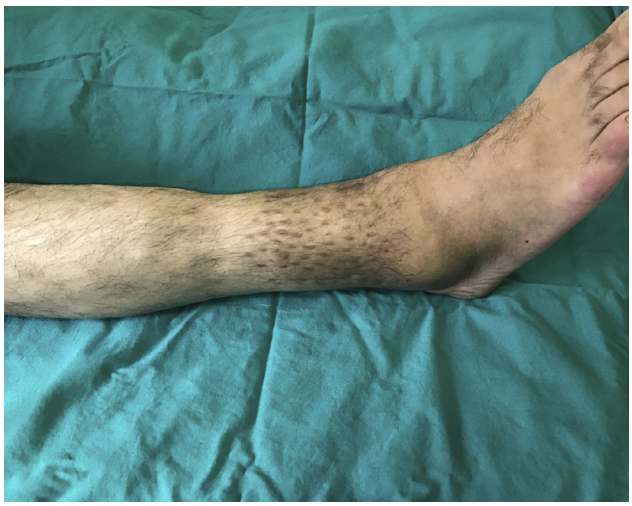

**Fig. 4.** Clinical appearance of a patient in pie-crusting group 6 months after the operation.

In the current study, the pie-crusting technique was used to reduce the tension between the 2 incisions in distal tibia and fibula fractures. The pie-crusting technique was first described in the English-language literature by Hasenhuttl as multiple superficial short skin incisions (13). The principles of this technique are similar to those for meshing a skin graft, as it provides up to 3 times greater tissue expansion and allows drainage of fluid accumulations (30). This technique is also known as dermal fenestration, fish-mouthing, multiple relaxing skin incisions, and tissue meshing (14–17).

Radin applied the pie-crusting technique to the skin around an elevated tibial tubercle in a series of 32 Maquet procedures and reported no soft tissue complications (15), Motley and Holt used a similar technique to repair surgical defects of the lower legs of 5 cases and encountered 1 superficial wound infection that was treated with antibiotics (31). DiStasio et al performed this technique on 22 patients with lower extremity trauma and reported that excellent cosmetic results were achieved and that no soft tissue complications were encountered (16). Poon et al combined the pie-crusting technique with negative pressure wound therapy and reported that good soft tissue results were obtained with minimum scarring in 2 patients with complex ankle-foot injuries (14). Nevertheless, the pie-crusting technique is not widely known in the literature, despite several small case studies reporting the efficacy of the technique on various parts of the body (18). No published comparative study could be found related to the use of this technique in any part of the body or for distal tibia and fibula fractures.

**Fig. 5.** Photograph of a patient in the classic wound closure group showing deep wound necrosis around the anteromedial incision.

**Fig. 6.** Clinical appearance of the patient shown in Fig. 5 at 7 months after flap surgery.

In the current study, no soft tissue complications were encountered in the group where the pie-crusting technique was applied. In cases of classic wound closure, 2 occurrences of wound dehiscence were observed in 2 patients, and deep infection developed in 1 of these patients. In 5 patients, superficial skin necrosis formed at the edges of the incision. The high-risk factors in the impairment of wound healing such as smoking history, diabetes mellitus, and peripheral arterial disease were similar between groups (32). Although there was no statistically significant difference in the rates of wound opening and infection, the number of patients with total complications was statistically significantly higher in the classic wound closure group where pie-crusting was not applied.

In the literature, 3- to 10-mm mini-incisions are generally recommended when using the pie-crusting technique. Although the cosmetic appearance appears to be a disadvantage of this technique, the cosmetic results would be worsened with incisions $>10$ mm, and reliable results were obtained with smaller incisions. In the current study, although the patients were not asked about cosmetic satisfaction, we believe the results were more acceptable than a potential flap surgery.

The pie-crusting technique is a simple-to-apply, safe, economic, and effective method. The most apparent advantages of the method are that expensive additional equipment is not required during the procedure, the learning curve is not long, there is no donor site morbidity, and the probability of requiring secondary surgery is minimized (17,18).

The limitations of the current study are that it was retrospective and the operations were carried out by different surgeons. Although the distribution of fracture types, number of plates used for distal tibia fixation, and patients with diabetes mellitus, peripheral arterial disease, and smoking history between the groups was similar, there was no randomization of the methods applied, the numbers of patients in the groups were small, there were different types of fractures, and the size of groups required to demonstrate a significant difference was not calculated.

**Table 2**
Complications (N = 34)

| Complication | Pie-Crust Technique (n = 16) | Classic Wound Closure (n = 18) | *p* Value |
|---|---|---|---|
| Superficial skin necrosis | 0 (0) | 5 (27.77) | .022 |
| Deep wound necrosis | 0 (0) | 2 (11.11) | .169 |
| Deep infection | 0 (0) | 1 (5.55) | .339 |

Data presented as n (%).

In conclusion, the results of the study demonstrated that fewer soft tissue complications were seen with the pie-crusting technique applied between 2 incisions compared with the classic wound closure used after open reduction and internal fixation of distal tibia and fibula fractures. By reducing the skin tension, the pie-crusting technique facilitates wound closure and reduces edema by allowing the drainage of exudate through the mini-incisions.

## References


1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury 2006;30:691–697.
2. Varsalona R, Lui GT. Distal tibial metaphyseal fractures: The role of fibular fixation. Strateg Trauma Limb Reconstr 2006;1:42–50.
3. Barei DP, Nork SE, Bellabarba C, Sangeorzan BJ. Is the absence of an ipsilateral fibular fracture predictive of increased radiographic tibial pilon fracture severity? J Orthop Trauma 2006;20:6–10.
4. Tarkin IS, Clare MP, Marcantonio A, Pape HC. An update on the management of high-energy pilon fractures. Injury 2008;39:142–154.
5. Song Z, Xue HZ, Zhang K, Li Z, Zhuang Y, Yang N. Pathogenesis and treatment strategies for pilon fractures with ankle dislocation. J Foot Ankle Surg 2015;54:815–820.
6. Molina CS, Stinner DJ, Fras AR, Evans JM. Risk factors of deep infection in operatively treated pilon fractures (AO/OTA: 43). J Orthop 2015;12:S7–S13.
7. Sirkin M, Sanders R, DiPasquale T, Herscovici D. A staged protocol for soft tissue management in the treatment of complex pilon fractures. J Orthop Trauma 2004;18:S32–S38.
8. Calori GM, Tagliabue L, Mazza E, de Bellis U, Pierannunzii L, Marelli BM, Colombo M, Albisetti W. Tibial pilon fractures: which method of treatment? Injury 2010;41:1183–1190.
9. Thordarson DB. Complications after treatment of tibial pilon fractures: prevention and management strategies. J Am Acad Orthop Surg 2000;8:253–265.
10. Wang Z, Qu W, Liu T, Zhou Z, Zhao Z, Wang D, Cheng L. A two-stage protocol with vacuum sealing drainage for the treatment of type C pilon fractures. J Foot Ankle Surg 2016;55:1117–1120.
11. Joveniaux P, Ohl X, Harisboure A, Berrichi A, Labatut L, Simon P, Mainard D, Vix N, Dehoux E. Distal tibia fractures: management and complications of 101 cases. Int Orthop 2010;34:583–588.
12. Viberg B, Kleven S, Hamborg-Petersen E, Skov O. Complications and functional outcome after fixation of distal tibia fractures with locking plate: a multicentre study. Injury 2016;47:1514–1518.
13. Hasenhuttl K. The treatment of unstable fractures of the tibia and fibula with flexible medullary wires: a review of two hundred and thirty-five fractures. J Bone Joint Surg Am 1981;63:921–931.
14. Poon H, Le Cocq H, Mountain AJ, Sargeant ID. Dermal fenestration with negative pressure wound therapy: a technique for managing soft tissue injuries associated with high-energy complex foot fractures. J Foot Ankle Surg 2016;55:161–165.
15. Radin EL. The Maquet procedure—anterior displacement of the tibial tubercle: indications, contraindications, and precautions. Clin Orthop Relat Res 1986;213:241–248.
16. DiStasio AJ, Dugdale TW, Deafenbaugh MK. Multiple relaxing skin incisions in orthopaedic lower extremity trauma. J Orthop Trauma 1993;7:270–274.
17. Wong TW, Sheu HM, Lee JY, Chao SC. Use of tissue meshing technique to facilitate side to side closure of large defects. Dermatol Surg 1998;24:1338–1341.
18. Singh D, Lomax A. Piecrusting to facilitate skin closure. Foot Ankle Spec 2016;9:367–371.
19. Dunbar RP, Taitsman LA, Sangeorzan BJ, Hansen ST. Technique tip: use of "pie crusting" of the dorsal skin in severe foot injury. Foot Ankle Int 2007;28:851–853.
20. Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, Prokuski L, Sirkin MS, Ziran B, Henley B, Audigé L. Fracture and dislocation classification compendium—2007: Orthopaedic Trauma Association Classification, Database and Outcomes Committee. J Orthop Trauma 2007;21(suppl 10):S1–S133.
21. Ruedi TP, Allgower M. The operative treatment of intra-articular fractures of the lower end of the tibia. Clin Orthop Relat Res 1979;138:105–110.
22. Teeny SM, Wiss DA. Open reduction and internal fixation of tibial plafond fractures. Variables contributing to poor results and complications. Clin Orthop Relat Res 1993;292:108–117.
23. Bonar SK, Marsh JL. Tibial plafond fractures: Changing principles of treatment. J Am Acad Orthop Surg 1994;2:297–305.
24. Lavini F, Dall'Oca C, Mezzari S, Maluta T, Luminari E, Perusi F, Vecchini E, Magnan B. Temporary bridging external fixation in distal tibial fracture. Injury 2014;45(suppl 6):S58–S63.
25. White TO, Guy P, Cooke CJ, Kennedy SA, Droll KP, Blachut PA, O'Brien PJ. The results of early primary open reduction and internal fixation for treatment of OTA 43.C-type tibial pilon fractures: a cohort study. J Orthop Trauma 2010;24:757–763.
26. Cronier P, Steiger V, Rammelt S. Early open reduction and internal fixation of pilon fractures. Fuß Sprunggelenk 2012;10:12–26.
27. Tang X, Liu L, Tu CQ, Li J, Li Q, Pei FX. Comparison of early and delayed open reduction and internal fixation for treating closed tibial pilon fractures. Foot Ankle Int 2014;35:657–664.
28. Jain D, Selhi HS, Yamin M, Mahindra P. Soft tissue complications in distal tibial fractures managed with medial locking plates: a myth or reality? J Clin Orthop Trauma 2017;8(suppl 2):S90–S95.
29. Leone VJ, Ruland RT, Meinhard BP. The management of soft tissues in pilon fractures. Clin Orthop Relat Res 1993;292:315–320.
30. Tanner JC, Vandeput J, Olley JF. The mesh skin graft. Plast Reconstr Surg 1964;34:287–292.
31. Motley RJ, Holt PJ. The use of meshed advancement flaps in the treatment of lesions of the lower leg. J Dermatol Surg Oncol 1990;16:346–348.
32. Abdelgaid SM, Moursy AF, Elgebaly EAA, Aboelenien AM. Minimally invasive treatment of ankle fractures in patients at high risk of soft tissue wound healing complications. J Foot Ankle Surg 2018;57:557–571.