

Subject Area: Orthopedic Surgery

The Effect Of The Primary Wound Closure Technique In The Surgical Treatment Of Closed Intra-Articular Calcaneal Fractures

Mohamed M. Abd El-Monem Gafar

Orthopaedic Surgery, Banha Teaching Hospital, Egypt, mgafar70@hotmail.com

Ashraf Hassen M. Mohammed

Orthopaedic Surgery, Qeft Teaching Hospital, Egypt

Ahmed A. Elseadawy

Orthopaedic Surgery, Banha Teaching Hospital, Egypt

Mohamed Salah Labib

Orthopaedic Surgery, Banha Teaching Hospital, Egypt

Follow this and additional works at: <https://jmisr.researchcommons.org/home>



Part of the [Medical Sciences Commons](#), and the [Medical Specialties Commons](#)

Recommended Citation

Gafar, Mohamed M. Abd El-Monem; Mohammed, Ashraf Hassen M.; Elseadawy, Ahmed A.; and Labib, Mohamed Salah (2024) "The Effect Of The Primary Wound Closure Technique In The Surgical Treatment Of Closed Intra-Articular Calcaneal Fractures," *Journal of Medicine in Scientific Research*: Vol. 7: Iss. 3, Article 5.

DOI: <https://doi.org/10.59299/2537-0928.1378>

This Original Study is brought to you for free and open access by Journal of Medicine in Scientific Research. It has been accepted for inclusion in Journal of Medicine in Scientific Research by an authorized editor of Journal of Medicine in Scientific Research. For more information, please contact m_a_b200481@hotmail.com.

ORIGINAL STUDY

The effect of the primary wound closure technique in the surgical treatment of closed intra-articular calcaneal fractures

Mohamed M. Abd El-Monem Gafar ^{a,*}, Ashraf H.M. Mohammed ^b,
Ahmed A. Elseadawy ^a, Mohamed S. Labib ^a

^a Department of Orthopaedic Surgery, Banha Teaching Hospital, Banha, Al-Qalyubia, Egypt

^b Department of Orthopaedic Surgery, Qeft Teaching Hospital, Qena, Egypt

Abstract

Aim: To assess the impact of the primary wound closure method in the surgical management of closed intra-articular calcaneal fractures, to improve postoperative wound healing, reduce complications, minimizing expenses, enhancing overall functional outcomes, and restoring foot function and patients' quality of life.

Design: Our study, a prospective and retrospective cohort clinical study, was conducted in our hospitals.

Patients and methods: Twenty-eight patients with 31 intra-articular calcaneal fractures were enrolled, following stringent inclusion and exclusion criteria for patient selection. These patients underwent open reduction using an extensile lateral approach and internal fixation with plates and screws at our institution between November 2020 and August 2023. Sixteen fractures were closed using the modified Allgöwer-Donati technique, while the remaining fifteen fractures were closed using the conventional vertical mattress suturing technique.

Results: The overall incidence of postoperative wound complications in the operated fractures in our series was 32.26% (10 out of 31 operated fractures). Two (12.5%) cases from the first group, which used the modified Allgöwer-Donati suturing technique, compared with 8 (53.33%) cases from the second group, which used the traditional vertical mattress suturing technique, showed postoperative wound complications in our series.

Conclusion: The use of the modified Allgöwer-Donati technique for surgical wound closure following open reduction and internal fixation of fresh closed intra-articular calcaneal fractures in adult patients resulted in improved wound healing and reduced post-operative wound complications compared with the standard technique. This improvement is attributed to the technique's ability to relieve tension on wound edges, which enhances skin vascularity and perfusion.

Keywords: Allgöwer-Donati technique, Calcaneus, Fracture, Postoperative wound complications

1. Introduction and rationale

Managing fractures of the calcaneus and associated soft tissue injuries poses a significant challenge [1]. The calcaneus, primarily made up of cancellous bone, is susceptible to deformation due to traumatic compressive events. Surgery is often necessary for perfect reduction and rigid fixation, particularly for intra-articular fractures, but it is technically demanding. Advances in diagnosis and internal fixation have made surgery a viable

treatment option with many authors reporting favorable outcomes [2,3]. However, the calcaneus has limited soft tissue coverage, with only a thin layer of skin and subcutaneous tissue. Any injury, including surgical intervention, can damage this soft tissue coverage and compromise its blood supply [4]. These postoperative wound complications can significantly impact treatment outcomes [5]. Therefore, improving surgical techniques to reduce these complications is crucial for enhancing overall treatment outcomes.

Received 26 March 2024; accepted 11 June 2024.
Available online 1 August 2024

* Corresponding author at: Orthopaedic Department, Banha Teaching Hospital, Al-Qalyubia, Egypt.
E-mail address: mgafar70@hotmail.com (M.M. Abd El-Monem Gafar).

<https://doi.org/10.59299/2537-0928.1378>

2537-0928/© 2024 General Organization of Teaching Hospitals and Institutes (GOTHI). This is an open access article under the CC BY-NC-SA 4.0 license (<https://creativecommons.org/licenses/by-nc-sa/4.0/>).

2. Specific aim and hypotheses

The occurrence of postoperative wound complications has been documented to reach up to 32.8% [3,5]. Carow *et al.* [6] found that nearly 30% of patients who undergo open reduction and internal fixation (ORIF) for calcaneal fractures will experience postoperative wound complications. Several authors have examined the factors contributing to these complications, which can be related to either patient factors (such as diabetes mellitus, limb vascularity, and smoking) or procedural factors (including surgeon experience, timing of surgery, improper soft tissue handling, extensive surgical dissection, and choice of wound closure technique).

This study aims to enhance postoperative wound healing in surgically managed intra-articular calcaneal fractures using ORIF. The goal is to improve the surgical wound closure technique to reduce postoperative wound complications (such as necrosis of wound edges, wound dehiscence, active discharge, superficial infections, delayed healing, or non-healing), ultimately leading to better treatment outcomes.

Donati's suture, also known as a vertical mattress suture, involves starting with through stitches that grasp the subcutaneous tissue from one side of the wound to the other. The stitches then continue by suturing only the dermis on the second side of the wound before returning to suture the dermis on the primary first side, creating a far-far-near-near (F-F-N-N) configuration. The Allgöwer-Donati Suture, or Allgöwer modification of Donati's suture, is a technique that serves as a transition between a subcuticular suture and a Donati's or vertical mattress suture. It comprises a subcutaneous suture on one side and an intracutaneous suture (sunk) on the other side, or a far-subcutaneous-near (F-S-N) configuration. This technique preserves the microcirculation to the skin and the wound edge intact (Fig. 1).

In our study, we sought to explore additional factors affecting wound healing. We employed the modified Allgöwer-Donati technique for primary surgical wound closure in adult patients with recent closed intra-articular calcaneal fractures treated with ORIF. We compared outcomes with those using the standard wound closure technique (vertical mattress suturing technique). The Allgöwer-Donati suture brings the dermal matrix of both wound sides in contact without folding or kinking, minimizing its effect on cutaneous blood flow compared with other suture techniques.

In a study utilizing a single porcine model to evaluate different suture techniques, it was observed

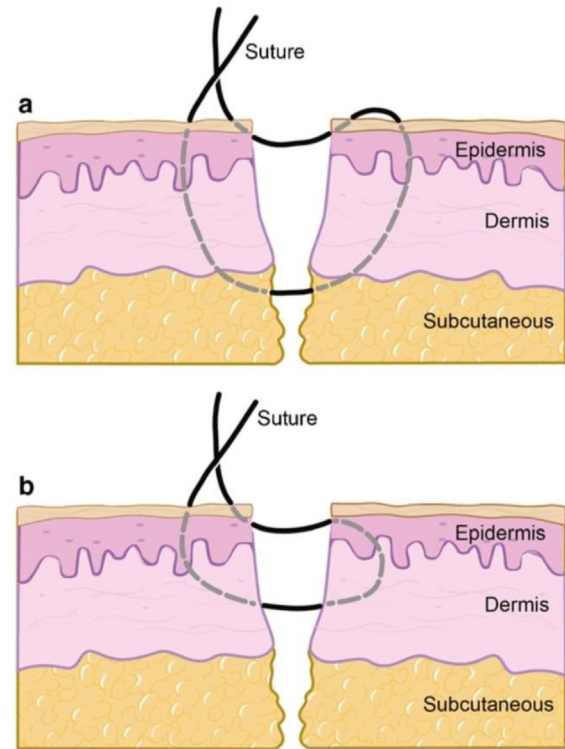


Fig. 1. Drawing showing difference between (a) Donati vertical mattress suture technique far-far-near-near and, (b) modified Allgöwer-Donati suture technique far-subcutaneous-near.

that as tension increased on the suture, the Allgöwer-Donati modification of the vertical mattress technique [7] showed the least alteration in cutaneous blood flow compared with the vertical mattress, horizontal mattress, and simple interrupted suture techniques. There was no statistically significant difference between the other suture patterns when compared with each other at all tension levels [8].

Our hypothesis posits that employing the modified Allgöwer-Donati technique for surgical wound closure following ORIF of recent closed intra-articular calcaneal fractures in adult patients enhances wound healing and reduces postoperative wound complications compared with the standard wound closure technique.

3. Background/significance

Fractures of the calcaneus, especially those involving the joint, are serious injuries often necessitating precise anatomical realignment through ORIF. Achieving this alignment is critical for restoring pain-free foot movement and weight-bearing, essential functions of the foot. However, performing ORIF in the hindfoot can result in a range of complications, particularly wound issues

like necrosis of wound edges, wound separation, and superficial infections. Various factors can affect the healing of surgical wounds. In our research, we explored the influence of the primary wound closure method in the surgical treatment of intra-articular calcaneal fractures.

Our study's significance lies in enhancing post-operative wound healing after ORIF for intra-articular calcaneal fractures. This enhancement can result in improved overall surgical outcomes, decreased costs, and the restoration of foot and patient functionality.

4. Research design and methodology

4.1. Study design

Our study was conducted as a prospective and retrospective cohort clinical study in our hospitals from November 2020 to August 2023. After ORIF of their intra-articular calcaneal fractures, 16 fractures were closed using the modified Allgöwer-Donati technique, and 15 fractures were closed using the traditional vertical mattress suturing technique.

4.2. Study population

Our study included a total of 28 patients with 31 intra-articular calcaneal fractures (three patients had bilateral fractures), divided into two groups. The study population was collected from our Emergency Room (ER) or Outpatient Department (OPD). Several inclusion and exclusion criteria were respected in patient selection.

4.3. Inclusion criteria

All included patients were adults who had reached skeletal maturity (after closure of the epiphyseal plates), with an average age of 14 years for females and 16 years for males. They were post-traumatically gathered from our Outpatient Department (OPD) or Emergency Room (ER), diagnosed with displaced intra-articular calcaneal fractures, deemed suitable for ORIF, had recent fractures (within 2 weeks), and had closed fractures.

4.4. Exclusion criteria

Young patients (skeletally immature), extra-articular fractures, pathological fractures, or minimally displaced fractures, open fractures, old fractures (more than 2 weeks), diabetic patients, chronic limb ischemia (confirmed by doppler), heavy smokers, severe swelling or skin blisters after two weeks of

elevation and treatment, and patients with debilitating diseases.

We analyzed 28 patients (with 31 intra-articular calcaneal fractures), comprising 23 males and five females, with a male-to-female ratio of 4.6:1. The mean age of the patients was 36.32 years, ranging from 17 to 58 years. Among them, 14 patients had right-sided fractures, 11 had left-sided fractures, and three had bilateral fractures. The primary mechanism of injury, observed in 21 (75%) cases, was falling from a height. In terms of occupation, the majority of patients (23; 82.14%) were blue-collar workers, while three (10.71%) were white-collar workers, and two (7.14%) were unemployed. All fractures were classified according to the Essex-Lopresti and Sander classification, and they were all closed fractures. The duration from injury to surgery ranged from 1 to 14 days, with a mean delay of 7.4 days, as detailed in [Table 1](#) and [Figs. 2 and 3](#).

4.5. Study technique and protocol

Our study was carried out in the orthopedic departments as a prospective and retrospective cohort clinical study, spanning from November 2020 to August 2023. A total of 28 patients with 31 intra-articular calcaneal fractures were enrolled, following the specified inclusion and exclusion criteria. Written approval was obtained from the Institutional Review Board (IRB) and Research Ethics Committee before commencing the research.

Before the surgery, patients were given informed consent by the revised Helsinki Declaration of 2000. Patient selection criteria included factors such as gender, occupation, fracture side or bilaterality, and a detailed description of the injury mechanism. Fractures were classified using the Essex-Lopresti and Sander classifications, and all fractures were recent (within 2 weeks) and closed. A thorough assessment was conducted for all patients.

The timing of the surgery is critical. Surgery might be postponed until the swelling reduces, skin wrinkling is evident, good capillary filling is observed, and there are no skin blisters (achieved through limb elevation, cold compression, and anti-edematous medication). However, surgery should not be postponed beyond 2 weeks to prevent fracture consolidation [9].

Table 1. Duration of delaying from injury till surgery in our series.

Time of surgery (Days)	N (Patients) (%)
1st –7th	16 (57.14)
8th–14th	12 (42.86)
Total	28 (100)

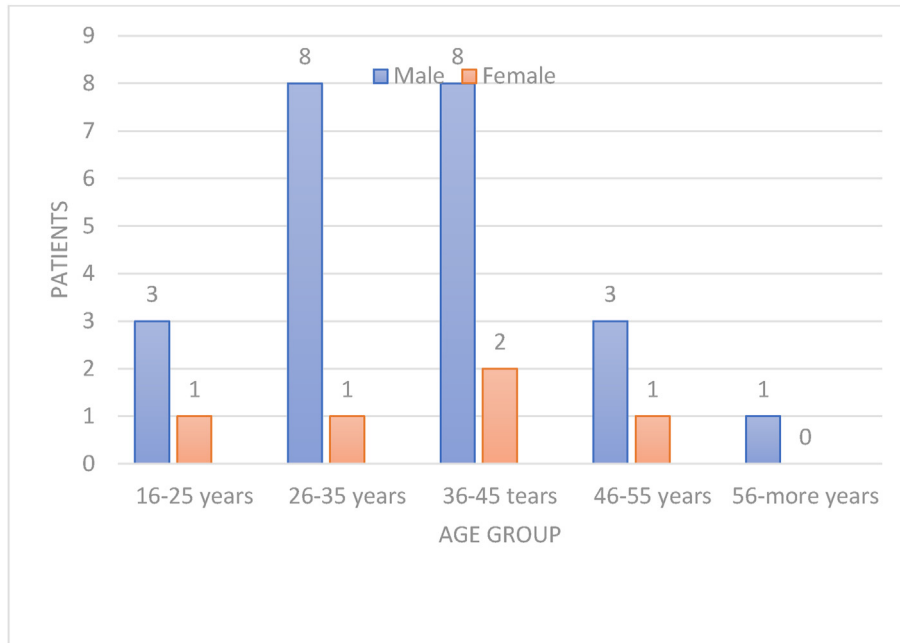


Fig. 2. Age groups distribution in correlation with the sex.

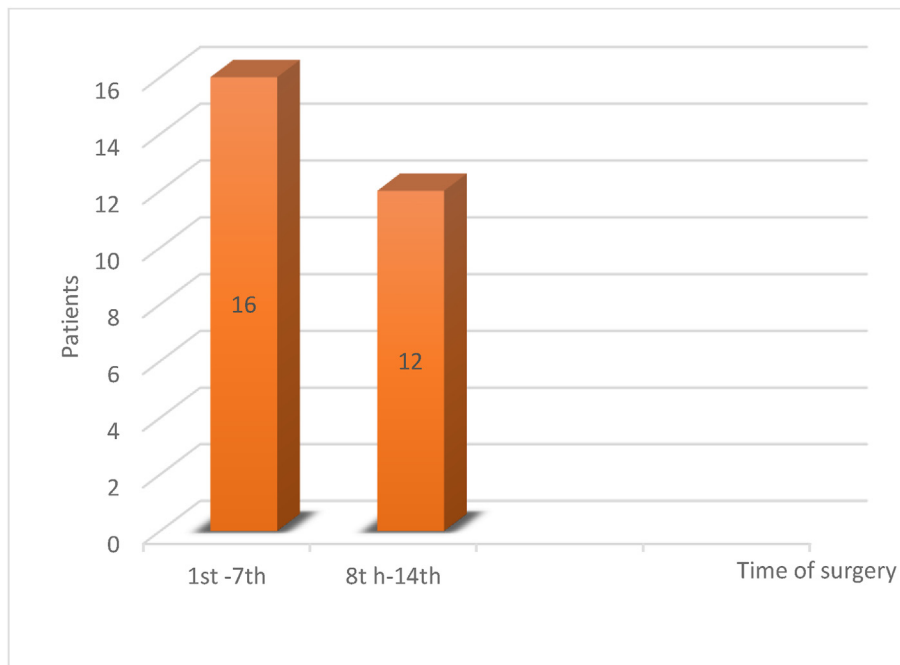


Fig. 3. Duration of delaying from injury till surgery in our series.

All patients underwent surgery through ORIF using an extended lateral approach. A tourniquet was applied in all instances, and a noncontact technique, full-thickness flap, and careful soft tissue management were utilized. The fractures were firmly fixed internally using low-profile locked calcaneal plates (Fig. 4).

For wound closure, a deep Hemovac drain was inserted. In the first group of 16 fractures, we utilized the modified Allgöwer-Donati technique. This involved using deep #0 absorbable sutures in an interrupted, figure-of-eight pattern, starting at the top of the incision (Fig. 5) and moving towards the proximal and distal ends (refer to Fig. 6a and b). The



Fig. 4. The surgical wound is ready for closure after the calcaneal fracture was reduced and rigidly fixed by a low profile locked calcaneal plate.



Fig. 5. The modified Allgöwer-Donati technique, beginning with the apex of the incision.

sutures were then individually tied by hand, progressing towards the two ends of the incision. In the second group of 15 fractures, the wound was closed using the conventional vertical mattress suturing technique.

After closure in both groups, the tourniquet was deflated, and sterile dressings were applied, followed by a large Jones dressing, as seen in postoperative images (Figs. 7 and 8). The operated limb was kept elevated, an elastic compression stocking

was worn, and analgesics and intravenous antibiotics were given for 72 h after the surgery, followed by prophylactic oral antibiotics for an additional week. The Hemovac drain was removed 48 h after the surgery. Patients were encouraged to start moving early. Anticoagulant therapy was stopped once the patient began moving out of bed.

Follow-up: The wounds were inspected and dressed every other day for any wound complications (such as edge necrosis, dehiscence, superficial infection, active discharge, delayed healing, or nonhealing). The stitches were removed after three weeks in both groups, and a final assessment of wound healing was conducted. Fig. 9 shows the final, successful complete wound healing after stitch removal (modified Allgöwer-Donati stitches) 3 weeks postoperatively.

4.6. Statistical analysis

We utilized descriptive statistics and various charts to illustrate the demographics and other characteristics of our patients. The analysis of our results, determining whether the postoperative wounds healed without complications, was conducted using P values. Our findings and results will be analyzed using the STATA program.

5. Results

Wound complications evidence that were taken into consideration were wound edges necrosis, dehiscence, superficial infection, active discharge, delayed healing, or nonhealing. In our research, out of thirty-one fractures cases, there were ten cases with post-operative wound complications with an overall ratio of 32.26%. Two fractures cases from the first group which used the modified Allgöwer-Donati technique, with a ratio of 12.5%, and eight fractures cases from the second group which used the traditional vertical mattress suturing technique with ratio of 53.33%. No. of complicated fractures cases was significantly lower in the first group (modified Allgöwer-Donati technique) compared with second group (traditional vertical mattress technique) (12.5% vs. 53.33%. $P = 0.023$) (Table 2) and (Fig. 10).

6. Discussion

Surgical closure of wounds with hypovascular skin flaps, such as after ORIF for calcaneal fractures, should be performed gently, minimizing tension on the wound edges to avoid the risk of devascularizing the edges. This approach helps reduce post-operative wound complications (such as edge



Fig. 6. (a, b) The modified Allgöwer-Donati technique, progressing the suture to the proximal and distal ends of the incision.



Fig. 7. The modified Allgöwer-Donati technique, immediate post-operative wound.

necrosis, dehiscence, superficial infection, active discharge, delayed healing, or non-healing) and improves overall treatment outcomes. The Allgöwer-Donati suture technique offers the advantage of grasping a relatively broad amount of tissue, spreading the tension force over a large area while minimizing disruption of vertical blood flow compared with a truly horizontal mattress suture. This technique is particularly useful in primary surgical wound closure after ORIF for calcaneal



Fig. 8. The traditional vertical mattress suturing technique, after haemovac removal postoperatively.



Fig. 9. Soundly complete wound healing after stitches (modified Allgöwer-Donati stitches) removal 3 weeks postoperatively.

Table 2. Results of the effect of the primary wound closure technique in the surgical treatment of closed intra-articular calcaneal fractures in our research series.

	Number of operated fractures cases	Number of complicated fractures cases. (%)	P value
First group (modified Allgöwer-Donati technique).	16	2 (12.5)	0.023 ^a
Second group (traditional vertical mattress technique).	15	8 (53.33)	
Total cases	31	10 (32.26)	

^a Statistically significant as P value less than 0.05.

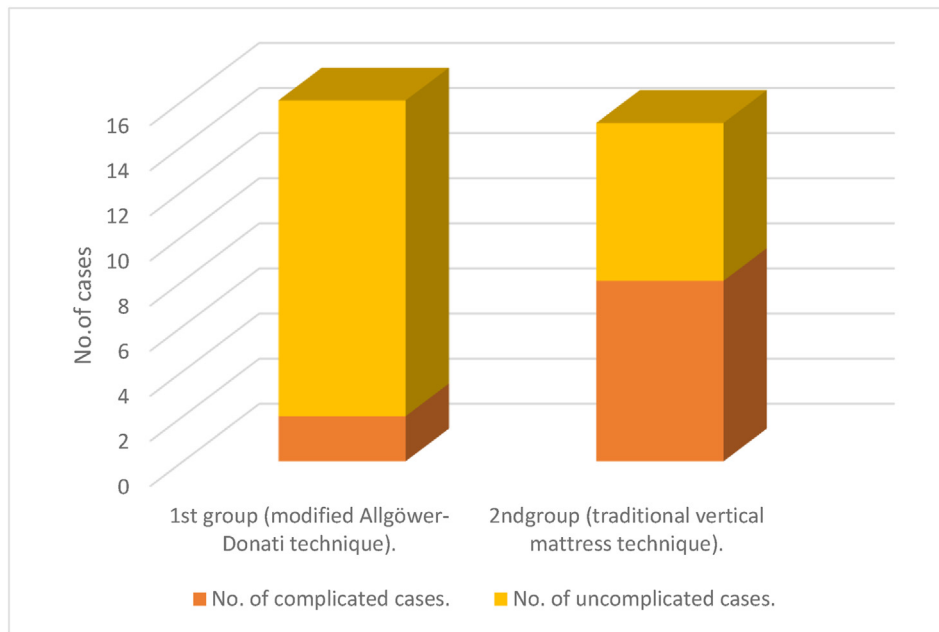


Fig. 10. Results of the effect of the primary wound closure technique in the surgical treatment of closed intra-articular calcaneal fractures in our research series.

fractures, as this area is anatomically less vascularized than others. Furthermore, when properly applied, the Allgöwer-Donati suture technique results in cosmetically acceptable scars [10].

In their study, Shannon *et al.* [11] compared the Allgöwer-Donati and vertical mattress suture techniques to evaluate which primary wound closure technique for ankle fractures provides the most robust perfusion, as measured by laser-assisted indocyanine green angiography. They conducted a study with two randomized groups, each consisting of 15 participants undergoing ORIF for ankle fractures. One group underwent closure with the Allgöwer-Donati technique, while the other group underwent closure with the vertical mattress technique. The study concluded that the Allgöwer-Donati suture technique offers improved incision perfusion compared with vertical mattress closure after open reduction internal fixation of ankle fractures [11].

In their study, Sagi *et al.* used color Doppler to investigate the effect of different suturing

techniques on cutaneous blood flow in a pig model [12]. They found that the Allgöwer-Donati suture caused the least distortion of cutaneous blood flow compared with the vertical mattress or simple suture techniques as tension was increased. The use of a porcine model is widely recognized in scientific literature as a reliable representation of human skin in terms of blood supply, flow dynamics, and wound-healing properties [13,14].

In our study, the number of complicated post-operative wounds was significantly lower in the first group ($n = 16$, using the modified Allgöwer-Donati technique) compared with the second group ($n = 15$, using the traditional vertical mattress technique) (12.5% vs. 53.33%). This difference yielded a calculated P value of 0.023, indicating statistical significance.

6.1. Conclusion

Two (12.5%) cases from the first group, which used the modified Allgöwer-Donati suturing

technique, experienced postoperative wound complications, compared with 8 (53.33%) cases from the second group, which used the traditional vertical mattress suturing technique. This demonstrates a higher incidence of post-operative wound complications in the second group. Hence, employing the modified Allgöwer-Donati suturing technique for surgical wound closure following ORIF of recent closed intra-articular calcaneal fractures in adult patients enhanced wound healing and reduced postoperative wound complications compared with the standard suturing technique. This method alleviates tension on the wound edge, promoting improved vascularity and perfusion to the skin. Surgeons should take this into account when selecting closure techniques for calcaneal fractures.

Financial support and sponsorship

Nil.

Institutional review board (IRB) approval number

HB000115.

Conflicts of interest

There are no conflicts of interest.

References

- [1] Sanders R, Fortin P, DiPasquale T, Walling A. Operative treatment in 120 displaced intraarticular calcaneal fractures. Results using a prognostic computed tomography scan classification. *Clin Orthop* 1993;290:87–95.
- [2] Be'zes H, Massart P, Delvaux D, Fourquet JP, Taz F. The operative treatment of intraarticular calcaneal fractures. *Clin Orthop Relat Res* 1993;290:55–9. View Record in ScopusCiting articles (122).
- [3] Leung KS, Yuen KM, Chan WS. Operative treatment of displaced intra-articular fractures of the calcaneum. Medium-term results. *J Bone Joint Surg* 1993;75-B:196–201. View Record in ScopusCiting articles (112).
- [4] Thornes BS, Collin AL, Timlin M, Corrigan J. Outcome of calcaneal fractures treated operatively and non-operatively. The effect of litigation on outcomes. *Ir J Med Sci* 2002;171:155–7.
- [5] Folk JW, Starr AJ, Early JS. Early wound complications of operative treatment of calcaneus fractures: analysis of 190 fractures. *J Orthop Trauma* 1999;13:369–72.
- [6] Carow JB, Carow J, Gueorguiev B, Klos K, Herren C, Pishnamaz M, et al. Soft tissue micro-circulation in the healthy hindfoot: a cross-sectional study with focus on lateral surgical approaches to the calcaneus. *Int Orthop* 2018;42:2705–13.
- [7] Mueller ME, Allgower M, Scheider R. *Manual of internal fixation. Techniques recommended by the AO-ASIF group.* third ed. New York: Springer-Verlag; 1995.
- [8] Sagi HC, Papp S, DiPasquale T. The effect of suture pattern and tension on cutaneous blood flow as assessed by laser Doppler flowmetry in a pig model. *J Orthop Trauma* 2008;22:171–5.
- [9] Abd El-Monem Gafar MM, Al-Akkad MT, Mostafaet A. New concept of delayed open reduction and internal fixation of closed recent intra-articular calcaneal fractures. *Int J Sci Res (IJSR)* 2016;5:5. paper ID: Nov 163565.
- [10] *AO principles of fracture treatment. Second expanded edition.* Thomas P Ruedi, Richrd E Buckley, Christopher G Moran.
- [11] Shannon SF, Houdek MT, Wyles CC, Yuan BJ, Cross WW, Cass JR, et al. Allgower-donati versus vertical mattress suture technique impact on perfusion in ankle fracture surgery: a randomized clinical trial using intra-operative angiography. *J Orthop Trauma* 2017;31:97–102.
- [12] Shannon Steven FMD, Houdek Matthew TMD, Wyles Cody CBS, Yuan Brandon JMD, Cross William WIIMD, Cass Joseph RMD, et al. *Journal of orthopaedic trauma: post acceptance 07 October 2016.* *J Orthop Trauma* 2008;22:171–5.
- [13] Germann GK, Eriksson E, Russell RC, Mody N. Effect of arteriovenous flow reversal on blood flow and metabolism in a skin flap. *Plast Reconstr Surg* 1987;79:375–80.
- [14] Myers B, Donovan W. The location of the blood supply in random flaps. *Plast Reconstr Surg* 1976;58:314–6.