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Original Article

Management of ankle fractures in diabetic patients: case series of seven patients

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Abstract

Objectives: To evaluate the effectiveness and safety of retrograde intramedullary nailing with antibiotic-impregnated cement in the management of ankle fractures in diabetic patients with peripheral neuropathy, focusing on postoperative outcomes.

Methods: This study included seven diabetic patients with traumatic ankle fractures and peripheral neuropathy. Postoperative data collection was performed, focusing on evaluating fracture healing through radiographic evidence, time to achieve full weight-bearing, and any complications, including infection, wound dehiscence, or the need for additional surgical intervention.

Results: Regarding postoperative complications, among seven diabetic patients with ankle fractures, only one patient developed a medial foot ulcer. Four patients achieved full weight-bearing without pain within five months, and no cases of delayed union, malunion, or nonunion were recorded.

Conclusions: Orthopedic surgeons face challenges treating ankle fractures in diabetic patients due to high morbidity and mortality rates. Our case series demonstrated that the minimally invasive tibiotalocalcaneal option may reduce infection risk and require fewer operations, with only one postoperative complication and no intraoperative issues.

Level of evidence IV; Case series.

Keywords: Ankle fractures; Arthrodesis; Peripheral vascular disease; Diabetes mellitus.

Introduction

Ankle fractures in diabetic patients are challenging. Most diabetic patients have existing peripheral neuropathy, arthropathy, vasculopathy, or poor bone quality, which makes fracture management difficult and controversial. Due to these pre-existing conditions in this population, high rates of nonunion, malunion, delayed union, or wound infections are anticipated[1]. These patients have a higher risk of complications than diabetic patients without pre-existing diabetes-related complications and non-diabetic patients[2]. Moreover, diabetic patients with high haemoglobin A1c (HbA1c) or uncontrolled blood glucose show poor prognosis even after receiving the appropriate management for their fracture[3].

The mainstream management of ankle fractures can be operative with either open reduction and internal fixation (ORIF), external fixation, or non-operative, depending on the type of fracture and the condition of surrounding soft tissues. For diabetic patients, non-operative treatment carries a significantly higher risk of complications when compared to operative one[4].

However, operative treatment itself is still controversial, with much ongoing research discussing surgical options and their outcomes for this population. One of the options that has been recently introduced is primary arthrodesis in the form of tibiotalocalcaneal (TTC) fusion, especially since most patients managed by fracture fixation already end with a fused ankle[5]. This approach also allows for a minimally invasive technique

Study performed at the King Salman Armed Forces Hospital, Tabuk, Saudi Arabia.

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to minimize the risk of infection, with evidence that this technique is associated with a lower number of operations when compared to other surgical management options[5]. This technique is well-documented in the literature, with previous studies showing that the use of antibiotic-coated intramedullary nails provides both mechanical stability and localized antibiotic delivery, significantly lowering the risk of postoperative infections[6]

Although TTC has promising outcomes, more studies are needed to provide better evidence regarding its advantages. According to our latest research, all available evidence to date is limited to case-series designs, which have provided good outcomes[7-9]. Similar studies have highlighted the importance of this approach, noting that TTC nailing has become an increasingly preferred method for managing complex ankle fractures in high-risk patients due to its ability to provide stable fixation and reduce the risk of infection[10].

However, no studies have been published in Saudi Arabia about this technique. The objective of this study is to show the postoperative outcomes and patients' satisfaction in our center as the first one in Saudi Arabia, to add evidence to the literature, and to help future researchers study larger data from different regions. Additionally, we describe a different surgical approach in an attempt to minimize the risk of infection.

Methods

This study has been approved by the Institutional Review Board (IRB) and Ethics Committee of our Institution, and the patients included in the study signed the Informed Consent form. The study was conducted at a tertiary care facility in Tabuk, Saudi Arabia. A consecutive series of nine diabetic patients was included who sustained traumatic ankle fractures and had peripheral neuropathy, with or without peripheral vascular disease (PVD). These patients, who were treated surgically between 2019 and 2023, were considered at high risk for postoperative infection if managed with classic treatment methods such as ORIF. Peripheral neuropathy was confirmed based on clinical examination (diminished monofilament sensation and absent ankle reflexes). PVD was identified using ankle-brachial index (ABI < 0.9). One patient with talus avascular necrosis (AVN) was excluded from the study based on the inclusion criteria. Additionally, during the follow-up period, one patient passed away due to an unrelated medical condition, giving the final data of seven patients with follow-up.

The inclusion criteria specifically targeted diabetic patients with peripheral neuropathy and/or PVD submitted to antibiotics-coated TTC nailing as a primary treatment for their ankle fractures. Any patient who did not meet these criteria was excluded.

Data collection

Collected data included patient demographics, comorbid conditions, HbA1c levels, presence of neuropathy, and PVD status. The mean age of patients was 65.2 years, with a range of 49-87 years, and the mean HbA1c was 8.3, with a range of 6.6-11.3.

Six patients sustained bimalleolar fractures, with or without dislocation, and one patient had a trimalleolar fracture dislocation.

Postoperative data collection focused on fracture healing, assessed via radiographic evidence, time to full weight-bearing, and any complications, such as infection, wound dehiscence, or the need for further surgical intervention.

Statistical analysis

Data analysis was performed using IBM SPSS Statistics version 27. Descriptive statistics were used to summarize the patient characteristics, surgical outcomes, and complications.

Surgical technique

The surgical procedure employed was retrograde intramedullary nailing with the application of antibiotic-impregnated cement. An approximately 4 cm incision was made on the plantar surface of the heel. Under fluoroscopic (C-arm) guidance, the entry point was identified at the central calcaneus in the anteroposterior view and between the anterior and middle thirds in the lateral view, aligning centrally with the tibial plafond and medullary canal.

Key steps of the procedure included incision of skin and subcutaneous tissues, preparation of the entry point using an entry reamer under C-arm guidance, passing through the calcaneus, talus, and distal tibia, insertion of a guide wire passing through the calcaneus and talus to the proximal tibia, measurement of the appropriate nail length under C-arm guidance, preparation of high viscosity polymethyl methacrylate cement at room temperature, mixed with 2 g of vancomycin and 2 g of ceftriaxone, and manual coating of a size 8 mm interlocking tibial nail to achieve a diameter of 12 to 13 mm, medullary reaming followed by insertion of the intramedullary tibial nail retrogradely through the calcaneal entry, placement of proximal and distal locking screws under C-arm guidance, with two distal screws, one in the talus and the most distal one in the calcaneus, and closure of the surgical site with appropriate washing and sterile dressing. The mean duration for the surgery was two hours.

Postoperative protocol

After surgery, all patients followed a standardized postoperative protocol to ensure optimal healing and minimize the risk of complications. This protocol was designed based on best practices reported in similar studies, where early mobilization and infection prevention were emphasized[11]. Immediately after surgery, patients were placed in a well-padded splint to maintain stability and reduce swelling. Weight-bearing was restricted for six weeks to allow for adequate bone healing. During this period, patients were instructed to keep the affected limb elevated, when possible,

to control oedema. At two weeks, patients returned for a surgical site wound check. At six weeks, radiographs were taken to assess the progression of bone healing. If the radiographs showed adequate healing, patients were transitioned to partial weight-bearing in a fracture boot, progressing to full weight-bearing as tolerated over the next several weeks. Pain management was tailored to each patient, with a focus on minimizing the use of opioids. Nonsteroidal anti-inflammatory drugs (NSAIDs) and acetaminophen were used as first-line treatments, with opioids reserved for breakthrough pain. Physical therapy was initiated around eight weeks postoperatively as part of the rehabilitation protocol, focusing on initiating weight-bearing and functional mobility. The rehabilitation process is critical, as noted in similar studies. Early initiation of physical therapy has been shown to improve outcomes and reduce the likelihood of long-term disability in patients recovering from complex ankle fractures[11].

Follow-up and outcomes measurement

Patients were followed up at intervals of two weeks, six weeks, three months, six months, and 12 months postoperatively. Clinical outcomes were primarily focused on subjective measures for each patient, as all included patients were neuropathic. The American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score was also used for objective assessment. Additionally, patient satisfaction with the surgical treatment was evaluated using a Likert scale, which described five scenarios: very satisfied, somewhat satisfied, neither satisfied nor dissatisfied, somewhat dissatisfied, and very dissatisfied. Literature supports the use of these subjective measures, particularly in neuropathic populations, as patient-reported outcomes provide critical insights into the success of surgical interventions in complex cases[12].

Results

Overall, all seven patients had diabetes mellitus (DM) and diabetic neuropathy (Table 1). Four of them were males (57%), with a mean age of 65.5 years and a standard deviation of 12.95. Other comorbidities included hypertension (62.5%), dyslipidemia (25%), hypothyroidism (12.5%), ischemic heart disease (37.5%), and colon cancer (12.5%) (Table 1). The mean HbA1c level was 8.2 ± 1.6, with all patients having values ≥ 6.5.

Regarding fracture patterns, seven patients presented with traumatic closed ankle fractures: bimalleolar fractures (42.8%), bimalleolar fracture-dislocations (42.8%), and trimalleolar fracture-dislocations (14.4%). The mean operative time was two hours from entry to the operating room to transfer to the recovery room. At the two weeks follow-up, all patients had a surgical site inspection. Radiographs were obtained at six weeks. Subsequent evaluations were conducted at three months, six months, and 12 months. All patients were seen in person at least once after six months, with later follow-up data (up to four years) obtained either through in-person visits or structured phone interviews, depending on patient availability. Only one patient (14.4%) developed a postoperative medial foot ulcer complication. The patient is a 72-year-old female with diabetes, diabetic neuropathy, hypertension, and ischaemic heart disease; her HbA1c is 6.9, and she has encountered a closed trimalleolar fracture. No surgical complications such as superficial/deep infections, hardware failure were reported, and none of the patients required reoperation or further surgical intervention.

Regarding weight-bearing and mobility outcomes, two patients (25%) began partial weight-bearing at six weeks. Between three and six months postoperatively, six patients (85.6%) had achieved full weight-bearing without pain, and one patient (14.4%) was mobilizing with minimal pain. The time to achieve full weight-bearing ranged from three to six months (Table 3). At final follow-up, all patients were walking: five used a walking frame, one used a walker, and one walked independently. Patient satisfaction was assessed using a Likert scale. Six patients (85.6%) reported being very satisfied with the surgical outcome, while one patient (14.4%) reported being somewhat satisfied (Table 2). The mean AOFAS score was 76 ± 6.3. Radiographic evaluation at final follow-up showed that four patients (57%) had complete fracture union. The remaining three patients (43%) showed good callus formation but had not achieved full radiographic union at the time of their last follow-up imaging. However, none of these patients demonstrated clinical instability or required further intervention. No cases of delayed union, malunion, or nonunion were formally diagnosed. The mean hospital stay was 5.1 days (range: 3-14 days) (Table 3).

Table 1. Demographic characteristics of included patients

Patient	Age	Sex	Diagnosis	Open fracture	Comorbidities	HbA1c	Neuropathy
1	80	Male	Bimalleolar fracture	No	DM, HTN, Colon cancer	6.3	Yes
2	50	Male	Bimalleolar fracture	No	DM	9.3	Yes
3	87	Male	Bimalleolar fracture dislocation	No	DM, IHD, Hypothyroidism	7	Yes
4	49	Male	Bimalleolar fracture	No	DM, IHD	11.3	Yes
5	69	Female	Bimalleolar fracture dislocation	No	DM, HTN, Dyslipidemia	7.1	Yes
6	60	Female	Bimalleolar fracture dislocation	No	DM, HTN, Dyslipidemia	9.2	Yes
7	72	Female	Trimalleolar fracture dislocation	No	DM, HTN, IHD	6.9	Yes

HbA1C: Haemoglobin A1C; DM: Diabetes mellitus; HTN: Hypertension; IHD: Ischemic heart disease.

Table 2. Patients' postoperative follow-up and clinical outcomes

Patient	Post-op complications	Surgical complications	Need future surgery	Last post-op follow-up	Last follow-up radiograph	Satisfaction	AOFAS score
1	No	No	No	6 weeks	Good callus formation	Very Satisfied	73
2	No	No	No	6 weeks	Good callus formation	Very Satisfied	78
3	No	No	No	2 Years	United	Very Satisfied	69
4	No	No	No	6 Months	United	Very satisfied	86
5	No	No	No	3 Years	United	Very Satisfied	78
6	No	No	No	13 Months	United	Somewhat satisfied	65
7	Medial foot ulcer	No	No	5 Months	Good callus formation	Very Satisfied	80

AOFAS: The American Orthopaedic Foot and Ankle Society.

Table 3. Patients' pre- and postoperative characteristics and outcomes

Patient	Length of hospital stay (days)	Preinjury ambulatory level	Last follow-up ambulatory level	Time to full weight-bearing (months)	Current mobilization level
1	14	Cane	Walking Frame	5	**Non-painful full weight-bearing**
2	3	Walking with no assistance	Walking	3	**Non-painful full weight-bearing**
3	3	Cane	Walking frame	6	**Non-painful full weight-bearing**
4	3	Non-painful full weight-bearing	Walker	3	**Non-painful full weight-bearing**
5	5	Non-painful full weight-bearing	Walker	3	**Non-painful full weight-bearing**
6	4	Walker	Walking frame	4	Mobilising with minimal pain
7	4	Walking frame	Walking frame	5	**Non-painful full weight-bearing**

Discussion

Diabetes and its complications, especially diabetic peripheral neuropathy and PVD, make ankle fracture prognosis worse than that of those with ankle fractures without being diagnosed with diabetes or diabetic patients without complications[2]. Management options are still controversial, but there is evidence that operative management has better outcomes than nonoperative[4]. Many emerging studies show the effectiveness of operative options, depending on the type and stability of the fracture and the patient's diabetic control[2]. TTC arthrodesis is one of the discussed options that has shown good results. However, few studies applying TTC to diabetic patients have been published[7-9]. In non-diabetic patients, a study by Childress[13] suggested using arthrodesis when local soft tissues did not allow for standard incisions for open reduction and internal fixation, or when patients were marginally ambulatory or had medical comorbidities. He reported overall good outcomes using vertical trans-articular pin fixation for 92 patients with ankle fractures.

In our study, we present eight patients with diabetes and diabetic peripheral neuropathy, with a mean age of 65.5 years and a mean HbA1C of 8.2. Seven of them had traumatic closed ankle fractures without other associated injuries, and one had osteomyelitis in the form of an infected previous implant after an ankle fracture treatment. All of them underwent a primary TTC and were followed up until they could maintain full weight-bearing with minimal pain. It was decided for a primary TTC arthrodesis instead of starting with fixation, as this operation is less invasive and needs a shorter operation time than fixation, which will reduce the risk of wound infections, especially in those patient populations where wound healing is poor. Regarding the choice of antibiotics in cement preparation, we chose vancomycin and ceftriaxone as they are the preferred and most used in cement preparation, they provide broad-spectrum coverage, have thermoresistant properties, and are available in powder form[14].

Infection can occur easily[15], and the earlier weight-bearing time reduces non-ambulation-related complications[16]. Also, the fixation provided by arthrodesis allows for faster bone healing when compared to fixation with plates and screws[16], as the bone healing process is already compromised in our patients as a complication of diabetes[17].

Regarding postoperative outcomes, only one patient developed a medial foot ulcer, representing 12.5% of the total cases. This percentage is satisfactory when compared to previous studies; Ebaugh et al.[7] reported a postoperative complication rate of 18.5%, and Jani et al.[8] reported a rate of 25%. Although in other studies, some patients who underwent a primary TTC ended with other surgeries or amputations[7,9], none of our patients did, representing a limb salvage rate of 100%. One possible explanation in our opinion to these satisfactory outcomes besides our modification in

the surgical approach as provided in the methodology, is our inclusion criteria that focuses on diabetic patients with ankle fractures excluding those with Charcot arthropathy, this is different from the study by Grote et al.[18], who reported 15% of Charcot arthropathy among their patients, and from Ayoub[19] who primarily focused on treating patients with Charcot arthropathy. While we didn't specify the type of fracture as being open or closed as part of our inclusion criteria, all our included patients had a closed fracture, which again makes our results more satisfactory with fewer complications in comparison to similar studies[18].

It is difficult to compare limb salvage rates in ankle fractures managed by a primary TTC and ORIF because of the lack of strong evidence about primary TTC. However, evidence suggests that ORIF has a high limb salvage rate of 97.9%[20]. The decision to utilize TTC nailing was guided by multiple considerations. This technique is minimally invasive and time-efficient, offering the dual benefits of reduced operative duration and the capacity for sustained local delivery of high-concentration antibiotics. These advantages are particularly pertinent in immunocompromised patients, in whom the risk of infection is elevated, thereby enhancing the potential for successful limb salvage.

The AOFAS score was used to assess patients' clinical outcomes. Although most patients achieved relatively high scores, we recognize that this tool may not accurately reflect true functional status in this population. The AOFAS score has known limitations in terms of validity and reliability, particularly when applied to diabetic patients with peripheral neuropathy, who may have altered pain perception and different functional baselines compared to non-diabetic individuals. Nevertheless, we selected this scoring system due to its widespread use in the literature and the lack of validated outcome measures specifically designed for fusion procedures in patients with peripheral neuropathy[21].

The strengths of our study include a long postoperative follow-up period and the fact that all fractures were closed, which allowed for a logical and more precise comparison of the outcomes. However, our study also has many limitations, including the study design, as case series hold a high rate of bias, the small number of patients, and the lack of a reliable and valid clinical assessment score to assess our patients' satisfaction.

Conclusion

This case series suggests that primary TTC arthrodesis may be a viable treatment option for diabetic patients with peripheral neuropathy who sustain traumatic ankle fractures. The procedure was associated with limb salvage in all cases, minimal complications, and satisfactory functional outcomes, with most patients achieving full weight-bearing within five months. While these preliminary findings are encouraging, the small sample size and absence of a comparative group limit the generalizability of the results. Further studies with larger cohorts and comparative designs are needed to validate these outcomes.

For future research, we recommend including a higher number of patients and using a better study design, if possible, such as a cohort study design or clinical trials. For the clinical assessment, we recommend considering a new assessment tool to help assess patients with neuropathy or vasculopathy, for which the present tools cannot be fully trusted, despite being already low in reliability and validity measures.

Authors' contributions: Each author contributed individually and significantly to the development of this article: AA *(https://orcid.org/0009-0000-6228-2814) Conceived and planned the activities that led to the study, and performed the surgeries;YD *(https://orcid.org/0009-0008-9211-7463) Performed the surgeries and participated in the review process; MA *(https://orcid.org/0009-0008-7438-7064) Performed the surgeries and interpreted the results of the study; SF *(https://orcid.org/0000-0001-5265-1452) Interpreted the results of the study and participated in the review process; AA *(https://orcid.org/0009-0002-6593-339X) Data collection and clinical examination; HE *(https://orcid.org/0009-0005-6170-6570) Performed the surgeries and survey of the medical records; AM *(https://orcid.org/0009-0000-8175-2770) Frmatting of the article and discussion writing; DS *(https://orcid.org/0009-0007-2035-2408) Statistical analysis, bibliographic review, and final editing. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID) iD.

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