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Original Article

Addressing the challenge of first metatarsal head ulcers: preliminary results of a minimally invasive base osteotomy approach

Valeria Lopez[1], Emanuel Gonzalez[1], Laura Gaitan[1], Gaston Slullitel[1], Maria Jose Varela[1], Gonzalo Alvarez[1], Juan Pablo Randolino[1]

1. Instituto de Ortopedia y Trauma Dr. Jaime Slullitel, Hospital Italiano de Rosario, Rosario 2000, Santa Fe, Argentina.

Abstract

Objective: This study reports preliminary results of a minimally invasive first metatarsal base osteotomy for chronic plantar diabetic foot ulcers (DFUs).

Methods: Five consecutive patients with neuropathic DFUs under the first metatarsal head, unresponsive to at least six weeks of conservative treatment, were enrolled. Patients with severe ischemia, osteomyelitis, or significant soft tissue loss were excluded. All underwent a dorsomedial percutaneous incomplete wedge osteotomy of the first metatarsal base, performed by a single surgeon. Ulcer care and postoperative follow-up were conducted according to standardized protocols.

Results: All ulcers healed within weeks, with no cases of radiographic nonunion, transfer lesions, or recurrence at a mean follow-up of 12 months. One superficial infection resolved with oral antibiotics.

Conclusion: These preliminary findings suggest that minimally invasive first metatarsal base osteotomy may be a feasible surgical option for selected patients with chronic plantar DFUs refractory to conservative care. Larger, controlled studies are warranted to validate its safety, effectiveness, and long-term outcomes.

Level of evidence IV, Case series.

Keywords: Metatarsal bones; Diabetic foot; Osteotomy; Treatment outcome.

Introduction

Diabetic foot ulcers (DFUs) represent one of the most devastating complications of diabetes mellitus (DM), affecting between 19% and 34% of patients during their lifetime[1]. Chronic plantar diabetic foot ulcers are associated with high recurrence, infection, and amputation rates[2].

Peripheral neuropathy, vascular disease, and altered plantar biomechanics—especially overload at the metatarsal heads – are the main contributors to ulcer development[3].

Ulcers located beneath the first metatarsal head present therapeutic challenges due to unique biomechanical, anatomical, and pathophysiological factors. This region endures some of the highest plantar pressures during the gait cycle, particularly during toe-off, which hinders healing even under standard off-loading protocols. Moreover, the hallux bears a disproportionate load when limited joint mobility – common in diabetic patients – increases forefoot pressure and predisposes the adjacent metatarsal heads to ulceration[4].

Conservative management, including total contact casting, custom orthoses, and shoe modifications, remains the first-line treatment[2]. However, recurrence rates are as high as 40% within the first year and 65% within five years[3].

When conservative measures fail, surgical intervention is required to reduce plantar pressure and promote ulcer healing.

In recent years, minimally invasive surgery (MIS) has gained popularity as a therapeutic option for forefoot disorders, particularly hallux valgus. Concurrently, in diabetic patients

Study performed at the Instituto de Ortopedia y Trauma Dr. Jaime Slullitel, Hospital Italiano de Rosario, Rosario 2000, Santa Fe, Argentina.

Correspondence: Valeria Lopez. San Luis 2534 Rosario, 2000 Stana Fe, Argentina. **Email:** vlastegiano@gmail.com. **Conflicts of interest:** none. **Source of funding:** none. **Date received:** October 29, 2025. **Date accepted:** February 25, 2026.

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with recurrent neuropathic plantar ulcers, the biological advantages of MIS have led to the publication of several studies reporting its use in the central metatarsals and, to a lesser extent, in the first metatarsal[5]. Regarding the first metatarsal, available evidence is limited, and most authors describe distal first-ray elevation procedures[5,6]. To date, we are not aware of any publications specifically addressing proximal MIS osteotomies of the first metatarsal for the treatment of recurrent neuropathic plantar ulcers.

The aim of this study is to assess ulcer healing and 12-month recurrence in patients with diabetic foot ulcers beneath the first metatarsal head who underwent minimally invasive first metatarsal base osteotomy.

Methods

Ethical approval was obtained before patient enrollment, and all patients received and signed an informed consent form. Five patients with first metatarsal ulcers who consecutively sought consultation at our outpatient clinic were enrolled. Patients with DM with peripheral neuropathy, who failed at attempted six weeks of conservative treatment were included. Failure of conservative treatment was defined as the absence of reduction in the ulcer's longest axis (in millimeters), further deepening of the lesion, or a decrease in the long axis of less than 50%. Current guidelines and expert reviews generally recommend an initial period of conservative offloading of at least six weeks, with many authors extending this period to 2–3 months before considering surgical intervention, depending on ulcer evolution and anatomical risk factors. In the present case, however, we judged that in this specific anatomical area the risk of progression to osteomyelitis – along with the difficulty of treating it once established – outweighed the potential risks associated with surgery. Exclusion criteria consisted of severe ischemia, as evaluated by an ankle-brachial index < 0.5, who were not candidates for previous revascularization, patients with active osteomyelitis, or those with severe soft tissue loss at the site of osteotomy.

All patients underwent a systematic evaluation that included laboratory tests for white blood cell count, erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP), as well as metabolic control assessed by HbA1c or fructosamine. Nutritional status was evaluated through serum albumin, vitamin D3, and platelet count. Plain anteroposterior (AP) and lateral (L) weight-bearing radiographs were taken at the initial consultation, at four weeks postoperative, and at the final follow-up visit. Magnetic resonance imaging (MRI) was performed in patients with ulcers persisting for more than four weeks to identify findings compatible with bone involvement.

Patients were classified according to the University of Texas Diabetic Wound Classification System (UTDWC), considering ulcer size, depth, and the presence or absence of infection and ischemia[7]. Ulcer dimensions were assessed using the method described by Coughlin et al.[8] with a transparent sheet at each clinical visit to record the ulcer diameter. The principal axes of the lesions were then measured manually based on the traced ulcer area.

Although additional biomechanical and functional assessments – such as plantar pressure analysis, functional outcome scores, objective measurement of first metatarsal elevation, and first metatarsophalangeal joint mobility – may provide complementary information, their routine use in patients with active plantar ulcers and diabetic neuropathy is limited by issues of feasibility and reliability; therefore, in keeping with previously published minimally invasive metatarsal osteotomy series, this study focused on ulcer healing, absence of recurrence, and radiographic union as the primary outcome measures.

Owing to the limited sample size, no inferential statistical analysis was undertaken, and outcomes are reported using descriptive statistics only.

Surgical technique

All procedures were performed by the same surgeon experienced in percutaneous and minimally invasive techniques, and informed consent was obtained prior to surgery. With the patient in the supine position under regional anesthesia, the base of the first metatarsal was identified using fluoroscopic guidance. A dorsomedial portal was established (Figure 1A), and with a 4.0 mm drill, an incomplete dorsal-based wedge osteotomy was performed, thinning the plantar cortex (Figure 1B, C, and D). By applying a dorsiflexion maneuver from the plantar aspect, the osteotomy was closed, thereby elevating the first metatarsal (Figures 2 and 3). In the patient with a pre-ulcerative lesion, a compression 4.0 mm partially threaded screw from medial dorsal to plantar lateral was placed. Patients were instructed to bear weight from the day of the procedure using a postoperative shoe, which was discontinued once the wound had fully epithelialized. Additionally, local debridement of the ulcer to viable tissue was performed during the same surgical procedure.

Postoperative ulcer care was conducted according to each patient's pre-established protocol.

Results

A total of five patients (4 men and 1 woman) were enrolled in this initial experience (Table 1). All DFUs were located under the first metatarsal head (Figure 1). All patients attempted conservative treatment for at least six weeks that consisted of wound healing with calcium alginate in the wound bed and off-loading with an anterior offload postoperative shoe.

No patients depicted radiographs or MRIs consistent with osteomyelitis at the first metatarsal head or at the osteotomy level.

Patients progressed to bone healing in a mean of 8.2 weeks (6 to 10 weeks), and ulcer healing was achieved in a mean of 51 days (15 to 90 days) (Figure 4).

Internal fixation was selectively used in only one patient with a pre-ulcerative lesion and intact soft tissues to enhance

Figure 1. A. Marking of the percutaneous portal height at the base of the first metatarsal. B and C. Percutaneous osteotomy performed using a Shannon burr. D. Completed osteotomy.

perceived osteotomy stability; in contrast, fixation was deliberately avoided in patients with open plantar ulcers to minimize infection risk, a strategy that introduces technical heterogeneity and is acknowledged as a limitation of this small case series.

One superficial infection at the osteotomy site occurred, successfully treated with oral antibiotics. We did not observe radiological nonunion in any of the cases. No transfer lesions or recurrence were recorded during a mean follow-up of 12 months.

Discussion

Although the successful treatment of DFUs often requires a combination of approaches – such as wound care, infection control, revascularization, and pressure offloading – pressure redistribution is generally considered the most critical element in the treatment of neuropathic DFUs. Currently, the gold standard for offloading is the use of a non-removable, knee-high device with a properly fitted foot–device interface, which has been shown to optimize ulcer healing. When this strategy fails, emerging evidence suggests that both surgical and alternative nonsurgical offloading methods may accelerate the healing process in plantar ulcers that remain refractory to standard conservative care[9].

The first metatarsal region presents a particular challenge because of the difficulty in effectively off-loading this area and the rapid progression of ulcers that develop there. Further complicating the issue, motor neuropathy-induced deformities such as hallux rigidus or claw hallux biomechanics shift load laterally, concentrating pressure on the first metatarsal head and hindering off-loading efforts[10].

Minimally invasive osteotomies of the lesser metatarsals have proven to be an efficient off-loading technique, with a low complication rate due to minimal soft tissue damage[11]. However, to the best of the authors' knowledge, there is

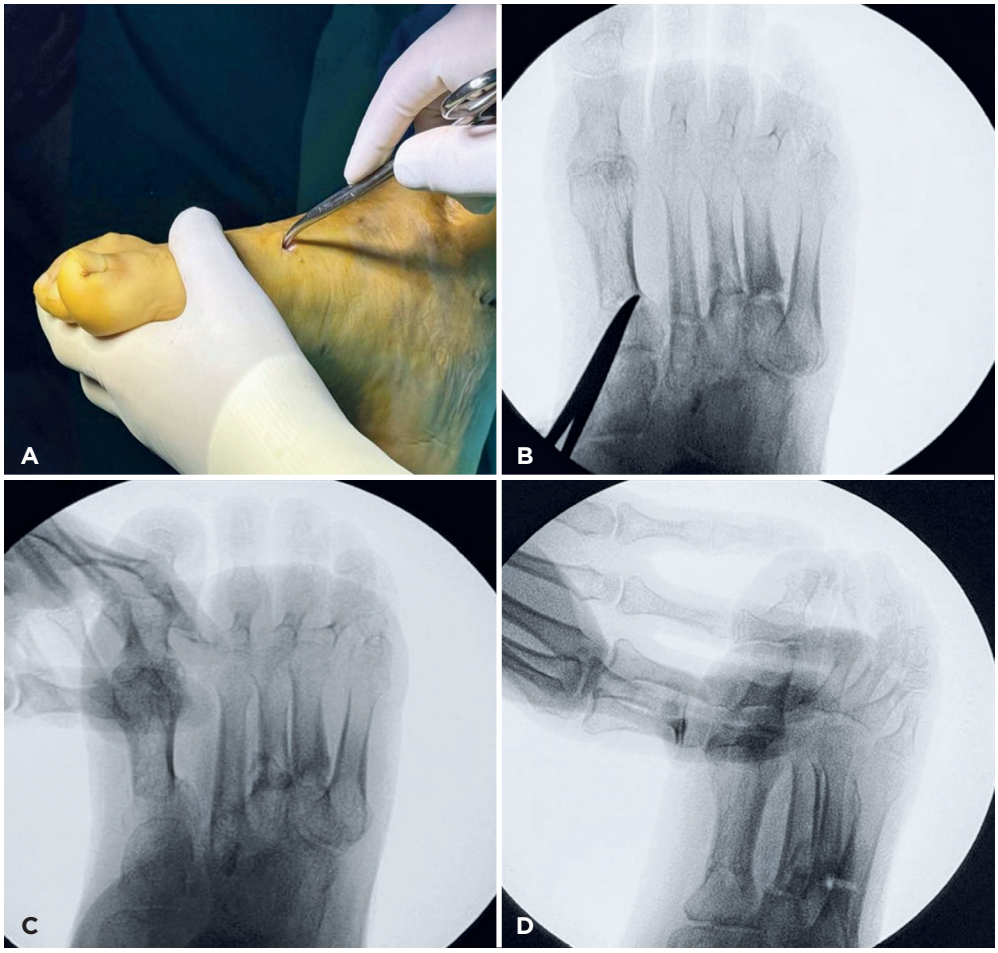

Figure 2. A and B. Elevation maneuver of the first metatarsal using a Halsted clamp. C and D. Intraoperative fluoroscopic control.

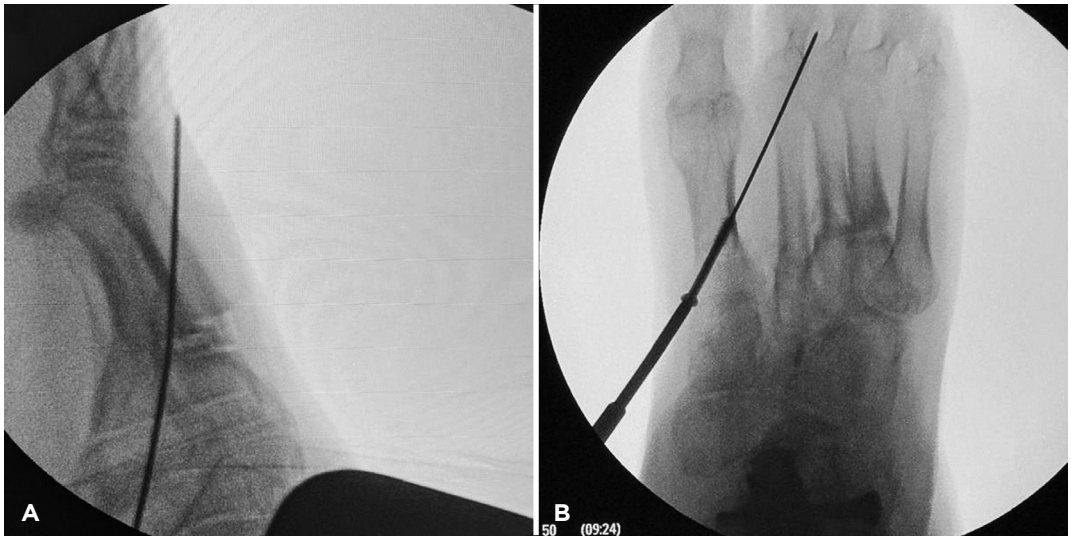

Figure 3. A. Sagittal fluoroscopic view showing guidewire placement for internal fixation. B. Final fixation with a 4.0 mm cannulated screw.

Table 1. Demographic data of the five patients.

Patient	Age	Sex	UTDWC	Time to closure	Time to bone healing	Complications	FU
1	54	F	A1	15 d	8 w	No	12.1 m
2	71	M	A3	60 d	10 w	SSI	12.5 m
3	70	M	A2	59 d	8 w	No	16 m
4	70	M	A3	92 d	9 w	No	21 m
5	73	M	A3	28 d	6 w	No	18 m

F: Feminine; M: Masculine; UTDWC: University of Texas Wound Classification; A1: Superficial lesion without penetration; A2: Wound that penetrates tendon or capsule; A3: Wound that penetrates bone or joint; SSI: Surgical site infection.

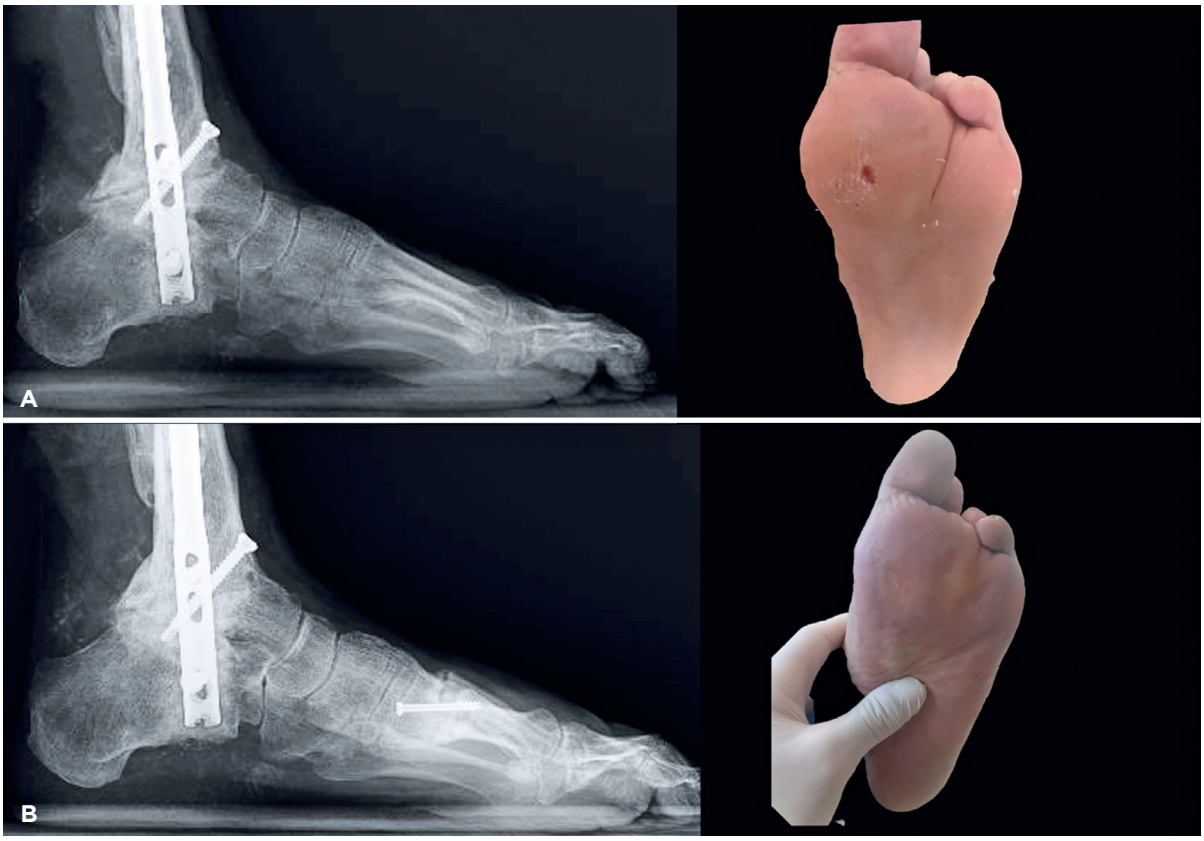

Figure 4. A. Plantar ulcer at the head of the first metatarsal and preoperative radiograph. B. Clinical and radiographic follow-up at three months postoperatively.

currently no available evidence on the application of this procedure to the first metatarsal.

Our findings support the role of minimally invasive metatarsal osteotomy as an effective and safe technique for the treatment of chronic plantar diabetic ulcers, particularly in patients unresponsive to conservative measures. All ulcers healed in a relatively short period, with minimal complications and no recurrence during follow-up.

Evidence on lesser metatarsal osteotomies may be extrapolated to this scenario. Our results are consistent with those of Tamir et al. (2016)[11], who reported that minimally invasive floating metatarsal osteotomy resolved resistant or recurrent ulcers in 85% of cases, with low complication rates. Similarly, Biz et al. (2017)[2] demonstrated in a prospective series that distal metatarsal diaphyseal osteotomies (DMDO) promoted ulcer healing and significantly improved functional outcomes, with no recurrence at mid-term follow-up. Uncertainties about recurrence over the long term were further addressed in 2024, in a study confirming the long-term safety and efficacy of DMDO, reporting improved functional scores and the absence of recurrence[12].

On a technical note, although the clinical implications of first and lesser metatarsal minimally invasive osteotomies may be similar, a first metatarsal base osteotomy is more demanding, as it is essential to avoid complete perforation of the plantar cortex to maintain a 'locked closed' osteotomy in dorsiflexion. Moreover, this technique is intrinsically less stable. The addition of a 4.0-mm screw may enhance stability, but in the context of an open lesion, its use must be carefully considered.

Limitations of this study include the small sample size and the lack of a control group. Furthermore, the absence of long-term follow-up precludes conclusions regarding late recurrence or transfer lesions. Prospective randomized trials are needed to validate these findings and to compare MIS osteotomies with other surgical strategies.

Conclusion

As demonstrated by studies on the lesser metatarsals, which provide more robust evidence, minimally invasive metatarsal osteotomy has been shown to be a safe, effective, and reproducible technique for managing chronic plantar diabetic foot ulcers that are unresponsive to conservative treatment. Our limited series does not allow us to draw conclusions regarding the validation, efficacy, or effectiveness of this approach. Consequently, these findings should not be considered definitive, but rather as preliminary, hypothesis-generating observations that support the feasibility of this technique and warrant further investigation in larger studies with longer follow-up.

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