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Original Article

Plate-mediated versus lag screw-driven compression in first metatarsophalangeal joint arthrodesis for end-stage hallux rigidus: A retrospective comparative cohort study

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Abstract

Objective: To compare two technical sequences using the same fixation construct but differing in the mechanism responsible for primary compression across the arthrodesis site.

Methods: A retrospective cohort study was performed including consecutive patients who underwent first metatarsophalangeal joint (MTPJ) arthrodesis for advanced hallux rigidus (Coughlin and Shurnas grades 3 and 4) between January 2015 and December 2024. All procedures were performed using cup-and-cone joint preparation, a low-profile dorsal plate, and an oblique cannulated screw. In technique 1 (T1), compression was generated primarily through the dynamic compression mechanism of the dorsal plate, whereas in technique 2 (T2), compression was generated primarily by the oblique lag screw. Clinical outcomes were assessed using the American Orthopaedic Foot & Ankle Society (AOFAS) hallux metatarsophalangeal-interphalangeal scale and the visual analog scale (VAS) for pain. Radiographic union, time to union, and complications were recorded.

Results: Fifty-five patients (68 feet) were included, comprising 39 feet treated with T1 and 29 feet treated with T2. Both techniques resulted in significant improvements in AOFAS and VAS scores ($p < 0.001$ for all comparisons). Nonunion occurred in 3 of 39 feet (7.7%) in T1 and 1 of 29 feet (3.4%) in T2 ($p = 0.631$). No statistically significant differences were observed between groups regarding final AOFAS scores, final VAS scores, or overall complication rates. Mean time to union was significantly shorter in T2 than in T1 (6.89 ± 0.79 vs 7.94 ± 1.17 weeks; $p < 0.001$). After adjustment for age and baseline clinical differences, T2 remained independently associated with faster union (adjusted coefficient -0.80 weeks; 95% confidence interval, -1.46 to -0.15; $p = 0.015$).

Conclusions: First MTPJ arthrodesis using a dorsal plate combined with an oblique cannulated screw provided reliable union, substantial pain relief, and significant functional improvement regardless of the sequence of implant application. Although both compression strategies yielded comparable union rates and clinical outcomes, lag screw-driven compression was associated with a significantly shorter time to fusion. These findings suggest that direct interfragmentary compression generated by the oblique lag screw may modestly accelerate arthrodesis consolidation without increasing complications.

Level of Evidence III; Retrospective Comparative Cohort Study.

Keywords: Hallux rigidus; Arthrodesis; Metatarsal bone; Bone screws.

Study performed at Hospital Israelita Albert Einstein, São Paulo, SP, Brazil.

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Introduction

Hallux rigidus (HR) is the second most common pathology affecting the human great toe and is characterized by progressive restriction of motion at the first metatarsophalangeal joint (MTPJ). This degenerative condition is associated with pain, swelling, and progressive articular cartilage degeneration, resulting in functional limitation and impaired gait mechanics[1].

This condition has several proposed etiologies, although its exact cause remains unclear. The most frequently cited causes of degenerative disease of the first MTPJ include osteochondral injury after repetitive microtrauma due to local biomechanical alterations, post-traumatic osteoarthritis after a single trauma or chronic MTPJ instability, turf-toe injury, local inflammation related to systemic diseases, primary osteoarthritis, iatrogenic causes, and osteochondritis dissecans[1-6].

The main constitutional factors associated with HR include first metatarsal adductus, a chevron-shaped or squared distal articular surface of the first metatarsal, abnormalities in first metatarsal length (either short or long), flatfoot, metatarsus primus elevatus, hallux valgus interphalangeal, and female sex[1].

Patients typically present with an insidious onset of forefoot pain involving the great toe that worsens during walking and improves with rest, usually associated with stiffness of the first MTPJ[4,7-9].

Physical examination demonstrates decreased passive range of motion of the first MTPJ, whose normal range of motion is approximately 80°. Initially, flexion is maintained but decreases as arthritis progresses. A dorsal bony prominence—dorsal bunion—may also be visible or palpable (Figure 1)[1,11-13].

Radiographs typically show irregular narrowing of the joint space, flattening and widening of the first metatarsal head, subchondral cysts and sclerosis, enlargement of the base of the proximal phalanx, hypertrophy of the sesamoids, and progressive gleno-sesamoid osteoarthritis. The typical aspect of dorsal osteophytes is the appearance of melted wax (Figure 2)[1,13].

In patients presenting with restricted first MTPJ motion, no radiographic evidence of degenerative changes, and associated synovitis, the differential diagnosis should include functional hallux rigidus[14] and inflammatory arthropathies[15].

The Coughlin and Shurnas[1,14,15] classification remains the most widely adopted system for grading HR, incorporating the degree of first MTPJ dorsiflexion, radiographic features, and clinical manifestations, particularly pain. In grade 0, first MTPJ dorsiflexion ranges from 40° to 60°, with no associated pain or radiographic abnormalities. In grade 1, dorsiflexion ranges from 30° to 40° and is accompanied by early radiographic changes, including small dorsal osteophytes and mild joint-space narrowing, as well as mild pain. In grade 2, first MTPJ dorsiflexion ranges from 10° to 30°, with the

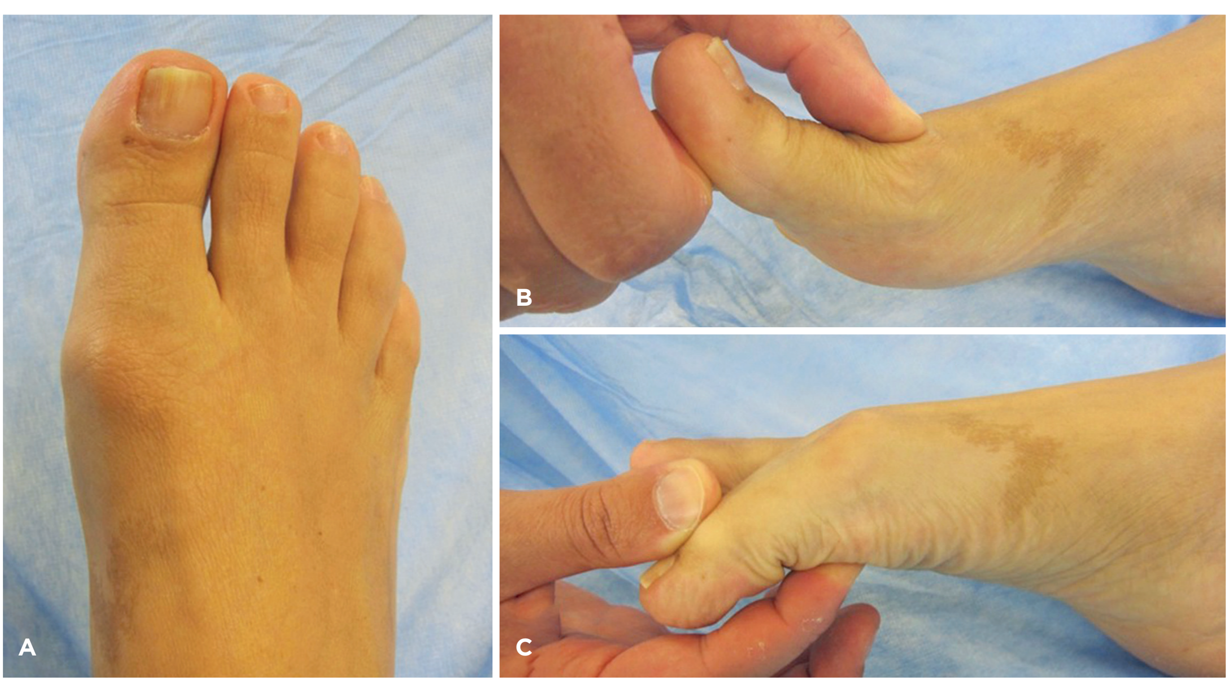

Figure 1. Classic clinical aspect of hallux rigidus. (A) Dorsal bunion (B) Significant limitation of metatarsophalangeal joint extension (C) Significant limitation of metatarsophalangeal joint flexion.

Figure 2. Main radiographic findings of the hallux rigidus. (A) Reduction of the metatarsophalangeal joint space (B) Exuberant dorsal osteophyte in the shape of "melted wax".

presence of periarticular osteophytes and moderate pain. In grades 3 and 4, dorsiflexion is less than 10°, and radiographs typically demonstrate extensive osteophyte formation and subchondral cysts. Clinically, grade 3 is characterized by significant pain at the extremes of motion, whereas grade 4 is distinguished by pain throughout the mid-range of motion, including passive joint movement[6].

First MTPJ arthrodesis is widely regarded as the gold-standard treatment for advanced degenerative disease of the first MTPJ, irrespective of the underlying etiology, including end-stage HR (Coughlin and Shurnas grades 3 and 4), inflammatory arthropathies, and post-traumatic arthritis. The procedure reliably restores or maintains first-ray length and stability, improves gait biomechanics, and provides durable pain relief, resulting in high rates of patient satisfaction[4,14].

A historical review of first MTPJ arthrodesis demonstrates a consistent improvement in clinical and radiographic outcomes over time. This progress can be largely attributed to advances in soft-tissue preservation techniques, optimization of joint surface preparation, greater attention to achieving physiological and functional alignment, and the development of more reliable fixation constructs[5,15]. Currently, there is little controversy regarding the use of convex-concave (cup-and-cone) reamers for joint preparation and the application of plate-and-screw constructs, in various configurations, for first MTPJ arthrodesis fixation[16].

The primary objective of the present study was to compare the outcomes of first MTPJ arthrodesis performed for end-stage HR using the same implants for two surgical technical sequences: plate-mediated vs lag screw-driven compression. They differed in the component responsible for generating the primary compression across the fusion site, namely the dorsal plate (Technique 1 – T1)[12,15,16] or the oblique compression lag-screw (Technique 2 – T2)[16,17]. Their potential influence on union rates, clinical outcomes, and complications was evaluated.

Methods

Study design

This retrospective cohort study was conducted at a single tertiary referral foot and ankle center between January 2015 and December 2024 and was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

Ethical approval

The study protocol was approved by the Institutional Review Board under the number 82911818.0.0000.0071. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki.

All patients provided written informed consent authorizing their participation in the study and the use of their anonymized clinical and imaging data for scientific publication.

Inclusion criteria

1. Adults ≥ 18 years with advanced primary or secondary osteoarthritis of the first MTPJ, classified as Coughlin and Shurnas grade 3 or 4.

2. Consecutive patients who underwent first MTPJ arthrodesis using a dorsal plate and an obliquely oriented screw.

Exclusion criteria

1. Associated acute fractures involving the foot or ankle.
2. Congenital or acquired forefoot deformities associated with severe shortening of the first ray.
3. Benign or malignant tumors of the foot or ankle.

Outcome measures

Demographic and clinical data, including sex, age, laterality, and comorbidities, were collected. Functional outcomes were assessed using the American Orthopaedic Foot & Ankle Society (AOFAS) hallux metatarsophalangeal-interphalangeal scale and the visual analog scale (VAS) for pain preoperatively and at final follow-up. Radiographic union, time to union, and postoperative complications were also evaluated.

Patients were subsequently divided into two groups according to the sequence of implant application. Although both groups received the same fixation construct, they differed in relation to the component responsible for generating the primary compression across the arthrodesis site (the dorsal plate or the oblique compression lag-screw). Union rates, clinical outcomes, and complication rates were then compared between the two fixation strategies.

Surgical technique

All procedures were performed through a dorsal longitudinal approach to the first MTPJ (Figure 3A). After careful dissection of the extensor hood and protection of the extensor hallucis longus and brevis tendons, the joint was exposed, and the degree of degeneration and osteophyte removal were assessed (Figure 3B and 3C).

Following adequate exposure, the longitudinal axis of the first metatarsal was identified using a Kirschner wire (K-wire) as a guide. A concave reamer of appropriate diameter was then used to remove the remaining articular cartilage from the metatarsal head and expose the underlying subchondral bone (Figure 3D). The corresponding articular surface of the proximal phalanx was subsequently prepared using a matching convex reamer (Figure 3E). This technique generated complementary concave-convex surfaces that provided a broad contact area, intrinsic stability, and optimal congruency between the fusion surfaces.

To enhance osseous healing, multiple perforations were created in both subchondral surfaces using a 1.2-mm K-wire (Figure 3F). The arthrodesis was positioned in approximately 10° to 15° of dorsiflexion and 10° of valgus relative to the first metatarsal axis. Precontoured low-profile dorsal plates incorporating these corrections were used as alignment guides and fixation devices. Temporary fixation was obtained with a K-wire inserted obliquely from the medial aspect of the proximal phalanx toward the metatarsal head (Figure 3G, H, and I).

Technique 1: Plate-generated compression

In T1, the dorsal plate was initially secured to the proximal phalanx using bicortical screw fixation. Compression across the arthrodesis site was subsequently achieved through the dynamic compression mechanism provided by the proximal oblong holes of the plate. Final fixation was completed with insertion of a cannulated screw over the previously placed oblique K-wire. In this construct, compression was generated primarily by the dorsal plate, whereas the oblique screw functioned as a neutralization device.

Technique 2: Screw-generated compression

In T2, the dorsal plate was initially fixed to the proximal phalanx in the same manner described for T1. An oblique cannulated lag-screw was then inserted over the guide K-wire, generating interfragmentary compression across the fusion site. The remaining proximal plate screws were subsequently inserted using standard bicortical fixation without activation of the dynamic compression mechanism of the plate. In this construct, compression was generated primarily by the oblique lag-screw, whereas the dorsal plate functioned as a neutralization device.

Postoperative protocol

Postoperatively, patients remained non-weight-bearing until radiographic evidence of union was observed. Fusion was subsequently confirmed by computed tomography (CT). Time to union was defined as the interval between surgery and CT confirmation of fusion involving more than 50% of the intended arthrodesis surface.

Following confirmation of union, a structured physiotherapy program was initiated, with gradual progression of weight-bearing until unrestricted ambulation with full forefoot loading was achieved.

Statistical methods

Given the retrospective design of this study, no formal "a priori" sample size calculation was performed. Instead, all consecutive patients who met the eligibility criteria during the study period were included to maximize statistical power and minimize selection bias. The final sample size was therefore determined by the number of eligible cases available in the institutional database. Effect estimates were reported with 95% confidence intervals whenever appropriate, and the possibility of type II error due to limited sample size was considered in the interpretation of non-significant findings.

The unit of analysis was the operated foot. A secondary sensitivity analysis was also performed at the patient level because some patients contributed bilateral procedures.

Continuous variables were summarized as mean ± standard deviation and also inspected for normality using the Shapiro-Wilk test. Given the sample size and non-normal distributions in several variables, non-parametric Mann-Whitney U tests were considered alongside Welch t-tests.

Figure 3. Surgical Technique. (A) Dorsal skin incision (B) Macroscopic aspect of the head of the first metatarsal showing an extensive area of subchondral bone exposure (C) Partial view of the proximal articular facet of the proximal phalanx of the hallux and the exuberant dorsal osteophyte of the metatarsal head (D) Debridement of the metatarsal head with a concave tool (E) Debridement of the articular facet of the phalanx with a convex tool (F) Multiple perforations of the subchondral bone of both complementary bone surfaces (G) Dorsal view of the metatarsophalangeal joint immediately after placement of both fixation elements of the arthrodesis area (oblique screw and dorsal plate) (H-I) Intraoperative radiographs (AP and lateral) demonstrating the positioning of the material used for bone fixation.

For categorical outcomes, Fisher exact tests were used.

Paired preoperative vs postoperative comparisons were assessed with paired t-tests and Wilcoxon signed-rank tests.

The primary outcome was nonunion/pseudarthrosis. Secondary outcomes included time to union, AOFAS score, VAS pain score, AOFAS improvement, VAS improvement, and complications.

The threshold for statistical significance was two-sided alpha = 0.05, with 95% confidence intervals. Exploratory adjusted models were performed using heteroscedasticity-robust linear regression.

Because only four nonunion events were present, multivariable logistic regression for nonunion was considered statistically unstable and was not used as a confirmatory model.

Results

Demographic characteristics

A total of 55 patients (68 feet) were included in the study. Thirty-three patients (39 feet) underwent arthrodesis using T1, whereas 22 patients (29 feet) were treated using T2. Bilateral procedures were performed in six patients in the T1 group and in seven patients in the T2 group.

The study population was predominantly female, comprising 25 women (75.8%) and eight men (24.2%) in T1, and 16 women (72.7%) and six men (27.3%) in T2. The mean age at the time of surgery was 59 years (range, 42-77 years) in T1 and 65 years (range, 38-77 years) in T2.

Regarding laterality, 24 procedures (61.5%) involved the right foot and 15 (38.5%) the left foot in T1, whereas 15 procedures (51.7%) involved the right foot and 14 (48.3%) the left foot in T2.

Patients included in T1 presented lower preoperative functional scores, with a mean AOFAS score of 33 points compared with 40 points in T2. Similarly, preoperative pain levels were slightly higher in T1 (VAS 7 vs 6). Rheumatoid arthritis was more prevalent in T1 (11 patients) than in T2 (2 patients) (Table 1).

The statistical data which involved 39 feet in group T1 and 29 feet in group T2, shows that the groups were not fully comparable at baseline: patients in T2 were older (65.24 ± 11.59 vs 58.95 ± 8.91 years; p = 0.018*), had higher preoperative AOFAS scores (39.83 ± 12.36 vs 31.87 ± 12.97; p = 0.013*), and lower preoperative VAS scores (5.97 ± 0.82 vs 7.41 ± 0.72; p < 0.001*). Sex distribution and operated side did not show statistically significant differences between groups (Table 2).

Both techniques produced significant clinical improvement. In T1, AOFAS score improved from 31.87 ± 12.97 to 80.33 ± 6.21 points (Wilcoxon p < 0.001), and VAS improved from 7.41 ± 0.72 to 1.49 ± 1.21 (Wilcoxon p < 0.001). In Technique

Table 1. Demographic Characteristics

	T1	%	T2	%
Patients (n)	33	60.0%	22	40.0%
Feet (n)	39	57.4%	29	42.6%
Bilateral surgery	6	18.2%	7	31.8%
Mean age (min-max)	59 (42-77)	---	65 (38-77)	---
Sex - Female	25	75.8%	16	72.7%
Sex - Male	8	24.2%	6	27.3%
Side - Right	24	61.5%	15	51.7%
Side - Left	15	38.5%	14	48.3%
RA patients	11	33.3%	1	4.5%
Preoperative AOFAS	33	---	40	---
Preoperative VAS	7	---	6	---

T1: Technique 1; T2: Technique 2; RA: Rheumatoid arthritis; AOFAS: American Orthopaedics Foot & Ankle Society; VAS: Visual analog scale.

Table 2. Baseline and postoperative continuous variables

Variable	T1 mean ± SD	T2 mean ± SD	Mean difference T2–T1	95% CI	Welch p	Mann-Whitney p
Age (years)	58.95 ± 8.91	65.24 ± 11.59	6.29	1.11 to 11.48	0.018*	0.007*
AOFAS preoperative	31.87 ± 12.97	39.83 ± 12.36	7.96	1.77 to 14.14	0.013*	0.015*
VAS preoperative	7.41 ± 0.72	5.97 ± 0.82	-1.44	-1.83 to -1.06	<0.001*	<0.001*
AOFAS postoperative	80.33 ± 6.21	83.90 ± 7.77	3.56	0.05 to 7.08	0.047*	0.006*
VAS postoperative	1.49 ± 1.21	1.17 ± 1.28	-0.31	-0.93 to 0.30	0.310	0.245
AOFAS improvement	48.46 ± 13.18	44.07 ± 11.74	-4.39	-10.45 to 1.67	0.153	0.203
VAS improvement	5.92 ± 1.53	4.79 ± 1.47	-1.13	-1.86 to -0.40	0.003*	0.004*
Time to union, weeks#	7.94 ± 1.17	6.89 ± 0.79	-1.05	-1.54 to -0.56	<0.001*	<0.001*

SD: Standard deviation; CI: Confidence interval; T1: Technique 1; T2: Technique 2; AOFAS: American Orthopaedics Foot & Ankle Society; VAS: Visual analog scale.
*All statistically significant values are marked with an asterisk. # Time to union excludes feet classified as pseudarthrosis. Positive differences indicate higher values in T2; negative differences indicate lower values in T2.

2, AOFAS improved from 39.83 ± 12.36 to 83.90 ± 7.77 points (Wilcoxon p < 0.001), and VAS improved from 5.97 ± 0.82 to 1.17 ± 1.28 (Wilcoxon p < 0.001) (Table 3).

The primary outcome, nonunion/pseudarthrosis, occurred in 3 of 39 feet (7.7%) treated with T1 and in 1 of 29 feet (3.4%) treated with T2. This difference was not statistically significant (Fisher exact test p = 0.631) (Table 4).

At the patient level, nonunion occurred in 3 of 33 patients in T1 and in 1 of 22 patients in T2 (Fisher exact test p = 0.642) (Table 5).

Time to union among consolidated cases was significantly shorter in T2 than in T1 (6.89 ± 0.79 vs 7.94 ± 1.17 weeks; Welch p < 0.001; Mann-Whitney p < 0.001) (Figure 4). After adjustment for age, preoperative AOFAS and preoperative VAS, T2 remained associated with a shorter time to union (adjusted coefficient, -0.80 weeks; 95% CI, -1.46 to -0.15; p = 0.015).

Unadjusted postoperative AOFAS was slightly higher in T2 (83.90 ± 7.77 vs 80.33 ± 6.21; Welch p = 0.047), but this difference was not maintained after adjustment for baseline AOFAS and age (p = 0.299). AOFAS improvement was similar between groups (44.07 ± 11.74 vs 48.46 ± 13.18; Welch p = 0.153). VAS improvement was greater in T1 in the unadjusted analysis (5.92 ± 1.53 vs 4.79 ± 1.47; p = 0.003), but this finding should be interpreted in the context of significantly higher baseline pain in T1; after adjustment for baseline VAS and age, the technique effect was no longer significant (p = 0.302) (Table 6).

The available data therefore do not demonstrate a statistically significant superiority of one technique over the other regarding nonunion, final pain, final function, or global complications. However, T2 showed a consistent association with shorter time to union, even after adjustment for baseline

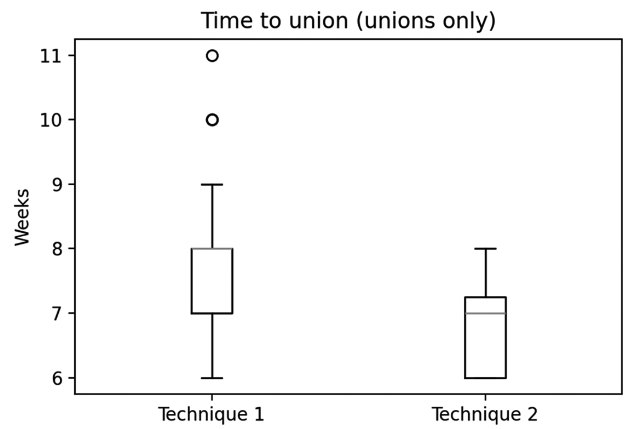

Figure 4. Time to union among consolidated cases.

Table 3. Within-group pre- to postoperative changes

Technique	Outcome	n	Preoperative mean ± SD	Postoperative mean ± SD	Mean improvement	95% CI	Wilcoxon p
T1	AOFAS	39	31.87 ± 12.97	80.33 ± 6.21	48.46	44.19 to 52.73	<0.001*
T1	VAS	39	7.41 ± 0.72	1.49 ± 1.21	5.92	5.43 to 6.42	<0.001*
T2	AOFAS	29	39.83 ± 12.36	83.90 ± 7.77	44.07	39.60 to 48.53	<0.001*
T2	VAS	29	5.97 ± 0.82	1.17 ± 1.28	4.79	4.23 to 5.35	<0.001*

SD: Standard deviation; CI: Confidence interval; T1: Technique 1; T2: Technique 2; AOFAS: American Orthopaedics Foot & Ankle Society; VAS: Visual analog scale. * All statistically significant values are marked with an asterisk.

Table 4. Primary outcome and categorical complications

Outcome	T1	T2	Risk difference T2–T1	Fisher p	Odds ratio	Risk ratio T2/T1	RR 95% CI
Pseudarthrosis	3/39 (7.7%)	1/29 (3.4%)	-4.2 pp	0.631	2.33	0.45	0.05 to 4.09
Wound complication	1/39 (2.6%)	0/29 (0.0%)	-2.6 pp	1.000	Inf	0.00	NA
Any recorded complication	3/39 (7.7%)	1/29 (3.4%)	-4.2 pp	0.631	2.33	0.45	0.05 to 4.09

CI: Confidence interval; T1: Technique 1; T2: Technique 2. pp = percentage points. Risk ratios are unstable because of the very low number of events. * All statistically significant values are marked with an asterisk.

Table 5. Patient-level sensitivity analysis

Outcome	T1	T2	Fisher p	Interpretation
Pseudarthrosis	3/33 (9.1%)	1/22 (4.5%)	0.642	No statistically significant patient-level difference.
Any recorded complication	3/33 (9.1%)	1/22 (4.5%)	0.642	No statistically significant patient-level difference.

T1: Technique 1; T2: Technique 2. * All statistically significant values are marked with an asterisk.

differences. This finding is compatible with the biomechanical rationale of direct interfragmentary compression using the oblique lag screw, with the dorsal plate acting as a neutralization device.

Discussion

The principal finding of the present study was that first MTPJ arthrodesis performed with a dorsal plate and an obliquely oriented cannulated screw produced predictable and satisfactory outcomes regardless of the sequence of implant application. Both fixation strategies resulted in substantial improvement in pain and function, high union rates, and low complication rates. No statistically significant differences were observed regarding pseudarthrosis, final AOFAS scores, final VAS scores, or overall complications (Figure 5). However, arthrodesis in which compression was generated primarily by the oblique lag screw achieved union significantly earlier than those in which compression was generated primarily through the plate compression mechanism. This difference remained significant after adjustment for age and baseline clinical differences.

First MTPJ arthrodesis is widely accepted as the gold-standard treatment for advanced HR and other end-stage degenerative conditions of the joint[12,15]. Numerous studies have demonstrated union rates exceeding 90%, together with substantial improvements in pain, function, and patient satisfaction[17-24]. The results observed in the present series are consistent with those reported by Coughlin et al. and by contemporary investigations evaluating dorsal plate and interfragmentary screw constructs[12,15,17-24]. The union rates observed in both groups, as well as the magnitude of improvement in AOFAS and VAS scores, confirm the reliability of modern plate-and-screw fixation systems for first MTPJ arthrodesis.

Table 6. Exploratory adjusted models

Outcome	Adjustment model	Adjusted effect of T2	95% CI	p value	n
Postoperative AOFAS	Age + preoperative AOFAS	2.18	-1.94 to 6.30	0.299	68
Postoperative VAS	Age + preoperative VAS	-0.54	-1.56 to 0.48	0.302	68
AOFAS improvement	Age + preoperative AOFAS	2.18	-1.94 to 6.30	0.299	68
VAS improvement	Age + preoperative VAS	0.54	-0.48 to 1.56	0.302	68
Time to union, (weeks)	Age + preoperative AOFAS + preoperative VAS	-0.80	-1.46 to -0.15	0.015*	64

CI: Confidence interval; T1: Technique 1; T2: Technique 2; AOFAS: American Orthopaedics Foot & Ankle Society; VAS: Visual analog scale. The coefficient represents T2 minus T1. Negative values for time to union indicate faster union with Technique 2. These models are exploratory and should not be overinterpreted as causal estimates. *All statistically significant values are marked with an asterisk.

Figure 5. Weigh-bearing radiographs at three years postoperative (right side) and two years postoperative (left side) of a patient who underwent metatarsophalangeal joint arthrodesis (T1). (A) Dorsoplantar view (B) Lateral view. The solid consolidation achieved was noticeable, and the patient remained without complaints at the time of the evaluation.

Although the overall outcomes were similar, the shorter time to union observed in T2 deserves particular attention. The biomechanical explanation is plausible[16,17,19]. In T2, interfragmentary compression is generated directly by the oblique lag screw before definitive plate fixation. This sequence may optimize compression at the arthrodesis interface and reduce micromotion during the early stages of healing. The dorsal plate subsequently acts primarily as a neutralization device, protecting the construct from bending and rotational forces. In contrast, T1 relies initially on the dynamic compression mechanism of the plate, while the oblique screw functions mainly as a supplemental stabilizer. While the present study was not designed as a biomechanical investigation, the findings suggest that the source and sequence of compression generation may influence the biological tempo of fusion.

An additional observation concerns the distribution of rheumatoid arthritis between groups. Patients with rheumatoid arthritis represented approximately one-third of the cohort treated with T1 but were uncommon in T2. Historically, inflammatory arthropathies have been associated with impaired bone quality, increased deformity severity, and a potentially greater risk of nonunion. Despite this imbalance, union rates and final clinical outcomes remained favorable in both groups. Although the sample size precludes definitive conclusions, these findings support previous reports indicating that modern fixation constructs can achieve reliable arthrodesis—even in patients with inflammatory joint disease—and serve as an important resource for salvage of pseudarthrosis cases (Figure 6).

The present study has several limitations. Its retrospective design inherently introduces the possibility of information

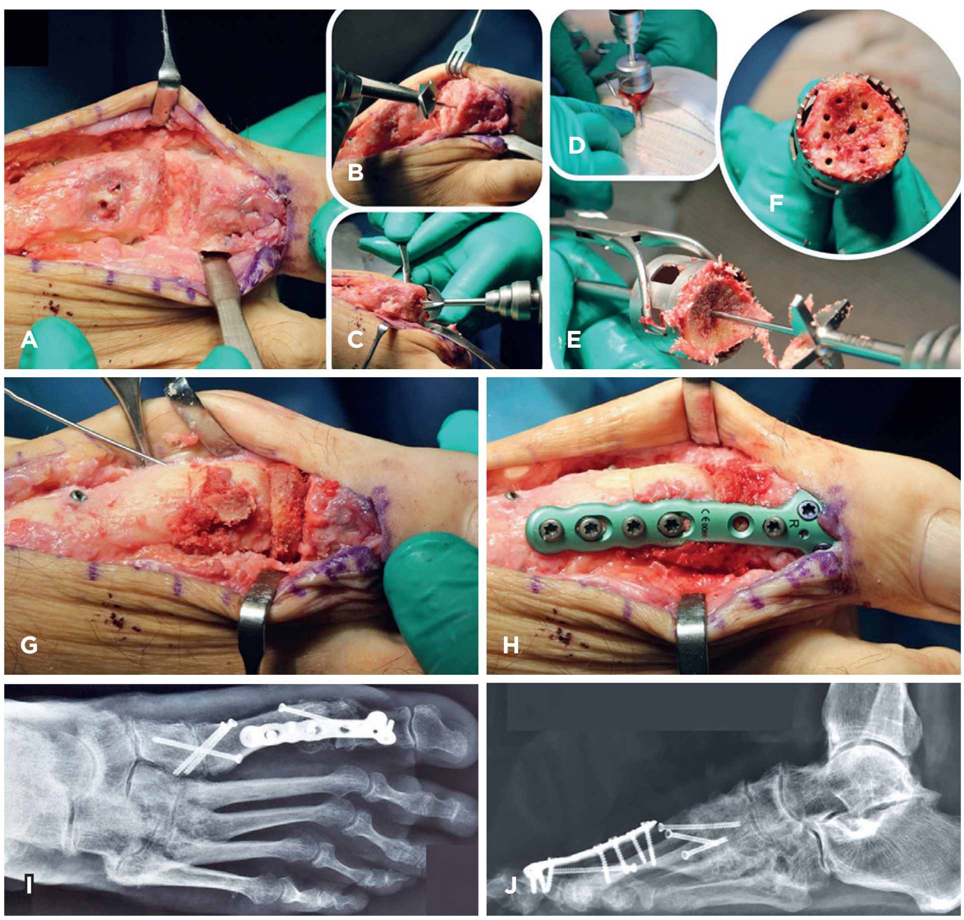

Figure 6. A. Dorsal view of the first metatarsophalangeal joint of a patient with pseudarthrosis. (B) Preparation of the hallux phalanx (C) Preparation of the first metatarsal head (D) Due to bone loss, an autologous graft was harvested from the iliac spine (E) Both surfaces of the iliac graft were prepared using the same reamers employed on the phalanx and metatarsal, creating one concave and one convex surface (F) Multiple perforations made in the autologous bone graft (G-H) After placing the bone graft into the bone defect, the construct was fixed with an oblique K-wire, followed by a dorsal plate and an oblique screw. In this case, the dorsal plate provided compression, while the oblique screw acted as a neutralization element (I-J). Radiographs at 6 months post-operatively, showing solid union at the arthrodesis site.

bias and residual confounding. The absence of randomization resulted in baseline differences between groups, including age, preoperative AOFAS scores, preoperative pain levels, and the prevalence of rheumatoid arthritis. Although exploratory adjusted analyses were performed, unmeasured confounding variables may still have influenced the results. In addition, the study was conducted at a single specialized foot and ankle center, which may limit external validity. Finally, because only four cases of pseudarthrosis were observed, the study may have lacked sufficient statistical power to detect small differences in rare complications, and the possibility of a type II error cannot be excluded.

Despite these limitations, the study has important strengths. All patients underwent surgery using the same fixation approach, identical joint preparation methods, and similar postoperative rehabilitation protocols. Furthermore, fusion was confirmed by CT, providing a more rigorous assessment of union than conventional radiography alone. To our knowledge, few clinical studies have specifically investigated whether the component responsible for generating primary compression within a plate-and-screw construct influences the outcomes of first MTPJ arthrodesis. The present findings suggest that both strategies provide excellent clinical results; however, the use of the oblique lag screw as the primary compression device may facilitate earlier union without increasing complications. Future prospective and randomized studies are required to confirm these observations and determine their clinical relevance.

Conclusion

First metatarsophalangeal joint arthrodesis using a dorsal plate combined with an oblique cannulated screw provided reliable union, substantial pain relief, and significant functional improvement in patients with end-stage hallux rigidus.

Fusion in which primary compression was generated by the oblique lag screw demonstrated a significantly shorter time to union. Both plate-mediated compression and lag screw-driven compression resulted in satisfactory clinical and radiographic outcomes, with no statistically significant differences in nonunion, final pain scores, final functional scores, or overall complications.

These findings suggest that both fixation sequences are safe and effective, although lag screw-driven compression may offer a modest advantage in accelerating radiographic consolidation. Further prospective studies with larger samples are required to confirm whether this difference has clinically meaningful implications.

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