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Comparative Outcomes of First Metatarsophalangeal Arthrodesis in Hallux Valgus Versus Hallux Rigidus

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ABSTRACT

Objective: This study aimed to compare the functional and radiological outcomes of first metatarsophalangeal (MTP) joint arthrodesis in patients with hallux valgus (HV) and hallux rigidus (HR).

Materials and Methods: This retrospective cohort study included 78 feet (39 HV and 39 HR) that underwent first MTP arthrodesis between 2015 and 2023. Data collected included demographic information, surgical technique, radiological measurements (hallux valgus angle and intermetatarsal angle), union rates, and clinical outcomes assessed by the American Orthopaedic Foot and Ankle Society (AOFAS) score and Visual Analog Scale for pain. Statistical analyses compared outcomes between the HV and HR groups.

Results: Post-operative AOFAS scores demonstrated no significant difference between the HV and HR groups (p=0.236). Union rates were comparable (87.2% in HV vs. 89.7% in HR, p=0.500). Complication rates, including implant failure and superficial infection, were low and similar between the groups. One symptomatic non-union was observed.

Conclusion: The findings indicate that first MTP arthrodesis yields comparable functional outcomes, union rates, and low complication rates in patients with both HV and HR. These outcomes support the efficacy of the procedure irrespective of the underlying pathology.

Keywords: Fixation techniques, Hallux rigidus, Hallux valgus, Metatarsophalangeal arthrodesis, Post-operative outcomes

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INTRODUCTION

First metatarsophalangeal (MTP) joint arthrodesis is a well-established surgical intervention aimed at alleviating pain and restoring function in patients suffering from advanced degenerative conditions or deformities of the first MTP joint.[1] Among the most common indications for this procedure are hallux rigidus (HR) and severe hallux valgus (HV), two pathologies with distinct etiologies and clinical manifestations.[2,3] HR is characterized by osteoarthritis of the first MTP joint, resulting in pain and limited range of motion, while HV involves lateral deviation of the great toe, leading to deformity, functional limitations, and discomfort.

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Although both conditions can be effectively treated with MTP arthrodesis, the functional and radiological outcomes may vary depending on the underlying pathology. Previous studies have highlighted differences in union rates, complication profiles, and post-operative function between patients with HV and HR. However, a direct comparison of these outcomes between the two groups is still limited in the literature (Table 1).[4-7] Understanding these differences is crucial for optimizing surgical planning and patient counseling and identifying potential challenges specific to each pathology.

This study aimed to provide a comprehensive comparison of the functional and radiological outcomes of first MTP arthrodesis in patients with HV and HR. By examining union rates, radiographic alignment, and patient-reported functional outcomes, this research seeks to elucidate the impact of the underlying pathology on the success of MTP arthrodesis and provide insights that may guide clinical decision-making in foot and ankle surgery. Given the structural complexity and deformity associated with HV, we hypothesize that functional outcomes and complications may be more pronounced in patients with HV compared to those with HR.

MATERIALS AND METHODS

Study Design and Participants

This retrospective cohort study included patients who underwent first MTP arthrodesis between 2015 and 2023 at the authors' institution. Patient data, including clinical and demographic information, were obtained from the hospital's digital medical records, and radiological assessments were retrieved from the Picture Archiving and Communication System. Eligible patients were classified into two groups based on the underlying pathology leading to the need for MTP arthrodesis. The first group (Group HV) comprised patients with HV, while the second group (Group HR) included patients with HR.

Inclusion criteria required patients to have undergone first MTP arthrodesis and completed at least 1 year of follow-up. Patients with incomplete clinical or radiological data, inadequate radiological follow-up, or insufficient final follow-up evaluations were excluded from the analysis. The study protocol was approved by the Clinical Research Ethics Committee of Antalya Training and Research Hospital (Approval Date: June 13, 2024; Approval Number: 189-9/18). Informed consent was obtained from all participants before their inclusion in the study. The research adhered to the ethical standards outlined in the Declaration of Helsinki, and the study methodology followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines to ensure transparency, accuracy, and methodological rigor.

Indications of MTP Arthrodesis

Among the 39 feet that underwent arthrodesis in the HR group, 36 patients presented with primary HR (grade 3 or 4). One patient underwent arthrodesis due to post-traumatic osteoarthritis of the MTP joint following a fracture dislocation, while another patient required the procedure after the failure of a total MTP joint replacement. Another patient underwent revision surgery following failed arthrodesis with bioabsorbable screws. In the HV group, 26 patients exhibited deformities with a hallux valgus angle (HVA) of 40° or greater. In addition, the group included two patients with rheumatoid arthritis, two patients with failed primary HV surgeries, two patients with juvenile-onset HV, and 17 patients with HV accompanied by osteoarthritis of the MTP joint.

Surgical Technique and Post-operative Rehabilitation

All procedures were performed under spinal anesthesia with a tourniquet, with the patient positioned supine. A medial approach was utilized to expose the first MTP joint. Osteophytes on both the metatarsal and phalangeal sides were carefully excised. The joint cartilage was debrided using curettes and rongeurs, ensuring removal down to the subchondral bone. Multiple perforations were made in the subchondral bone using a Kirschner wire (K-wire), extending into the intramedullary cavity to enhance union. Temporary fixation with a K-wire was applied, and the desired arthrodesis position (neutral rotation, 0–15° HVA, 0–15° dorsiflexion) was confirmed using fluoroscopy. Three different fixation constructs were employed: [1] Plate fixation alone, [2] Plate fixation with a single interfragmentary compression screw, and [3] Plate fixation with crossed interfragmentary screws. For constructs involving compression screws, they were inserted before plate fixation. All plates were secured using locked screws to ensure optimal stability. In HV patients, lateral tenotomy was not performed. Arthrodesis was achieved solely through joint preparation and fixation techniques without additional soft-tissue interventions. In 14 cases with insufficient bone apposition, an autograft harvested from the distal tibia was applied to the fusion site to promote bone healing. In addition, in 12 patients, concurrent procedures were performed on the second or fifth toes, addressing conditions such as hammer or claw toe deformities and bunionectomy.

Following the procedure, a short-leg splint was applied for immobilization. Postoperatively, patients remained immobilized with the splint for 3 weeks to allow soft-tissue healing and edema control, adhering to strict non-weight-bearing instructions with crutches. After 3 weeks, the splint was removed, and partial weight-bearing was initiated using a range-of-motion walker. Full weight-bearing was gradually introduced based on clinical and radiological evaluations, considering the outcomes of any additional procedures performed.

Table 1. List of previous studies that compared the outcomes of 1st MTP arthrodesis in HV versus HR cases

Author	Year	# Procedures	Fixation technique	Union rate	Functional outcome	Complications	Conclusion
Korim and Allen[4]	2015	134 (49 HV, 46 HV, 34 Inflammatory, 5 salvage)	Flat cut surfaces, crossed screws (92.5%), dorsal plate w/wo screws (7.5%)	91.8% (radiographic)	Not Reported	14% non-union in the HV group, 12% in Inflammatory, None in the HR nd Salvage groups	HV group may require a stronger construct to achieve union rates comparable to HR
Chien et al.[5]	2017	112 (65 HR, 47 HV)	Cup and cone preparation, single compression screw and dorsal plate	98.5% (HR), 100% (HV)	Not Reported	1.5% non-union in HR group	Cup and cone with screw and plate provides strong fixation for both HV and HR
Chodaba et al.[6]	2023	98 (61 HV, 37 HR)	Cup and cone preparation, interfragmentary screws, and dorsal locking plate	93% (HV), 95% (HR)	PROMIS and FFI scores are comparable to the general population	4% wound complications, 6% non-union (1 asymptomatic)	MTP fusion is reliable for both hallux valgus and hallux rigidus, with similar patient-reported outcomes
Roth et al.[7]	2023	148 (57 HR, 47 HV, 44 Combined)	Not Reported	86% overall	PROMIS improved for all groups (FAOS, FAAM, VAS)	Overall, 34% complications, 14% non-union, 20% eoperations	Comparable outcomes between HR and HV groups; HR shows greater long-term improvement in PROMs.
Current Study	2024	78 (39 HR, 39 HV)	Plate fixation, plate + compression screws, crossed screws	87.2% (HV), 89.7% (HR)	AOFAS and VAS scores comparable between groups	11.5% Non-union, 6.4% implant failure, 3.8% implant removal. 4.3% superficial infection	Comparable union rates; HV group shows higher residual HVA; autografting more common in HR group.

HV: Hallux valgus, HR: Hallux rigidus, PROMIS: Patient-reported outcomes measurement information system, FFI: Foot function index, FAOS: Foot and ankle outcome score, FAAM: Foot and ankle ability measure, VAS: Visual Analog Scale, AOFAS: American Orthopaedic Foot and Ankle Society, HVA: Hallux valgus angle, MTP: Metatarsophalangeal.

Radiological Evaluations

Radiological evaluations were conducted preoperatively and during follow-up using standard weight-bearing radiographs. The HVA was measured as the angle between the longitudinal axes of the first metatarsal and the proximal phalanx, while the intermetatarsal angle (IMA) was determined as the angle between the longitudinal axes of the first and second metatarsals.[8] Both measurements were performed by an orthopedic surgeon specializing in foot surgery (Senior author MBE). Measurements were made according to the guidelines established in foot and ankle surgery literature, ensuring consistency and accuracy across all evaluations. The radiographic grading of osteoarthritis in the first MTP joint was classified using the Coughlin and Shurnas classification system.[9] This system categorizes osteoarthritis based on joint space narrowing, osteophyte formation, and subchondral sclerosis observed on radiographs, ranging from mild to severe. Union was assessed through radiographic evidence of bridging bone across at least three cortices on orthogonal views. Non-union was defined as the absence of fusion on the final follow-up radiographs or persistent pain at the arthrodesis site. These radiological assessments were consistently performed at follow-up intervals to evaluate the progression of bone healing and joint alignment.

Clinical Outcomes

Clinical outcomes were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Hallux MTP-Interphalangeal Scale, which evaluates pain, function, and alignment. Pain levels at the final follow-up were quantified using the Visual Analog Scale (VAS). Throughout the follow-up period, all complications were meticulously recorded, including early and late post-operative issues such as infection, delayed union, non-union, and hardware failure. For patients who were unable to attend their final follow-up appointments in person, clinical outcomes were collected through a structured telephone interview. These interviews were conducted by one of the authors (MY), and the same AOFAS and VAS scoring systems were used to ensure consistency in the data collected through phone.

Statistical Analysis

All statistical analyses were performed using Statistical Package for the Social Sciences software (version 27.0; IBM, Armonk, NY). Continuous variables were expressed as mean±standard deviation, and categorical variables were presented as frequencies and percentages. The normality of the data was assessed using the Shapiro–Wilk test. Comparisons between the two groups were conducted using appropriate statistical tests based on the distribution of the variables. Continuous variables were analyzed using either the Mann–Whitney U test for non-normally distributed data or the Student's t-test for normally distributed data. Categorical variables were compared using the Chi-square test. A $p<0.05$ was considered statistically significant, and all p-values were two-tailed. Bold p-values in the tables indicate statistically significant differences between the groups.

RESULTS

The cohort consisted of 32 patients in the HV group and 37 in the HR group. Seven patients in the HV group and two patients in the HR group underwent bilateral sequential MTP arthrodesis. Thus, 78 (39 feet in each group) were evaluated. There were no significant differences between the groups in terms of age at operation (p=0.682), sex distribution (p=0.397), smoking status (p=0.395), diabetes mellitus (p=0.5042), and American Society of Anesthesiologists score (p=0.627). However, the HR group had a significantly higher body mass index (27.8±3.1 kg/m^2 vs. 26.1±3.0 kg/m^2, p=0.018). Pre-operative radiographic assessments revealed a significantly higher HVA and IMA in the HV group compared to the HR group (p=0.0011 for both). Pre-operative VAS scores were higher in the HR group (7.8±1.8 vs. 6.8±2.0, p=0.0401), while pre-operative AOFAS scores showed no significant difference (p=0.7751). The distribution of fixation techniques did not differ significantly between the groups (p=0.872). Concomitant procedures were similar between the groups (25.6% vs. 5.1%, p=0.058), while autografting was more common in the HR group (25.6% vs. 10.3%, p=0.069). The summary of patient characteristics is presented in Table 2.

The clinical follow-up duration was significantly longer in the HV group compared to the HR group (71.5±32.1 months vs. 54.8±34.6 months, p=0.019). However, radiographic follow-up durations did not differ significantly (p=0.131). Post-operative radiographic measurements showed a significantly higher HVA in the HV group (15.3±5.6° vs. 11.8±5.2°, p=0.006). Post-operative IMA and AOFAS scores were comparable between the groups (p=0.113 and p=0.236, respectively). Although the HV group had a slightly lower post-operative VAS score, this difference was insignificant (p=0.166).

Union rates were comparable between the HV and HR groups (87.2% vs. 89.7%, p=0.500). Although non-union was observed in nine cases, eight were asymptomatic (Fig. 1), and only one case was evaluated as symptomatic. Among the five non-union cases in the HV group, none had a history of prior HV correction surgery. This indicates that previous surgical intervention was not associated with non-union in our study population. Implant failure, painful implant removal, and superficial infection rates were low in both groups and showed no significant differences. A summary of clinical and radiographic outcomes is presented in Table 3.

Table 2. Demographic and clinical characteristics of patients in the cohort

Variables	Group HV	Group HR	p
Age at operation (years±SD)	56.7±14.9	60.4±7.6	0.682[1]
Sex (n, %)			0.397[2]
Female	26 (81.2)	28 (75.7)	
Male	6 (18.8)	9 (24.3)	
Weight (kg±SD)	66.8±8.8	73.0±10.2	**0.005[3]**
Height (cm±SD)	160.0±8.4	161.8±6.6	0.320[1]
BMI (kg/m^2)	26.1±3.0	27.8±3.1	**0.018[3]**
Side (n, %)			0.450[2]
Right	23 (59.0)	22 (56.4)	
Left	16 (41.0)	17 (43.6)	
Diabetes (n, %)			0.504[2]
Yes	6 (18.8)	8 (21.6)	
No	26 (81.3)	29 (78.4)	
Smoking (n, %)			0.395[2]
Active smoker	6 (18.8)	5 (13.5)	
None/Quitted	26 (79.5)	32 (86.5)	
ASA Score (n, %)			0.627[2]
ASA I	8 (20.5)	5 (12.8)	
ASA II	29 (74.4)	32 (82.1)	
ASA III	2 (5.1)	2 (5.1)	
Pre-operative HVA (°±SD)	41.5±8.9	18.6±6.1	**0.001[1]**
Pre-operative IMA (°±SD)	13.3±4.6	10.0±2.1	**0.001[1]**
Radiographic Stage for HR (n, %)			NA
Grade I			
Grade II			
Grade III	-	21 (53.8)	
Grade IV	-	18 (46.2)	
Pre-operative AOFAS (score ±SD)	43.0±10.3	40.6±13.4	0.775[1]
Pre-operative VAS (score ±SD)	6.8±2.0	7.8±1.8	**0.040[1]**
Fixation technique (n, %)			0.872[2]
Plate	9 (23.1)	11 (28.2)	
Plate and single screw	19 (48.7)	18 (46.2)	
Plate and crossed screw	11 (28.2)	10 (25.6)	
Concomitant procedures (n, %)			0.058[2]
Yes	10 (25.6)	2 (5.1)	
No	29 (74.4)	37 (94.9)	
Autografting			0.069[2]
Yes	4 (10.3)	10 (25.6)	
No	35 (89.7)	29 (74.4)	

[1]Mann–Whitney-U Test; [2]Chi-Square Test. [3]T-test, Bold p-values are statistically significant. SD: Standard deviation; HV: Hallux valgus; HR: Hallux rigidus; HVA: Hallux valgus angle; IMA: Intermetatarsal angle; AOFAS: American Orthopaedic Foot and Ankle Society; NA: Not applicable.

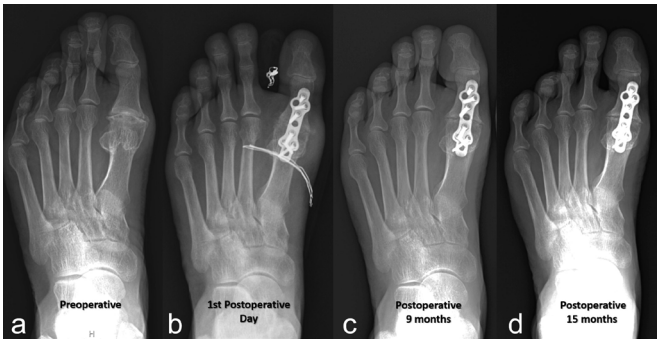

Figure 1. Asymptomatic non-union case in a 57-year-old female patient. **(a)** Pre-operative radiograph showing the Grade 4 Hallux Rigidus. **(b)** The radiograph on the 1st post-operative day, demonstrating fixation with a dorsal plate. **(c)** Nine-month post-operative radiograph showing evidence of delayed healing and non-union signs. **(d)** Fifteen-month post-operative radiograph confirming persistent non-union. However, the American Orthopaedic Foot and Ankle Society score was 77 points (good), and the Visual Analog Scale was 2 points at the 65th-month final follow-up.

DISCUSSION

This study highlights the reliability of the first MTP joint arthrodesis as an effective treatment for both HV and HR. Our union rates of 87.2% for HV and 89.7% for HR closely align with the high success rates reported in studies, confirming the consistent outcomes of this procedure across different cohorts.[5-7,10-14]

Furthermore, studies by Chodaba et al.[6] and Roth et al.[7] emphasized comparable functional outcomes and low complication rates for HV and HR, which closely match our findings. Their reported union rates exceeding 90% align with the consistency observed in our study, further validating the use of robust fixation techniques, such as compression screws and plates, in achieving successful outcomes. In addition, Roth et al.[7] highlighted the importance of patient-reported outcomes, such as Patient-Reported Outcomes Measurement Information System and Foot Function İndex scores, which provide a nuanced perspective on functional recovery. Although these specific metrics were not assessed in our study, the comparable AOFAS scores between HV and HR groups in our cohort support the notion of similarly favorable functional outcomes. These results are consistent with the literature.[2,11,15-20]

Table 3. Clinical and radiographic outcomes

Variables	Group H	Group HR	p
Clinical Follow-up (months±SD)	71.5±32.1	54.8±34.6	0.019*
Radiographic Follow-up (months±SD)	30.0±18.1	25.5±18.6	0.131*
Post-operative HVA (°±SD)	15.3±5.6	11.8±5.2	**0.006****
Post-operative IMA (°±SD)	10.5±2.6	9.6±1.9	0.113*
Post-operative AOFAS (score±SD)	83.6±8.6	81.3±10.4	0.236*
AOFAS Outcome			0.479***
Excellent	-	-	
Good	34 (87.2)	31 (79.5%)	
Fair	5 (12.8)	7 (17.9%)	
Poor	-	1(2.6%)	
Post-operative VAS (score ±SD)	1.4±0.6	1.9±1.4	0.166*
Radiographic union (n, %)			0.500***
Yes	34 (87.2)	35 (89.7)	
No	5 (12.8)	4 (10.3)	
Implant failure (n, %)			0.179***
Yes	3 (7.7)	1 (2.6)	
No	36 (92.3)	38 (97.4)	
Painful implant removal (n, %)			0.500***
Yes	1 (2.6)	2 (5.1)	
No	38 (97.4)	37 (94.9)	
Superficial ınfection (n, %)			0.500***
Yes	2 (5.1)	1 (2.6)	
No	37 (94.9)	38 (97.4)	

**Mann–Whitney-U test; **Student-T TEST; ***Chi-square test. Bold p-values are statistically significant. SD: Standard deviation; HV: Hallux valgus; HR: Hallux rigidus; HVA: Hallux valgus angle; IMA: Intermetatarsal angle; AOFAS: American Orthopaedic Foot and Ankle Society; NA: Not applicable.

Another observation in our study was the more frequent need for autografting in HR cases (25.6% vs. 10.3% in HV). Although this difference was not statistically significant, it reflects the greater bone loss typically associated with advanced osteoarthritis in HR patients, requiring grafts to support deformity correction and ensure stable fixation. This finding reflects the greater bone loss typically associated with advanced osteoarthritis in HR patients, requiring grafts to support deformity correction and ensure stable fixation.

The wound complication rates in our study, 5.1% for HV and 2.6% for HR, are consistent with the low rates reported in the literature. Chodaba et al.[6] similarly observed minimal wound-related issues across their patient population. This reinforces the efficacy of meticulous surgical technique and perioperative care in minimizing risks.

Our findings, particularly the comparable union rates between HV (87.2%) and HR (89.7%), our comparable union rates between HV (87.2%) and HR (89.7%) align with the general trends in the literature, yet differ from some studies.[2,4,21-24] Korim and Allen, who reported a significantly lower union rate for HV cases (86%) compared to HR (100%).[4] One potential explanation for this difference is the variation in surgical techniques. Korim and Allen employed flat cuts and crossed screw fixation, which may not effectively address the deforming forces associated with severe HV deformities or osteopenic bone quality.[4] By contrast, the use of compression screws and plates in our study likely provided enhanced stability, mitigating these challenges and contributing to our consistent union rates.

Another key factor may be differences in patient populations. Korim and Allen's cohort included a higher proportion of severe deformities and comorbid conditions such as inflammatory arthropathy, which can negatively impact bone healing.[4] Our study population, defined by standardized inclusion criteria, may represent a less heterogenous group, allowing for more controlled outcomes. These factors underscore the importance of tailoring surgical techniques and fixation methods to the specific demands of HV cases, ensuring robust constructs to achieve successful union outcomes.

Our study has several limitations. The retrospective design and relatively small sample size may limit the generalizability of the results. In addition, the lack of long-term follow-up may underestimate the true rate of complications and non-union. However, the study's strengths include the direct comparison of HV and HR groups using consistent surgical techniques and objective outcome measures. The inclusion of both clinical and radiographic evaluations enhances the reliability of our findings.

CONCLUSION

First MTP joint arthrodesis is an effective treatment for both HV and HR, providing comparable union rates, functional outcomes, and low complication rates. While HV cases may pose additional challenges due to deformity severity, appropriate surgical techniques can mitigate these risks. Future prospective studies with larger cohorts and long-term follow-up are needed to further validate these findings.

DECLARATIONS

Ethics Committee Approval: The study was approved by Antalya Training and Research Hospital Ethics Committee (No: 189-9/18, Date: 13/06/2024).

Author Contributions: Concept – M.B.E., M.Y., Ö.K.; Design – M.B.E., M.Y., Ö.K.; Supervision – Ö.K.; Data collection &/or processing – V.B., M.Y., M.B.E., Ö.K.; Analysis and/or interpretation – V.B., Ö.K., M.Y.; Literature search – M.B.E., M.Y., İ.E., Ö.K.; Writing – M.B.E., M.Y., İ.E., Ö.K.; Critical review – İ.E., Ö.K., M.B.E.

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Data Availability Statement: Data are available from the authors upon reasonable request.

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