Journal of Inonu University Health Services Vocational School
İnönü Üniversitesi Sağlık Hizmetleri Meslek Yüksekokulu Dergisi

e-ISSN: 2147-7892 Volume 13, Issue 2 (2025) 441-447 doi: 10.33715/inonusaglik.1641466

Research Article

PREOPERATIVE AND POSTOPERATIVE RADIOLOGIC EVALUATION IN HALLUX VALGUS SURGERY

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Article Info

Received: *17 February 2025*
Accepted: *14 April 2025*

Keywords

First metatarsal length,
Hallux valgus,
Hallux valgus angle,
Intermetatarsal angle

ABSTRACT

In this research radiological outcomes of hallux valgus surgeries which involved osteotomies of the first metatarsal has been retrospectively analyzed. A total of 25 patients who underwent surgery between 2020 and 2024 were evaluated. Preoperative and postoperative weight-bearing X-rays were analyzed to measure hallux valgus angle (HVA), intermetatarsal angle (IMA), and the first and second metatarsal length ratio (D1/D2). The results showed significant reductions in HVA and IMA after surgery, alongside a shortening of first metatarsal, indicating enhanced metatarsal alignment. The study concluded that surgical interventions effectively reduce hallux valgus deformity and improve both radiological and clinical outcomes. However, there exists limitations such as small sample size and short follow-up periods. Further studies are recommended to validate these findings and explore long-term effects.

INTRODUCTION

Hallux valgus (HV) as the most common forefoot deformity is marked by the outward displacement of the hallux and the inward displacement of the first metatarsal. In a meta-analysis involving 45 researches, the results showed the prevalance to be 23.74% in females and the overall prevalance 19% (Cai et al., 2023). Alkhalifah et al. have determined the prevalance as 25%, but also have pointed on widely varying reports about the topic (Alkhalifah et al., 2023). Besides gender; increasing age (the prevalance increases to 35.7% after the age of 60), body mass index, constricting footwear and family history are considered to be risk factors for HV (Alkhalifah et al., 2023; Kwan, Yick, Yip & Tse, 2021; Ray et al., 2019).

HV often causes pain, but also leads to functional limitations, joint mechanics alterations, decreased mobility, and cosmetic concerns (Ray et al., 2019; Schmeichel & Krähenbühl, 2022; Zirngibl, Grifka, Baier & Götz, 2017). Some of the kinematic changes obtained in HV are reduction in coronal plane motion of the hindfoot-shank during preswing, reduced force in the hallux region, reduced peak pressure at the medial and lateral hidfoot(Rosemberg et al., 2023). All these complications prompt many patients to seek surgical intervention when conservative treatment fails (Schmeichel & Krähenbühl, 2022). Surgical correction aims to restore proper

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alignment and function, alleviate symptoms and improve the patient's life quality (Dias, Godoy-Santos, Ferrari, Ferretti & Lenza, 2024).

Radiological evaluation plays a crucial role in determining pathoanatomical concepts and assessing the effectiveness of surgical interventions for HV (Motta et al., 2022; Soares, Gomes, Garibaldi, Monteverde & Oliva, 2023). By this aspect, key parameters such as the hallux valgus angle (HVA), the intermetatarsal angle (IMA) measured by using radiological imaging are frequently used to quantify the deformity and monitor postoperative outcomes (Motta et al., 2022). HVA and IMA are evaluated to be the best in correlating the magnitude of HV deformity (Canella, 2020). The studies have demonstrated that successful surgical correction results in significant improvements in HVA and IMA radiographic measures, suggesting that the deformity is effectively addressed (Dias et al., 2024). The metatarsal length change and the ratio of the first to second metatarsal lengths (D1/D2) are the other parameters that have been investigated and shown to be valuable parameters in assessing the results previously (Lee, Lee, Song & Choi, 2015; Sovilj, Baljozović & Baščarević, 2021)

The objective of this study was to assess the radiological outcomes of patients who underwent surgical treatment for HV by comparing preoperative and postoperative X-rays. Specifically, the HVA, IMA and D1/D2 ratio were analyzed on weight-bearing anterior-posterior foot X-rays.

MATERIAL AND METHOD

This retrospective study was performed at a training hospital after obtaining the ethics committee approval (18.09.2024/04). Patients with HV who were treated surgically in our clinic between March 2020 and July 2024 were screened in this study.

Inclusion criteria were; 1) osteotomy with a diagnosis of HV, 2) accessibility of data in patient files.

Exclusion criteria were; 1) Those who underwent arthrodesis techniques usage in the treatment, 2) Those who underwent double osteotomy, 3) Those who underwent phalangeal osteotomy, 4) Those who underwent only soft tissue procedures.

The age, sex, side, follow-up time, American Orthopaedic Foot and Ankle Society Metatarsophalangeal-Interphalangeal Scale (AOFAS MTP-IF) scores at the last follow-up were noted. HVA, IMA, first and second metatarsal lengths were calculated separately in the preoperative and postoperative standing anteroposterior foot X-rays. The metatarsal lengths were not compared due to the error potential caused by the magnification that could be observed in the X-rays (Figure 1 A, B). Instead of comparing the preoperative and postoperative first

metatarsal lengths, the first and second metatarsal lengths were measured separately on each X-rays and then compared to eachother (D1/D2 ratio). Since a change in the length of the first metatarsal after osteotomy is predicted, the second metatarsal, which remains constant, does not change in the denominator. It was investigated whether there was a change in the first metatarsal length before and after surgery due to the change in the D1/D2 ratio. Preoperative and postoperative HVA, IMA and D1/D2 ratios were compared in all patients. The locations of the metatarsal osteotomies were noted by proximal osteotomy, shaft osteotomy or distal osteotomy.

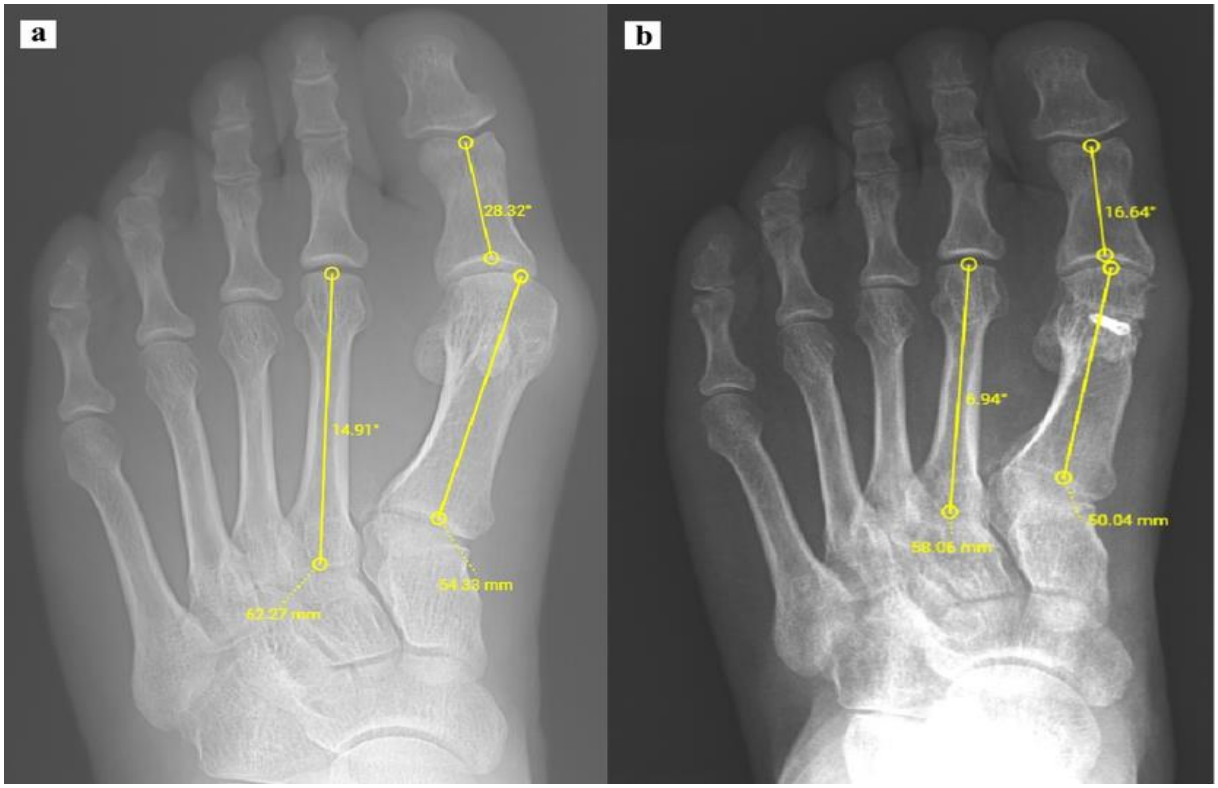

Figure 1: The weight-bearing anteroposterior foot X-rays a) Shows the preoperatively measurement of hallux valgus angle: 27.25^0, intermetatarsal angle: 14.62^0, and the lengths of the first metatarsal: 60.76 mm, and second metatarsal: 69.09 mm. b) Shows the postoperatively measurement of hallux valgus angle: 8.96^0, intermetatarsal angle: 3.59^0, and the lengths of the first metatarsal: 55.39 mm, and second metatarsal: 65.73 mm.

Statistics

Data for continuous variables were given as mean and standard deviation. Data for qualitative variables were given as frequency and percentage. Shapiro-Wilk test was used to evaluate the normality of the data. Paired samples t test was used to compare before and after measurement means. Analyses were performed by using SPSS 27 (IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp).

RESULTS

In the research 25 patients, 20 female and 5 male, who met the study criteria were included (Table 1). With mean follow-up time of 28.08±13.87 months, the average age of the patients at the end of their follow-up was determined to be 49.92±13.18. Of the 25 hallux valgus osteotomy operations, 14 were performed on the left foot and 11 was done to right foot. When osteotomy sites were considered; 3 (12%) were proximal, 7 (28%) were shaft and 15 (60%) were distal site operations (Table 1).

Table 1. Gender, Direction and Osteotomy Site Variables. Data are Shown as n and %.

Variable		N	%
Gender	Male	5	20
	Female	20	80
Direction	Left	14	56
	Right	11	44
Osteotomy site	Proximal	3	12
	Shaft	7	28
	Distal	15	60

AOFAS MTP-IF mean score was determined to be 93.36±8.97. Preoperative and Postoperative D1/D2 Ratio mean scores were 0.9±0.06 and 0.89±0.06 respectively and showed statistically significant difference ($p < 0.001$). When HVA scores were considered, posoperative mean HVA score 14.52±8 was determined to be statistically significantly different from preoperative HVA score of 33.83±8.61 ($p < 0.001$).Likewisestatistically significantly difference was obtained among preoperative 14.36±2.54 and postoperative 7.74±2.87 IMA values ($p < 0.001$) (Table 2).

Table 2. AOFAS MTP-IF, Preoperative and Postoperative D1/D2 Ratio, Preoperative and Postoperative HVA, Preoperative and Postoperative IMA Values. Data are Shown as Mean±Standard Deviation. Paired Samples t Test was Used, $p<0.001$. AOFAS MTP-IF: American Orthopaedic Foot and Ankle Society Metatarsophalangeal-Interphalangeal Scale, HVA: Hallux Valgus Angle, IMA: Intermetatarsal Angle.

Variables	Mean±Standard Deviation	p
AOFAS MTP-IF	93.36±8.97	
Preoperative D1/D2 ratio	0.9±0.06	<0.001
Postoperative D1/D2 ratio	0.89±0.06	
Preoperative HVA	33.83±8.61	<0.001
Postoperative HVA	14.52±8	
Preoperative IMA	14.36±2.54	<0.001
Postoperative IMA	7.74±2.87	

DISCUSSION

HV is a common deformity that significantly impacts patients' life quality by the pain and anatomical deformities, and cosmetic concerns it causes. Surgical interventions are frequently assessed when conservative treatments fail (Schmeichel & Krähenbühl, 2022; Zirngibl et al.,

2017). The results of this study confirm that surgical correction effectively improves both radiological and clinical outcomes, as evidenced by significant reductions in the HVA, IMA, and D1/D2 ratio, alongside improved patient-reported outcomes.

The reduction in HVA and IMA observed postoperatively in our study aligns with previous literature, which consistently shows that correction of these angles leads to improved alignment and symptom relief (Canella, 2020; Dias et al., 2024). These findings suggest that the surgical procedures employed were successful in realigning the hallux and reducing the deformity severity, consistent with other studies that emphasize the importance of these radiological measures (Motta et al., 2022). The D1/D2 ratio, which reflects the metatarsal length distribution, also demonstrated a significant improvement, and these findings are similar to the findings of Sovilj et al. (Sovilj et al., 2021). This improvement in the D1/D2 ratio may indicate a better metatarsal alignment, which could contribute to better foot biomechanics and potentially reduce the risk of postoperative complications. The first metatarsal shortening can lead to metatarsalgia, particularly when the shortening exceeds 4 mm (Justiniano et al., 2022). Due to magnification-related technical errors on X-ray, in the current study the preoperative and postoperative lengths of first metatarsal could not be compared (Shigematsu et al., 2013). Therefore, metatarsal length could not be presented in mm, but was evaluated as a ratio. Although there is statistical significance according to the change between the D1/D2 ratios, the small mean difference between the preoperative and postoperative ratios suggests that the shortening of the first metatarsal is too minor to cause pain.

Additionally, the AOFAS HV-IF score observed in our study underscores the positive correlation between radiological corrections and functional outcomes, as also reported by Dias et al. (Dias et al., 2024). This suggests that the surgical interventions not only corrected the deformity but also enhanced the patients' overall foot function and quality of life. The results of current study confirm that surgical correction of HV results in significant improvements in radiological measurements and clinical outcomes, supporting the efficacy of surgical intervention for this condition (Dabelea et al., 2017; Dias et al., 2024).

The comparison of osteotomy locations for HV reveals varying outcomes based on the specific techniques employed. Different osteotomy sites, such as proximal, shaft, and distal have been evaluated for their effectiveness in correcting HV deformities. Studies usually indicate no significant differences in outcomes between the locations of osteotomies (Fukushi et al., 2022; Santos, Roseiro, Cortesão Seiça & Amaro, 2024). Although the small sample size in the study does not allow us to make comparisons according to the location of the osteotomy,

the observation of adequate radiologic improvement in the patients was consistent with the literature.

However, this study has some limitations. The sample size was relatively small, and the follow-up period was short, which may affect the long-term applicability of our results. Another limitation is that subgroups could not be compared according to the localization of the osteotomy due to the small sample size. The absence of the first metatarsal length in mm is another limitation. The lack of sesamoid x-rays, owing to technical constraints, also constitutes a limitation. Further studies with larger cohorts and longer follow-up are needed to confirm the durability of the observed improvements and assess the role of other factors, such as metatarsal length changes, in postoperative outcomes.

CONCLUSION

This study demonstrates that osteotomy-based surgical interventions for hallux valgus deformity significantly improve radiological parameters, such as the hallux valgus angle and intermetatarsal angle, indicating effective correction of the deformity. A statistically significant decrease in D1/D2 metatarsal ratios may not always have clinical significance, as it may be more meaningful to demonstrate the change in metatarsal length with mm measurement. Despite these promising results, the study's limitations, including a small sample size and short follow-up period, warrant caution in generalizing the findings. Further large-scale studies with extended follow-up, measuring the length in mm are necessary to confirm the long-term efficacy and safety of these surgical techniques in the management of hallux valgus.

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