Scientific Research Publishing

Open Journal of Orthopedics, 2023, 13, 84-96
https://www.scirp.org/journal/ojo
ISSN Online: 2164-3016
ISSN Print: 2164-3008

# The Radiological Outcome of Surgical Correction of Hallux Valgus with Combined Scarf and Akin Osteotomies

**Sami Nogdallah[1], Mohamed Alhassan Osman[2], Montaser Fatooh[1], Alaa Mohamed Mohamed Khairy[3], Hozifa Mohammed Ali Abd-Elmaged[4], Osama Gamal Nubi[5]**

[1]Orthopedics Surgery Department, Alneelain University, Khartoum, Sudan
[2]Bashaer Teaching Hospital, Khartoum, Sudan
[3]Orthopaedic Registrar Sudan Medical Specialization Board, Khartoum, Sudan
[4]Orthopedics Surgery Department, Alzaiem Alazhari University, Khartoum, Sudan
[5]Bashaer University Hospital, MBBS Al Neelan University, Khartoum, Sudan
Email: alaaakhairy@gmail.com

**How to cite this paper:** Nogdallah, S., Osman, M.A., Fatooh, M., Khairy, A.M.M., Abd-Elmaged, H.M.A. and Nubi, O.G. (2023) The Radiological Outcome of Surgical Correction of Hallux Valgus with Combined Scarf and Akin Osteotomies. *Open Journal of Orthopedics*, **13**, 84-96.
https://doi.org/10.4236/ojo.2023.133010

**Received:** February 26, 2023
**Accepted:** March 28, 2023
**Published:** March 31, 2023

Copyright © 2023 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/

Open Access

## Abstract

**Background:** Hallux valgus deformity is one of the most common chronic and progressive foot deformities. Surgical correction of the deformity plays a central role in the treatment of symptomatic hallux valgus. However, more than one hundred different surgical techniques have been described. **Objective:** To assess the radiological outcome of hallux valgus surgical correction using a scarf and akin osteotomies. **Materials and methods:** A cross-sectional hospital-based study was conducted on 25 adult patients (36 feet). Twenty-two females and two males with hallux valgus were treated with surgical correction using a scarf and akin osteotomies. All candidates were kept on regular postoperative, scheduled clinical follow-up programs for one year and assessed radiologically. **Results:** Twenty-five patients (36 feet) were included in this study. The hallux valgus angle significantly shifted to the normal range (less than 15˚) after surgery, and the inter-metatarsal angle also improved to the normal range (less than 9˚). **Conclusion:** Using scarf and akin osteotomies in treating moderate and severe hallux valgus deformity provides the satisfactory radiological outcomes in form of decreasing hallux valgus angle and inter-metatarsal angle.

## Keywords

Hallux Valgus, Scarf Osteotomy, Akin Osteotomy, Valgus Angle, Intermetatarsal Angle

# 1. Introduction

## 1.1. Background

Hallux valgus (HV) deformity is one of the most common chronic and progressive foot deformities [1] [2], occurring when the hallux deviates laterally towards the other toes and the first metatarsal head becomes prominent medially. The pooled prevalence of hallux valgus deformity in the reported literature has been estimated to be 23% among those 18 to 65 years of age and 35.7% among those over 65 years of age [3]. The pathogenesis of HV deformity is a complex process that starts with a lateral deviation of the phalanx, this leads to varus malalignment of the metatarsal and medial displacement of the metatarsal head. These changes result in the lateral shift of the sesamoid complex. The sesamoids are connected to the proximal phalanx by the sesamoid-phalangeal ligament, this lateral shift can lead to transfer metatarsalgia because of the change in weight bearing axis. Following this, the medial capsule of the 1st metatarsophalangeal joint becomes lax while the lateral capsule becomes tense. The lateral shift of the extensor halluces longus adds to the deforming forces added to the plantar and lateral shift of the abductor halluces. The windlass mechanism is significantly affected and becomes weak and transfer metatarsalgia is frequently seen [4].

There are a lot of risk factors for hallux valgus deformity. It can be divided into intrinsic and extrinsic factors. Genetic predisposition (70% of patients), increased distal metaphyseal articular angle (DMAA), ligamentous laxity, convex metatarsal head, second toe deformity or amputation, pes planus, and rheumatoid arthritis are important intrinsic factors. Extrinsic factors include inappropriate shoes with high heels and a narrow toe box.

The patient typically complains of pain over prominence at the MTP joint and difficulties wearing shoes because of medial eminence, and other functional disabilities with HV; due to that, surgery is usually indicated, depending on the degree of deformity based on the radiological findings as well as the physical examination findings. Radiological assessment includes weight-bearing anteroposterior (AP) and lateral imaging of the foot. The severity of the deformity is usually classified as mild when the hallux valgus angle (HVA) is up to 19˚, inter-metatarsal angle (IMA) up to 13˚, moderate when HVA is 20˚ to 40˚; and severe when HVA is > 40˚ and IMA > 20˚.

Surgical correction of the deformity has a major role in treating HV deformity, and >100 different surgical techniques have been described [5] [6]. Surgery entails releasing soft tissue and correcting alignment with a carefully planned metatarsal osteotomy [7]. Distal osteotomies of the first metatarsal are primarily advocated for mild to moderate hallux valgus deformities. For more severe abnormalities, additional proximal first metatarsal osteotomies have been carried out [8].

The scarf osteotomy is a Z-step cut in the first metatarsal bone used to reduce hallux valgus deformity's increased inter-metatarsal angle (IMA). The term "scarf" is a carpentry term referring to a joint created by notching two pieces of wood. This osteotomy is used widely in France and the United States and con-

tinues to evolve and increase in popularity in the surgical community [8]. The use of the proximal phalanx (Akin) osteotomy as an adjunct to the scarf osteotomy has been described frequently [9] [10] [11]. When the hallux is still in more than 10 valgus, it is typically introduced after the scarf osteotomy, and soft tissue repair are finished [12]. The scarf osteotomy is a Z-step cut in the first metatarsal bone used to reduce hallux valgus deformity's increased inter-metatarsal angle (IMA). The term "scarf" is a carpentry term referring to a joint created by notching two pieces of wood. This osteotomy is used widely in France and the United States and continues to evolve and increase in popularity in the surgical community [8]. The use of the proximal phalanx (Akin) osteotomy as an adjunct to the scarf osteotomy has been described frequently [9] [10] [11]. When the hallux is still in more than 10 valgus, it is usually introduced after the scarf osteotomy and soft tissue repair are completed [12].

### 1.2. Objectives

- **General objective:**

To assess the radiological outcome of hallux valgus after surgical correction using scarf and akin osteotomies.

- **Specific objectives:**

1) To measure the hallux valgus angle before and after surgery.

2) To compare the inter-metatarsal angle before and after correction

3) To identity the shape of the 1st metatarsal head, congruency of the 1st metatarso-phalangeal joint and the mmetatarsal Cascade.

## 2. Methodology

### 2.1. Study Design

Cross-sectional, hospital-based study.

### 2.2. Study Area

The study was conducted at Future Hospital in Khartoum, Sudan. From January 2019 to December 2022.

### 2.3. Study Population

Inclusion criteria were all adult patients from both genders with hallux valgus deformity who underwent acute surgical correction were included in this study. Patients with other foot deformities were excluded.

### 2.4. Sample Size and Sampling Technique

Total coverage of all patients with hallux valgus deformity was treated with acute surgical correction and met the inclusion criteria.

### 2.5. Data Collection and Analysis

Data were collected using a structured questionnaire, and the questionnaire was

designed and filled out by the first and second authors. Attached in the appendix, including the patient's demographic data, history, examination findings, and radiographic assessment for the hallux valgus angle and inter-metatarsal angle, were measured before surgery and one year after surgery. These angles were measured from weight-bearing X-rays using computer software anteroposterior (AP) and lateral imaging of the foot. Collected questionnaires were revised for completeness and accuracy, and clearance. Data were entered using the Statistical Package for Social Sciences (SPSS) version 27.0 for data analysis.

Descriptive terministic in terms of frequency tables with percentages and graphs. Chi-square test to assess associations (P value of 0.05 or less is considered significant).

### 2.6. Our Study Limitations

Small sample size and short follow-up period.

### 2.7. Surgical Technique and Post-Operative Plan

Careful clinical and radiological assessment of patients was handled before surgery. Counselling and consent were obtained. Spinal anesthesia was chosen in this series, and a tourniquet was applied to all patients. The sesamoid apparatus, adductor halluces tendon, and lateral sesamoid ligament were freed from the insertion in the metatarsal head and proximal phalanx through a dorsal incision in the joint capsule between the metatarsal head. A medial incision at the sagittal groove removed the first metatarsal's medial eminence. A guide wire was placed proximal to the metatarsal head articular surface and inferior to the first metatarsal dorsal cortex. The guide wire was pointed planetary at the third metatarsal head's plantar surface but perpendicular to the second metatarsal's long axis. A power saw was cut horizontally along the metatarsal shaft from proximal to the articular surface of the metatarsal head to the basal tuberosity after positioning an osteotomy jig on the guide wire. To enable rotation, the proximal cut was performed at roughly a 45˚ angle from medial proximal to lateral distal, parallel to the guide wire. The inferior fragment then rotated toward the second metatarsal to lessen the inter-metatarsal angle after the lateral capsule was freed. By measuring the inter-metatarsal angle on an X-ray anterior-posterior and oblique views, it was possible to determine the required degree of rotation before surgery. The inter-metatarsal angle was intended to be reduced to 7˚. The bone fragments were held with a clamp and fixed with two 2.0 millimeters cortical screws. The medial side of the metatarsal shaft then had the overhanging margins of the bone cut off. In each example, the proximal phalanx underwent an Akin closing wedge osteotomy. The Akin osteotomy was fixed using bone staples. Finale X-rays were checked by fluoroscopy, wound dressing and sterile dressing were performed after 2 weeks follow up stitches were removed. Immobilization in a walker boot was applied for two months, followed by physiotherapy sessions. All patients had their physiotherapy sessions at the same center,

and the same protocol was done for them. X-rays were taken immediately after surgery, then at four weeks, 12 weeks, and six months.

## 3. Results

This study included 25 participants and 36 feet. The average age was 62.2 years old. The main age group included 11 patients (44%), ranging in age from 60 to 69 years. There were 9 patients over the age of 70 (36%) and 5 patients under the age of 60 (20%) (Figure 1). Among the 25 participants, 22 were females (88%) and 3 were males (12%) (Figure 2). Following surgery, the average follow-up time was more than 12 months in 18 patients (72%), 6 - 12 months in 4 patients (16%), and less than 6 months in 3 patients (12%) (Figure 3). 10 patients (40%) had surgical correction in their right foot, 5 patients (20%) had surgery on their left side, and 10 patients (40%) had bilateral correction (Figure 4). When evaluating radiological measures: The average pre-operative hallux valgus angle was 36.2 degrees. The deformity was found to be severe (more than 39 degrees) in 14 feet and moderate (between 30 and 39 degrees) in 22 feet (Table 1). The average post-operative hallux valgus angle was 16.9 degrees. This means that it had improved by 19.2 degrees (from 36.2 to 16.9 degrees). This gain was statistically significant. The preoperative inter-metatarsal (IM) angle disturbance was mild (9 - 11 degrees) in 6 feet, moderate (12 to 17 degrees) in 17 feet, and severe (more than 17 degrees) in 13 feet (Table 2). The post-operative inter-metatarsal angle was 9.5 degrees on average. This represents a 9.9-degree improvement (from 19.4 to 9.5 degrees).

The postoperative shape of the first metatarsal head was round in 16 feet, intermediate in 6 feet, and marginal in 14 feet, according to the study (Table 3). Postoperative metatarsophalangeal (MTP) joint congruency was found in 28 joints, while 8 joints were incongruent (Table 4). We also assessed the metatarsal

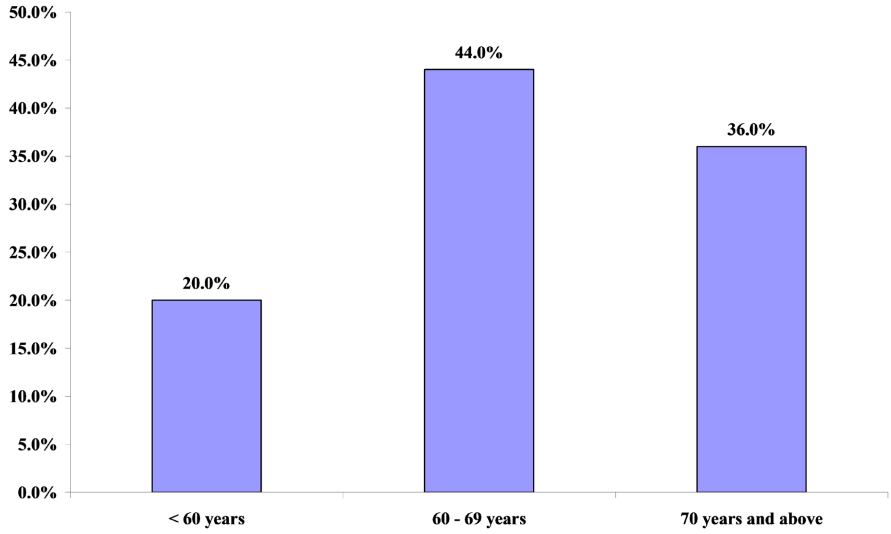


Figure 1. Showing age group.

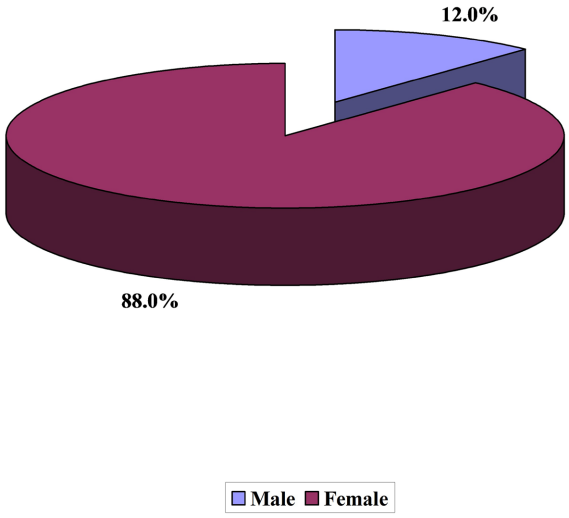


Figure 2. Showing gender.

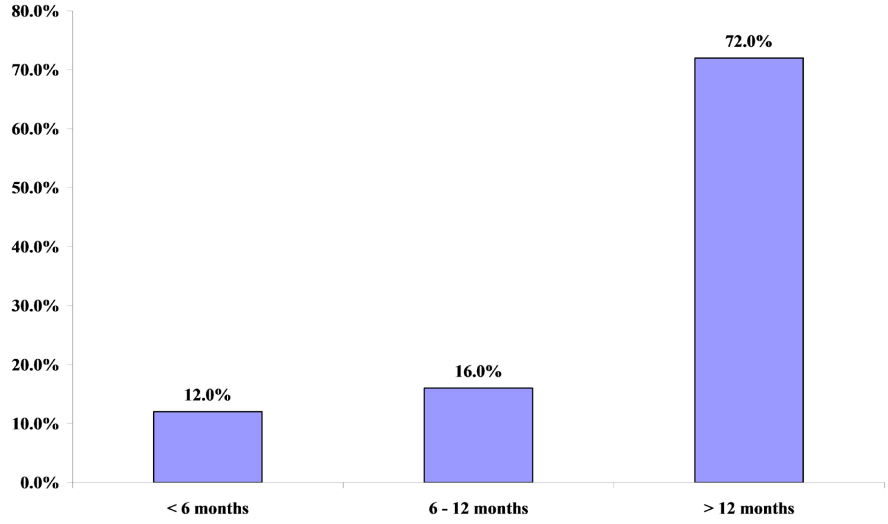


Figure 3. Duration of follow up.

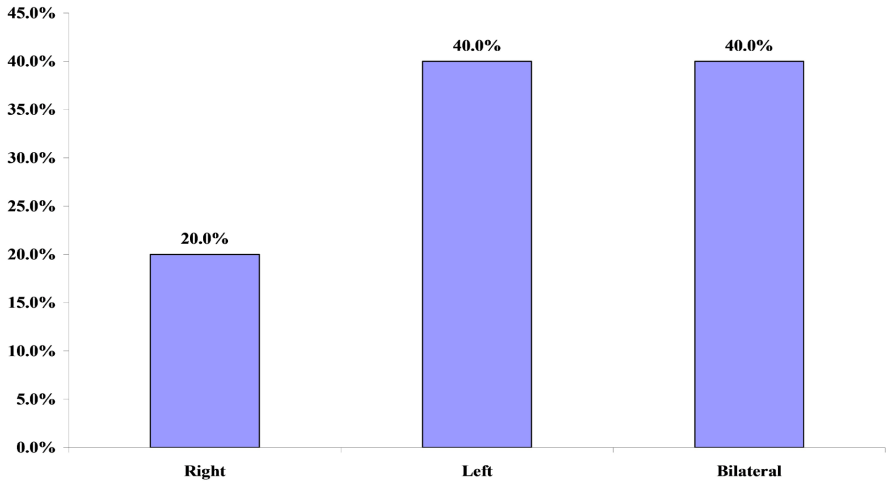


Figure 4. Showing the side of operation.

**Table 1.** Hallux valgus (HV) angle in preoperative and post-operative.

| HV angles | Pre | | | | Post | | | |
|---|---|---|---|---|---|---|---|---|
| | R | | L | | R | | L | |
| | N | % | N | % | N | % | N | % |
| <15 normal | 0 | 0.0 | 0 | 0.0 | 5 | 31.3 | 7 | 35.0 |
| 15 - 20 mild | 0 | 0.0 | 0 | 0.0 | 5 | 31.3 | 8 | 40.0 |
| 21 - 39 moderate | 9 | 56.2 | 13 | 65.0 | 6 | 37.5 | 5 | 25.0 |
| >39 severe | 7 | 43.8 | 7 | 35.0 | 0 | 0.0 | 0 | 0.0 |
| Total | 16 | 100.0 | 20 | 100.0 | 16 | 100.0 | 20 | 100.0 |
| P value | | | | | 0.026 | | 0.017 | |

**Table 2.** Inter-metatarsal (IM) angle pre-operative and post-operative.

| MI angle | Pre | | | | Post | | | |
|---|---|---|---|---|---|---|---|---|
| | R | | L | | R | | L | |
| | N | % | N | % | N | % | N | % |
| <9 normal | 0 | 0.0 | 0 | 0.0 | 7 | 43.8 | 7 | 35.0 |
| 9 - 11 mild | 4 | 25.1 | 2 | 10.0 | 6 | 37.5 | 5 | 25.0 |
| 12 - 17 moderate | 8 | 50.0 | 9 | 45.0 | 2 | 12.5 | 8 | 40.0 |
| >17 severe | 4 | 25.0 | 9 | 45.0 | 1 | 6.3 | 0 | 0.0 |
| Total | 16 | 100.0 | 20 | 100.0 | 16 | 100.0 | 20 | 100.0 |
| P value | | | | | 0.014 | | 0.018 | |

**Table 3.** Postoperative shape of the 1st Metatarsal head.

| Shape of the 1st MT head | R | | L | |
|---|---|---|---|---|
| | N | % | N | % |
| Rounded | 6 | 37.5 | 10 | 50.0 |
| Intermediate | 2 | 12.5 | 4 | 20.0 |
| Marginal | 8 | 50.0 | 6 | 30.0 |
| Total | 16 | 100.0 | 20 | 100.0 |

**Table 4.** Postoperative congruency of metatarsophalangeal (MTP) joint.

| Congruency of MTP joint | R | | L | |
|---|---|---|---|---|
| | N | % | N | % |
| Incongruent | 4 | 31.3 | 4 | 19.0 |
| Congruent | 11 | 68.8 | 17 | 81.0 |
| Total | 16 | 100.0 | 20 | 100.0 |

cascade after surgery in this study, and it was found to be disturbed in 27 feet and normal in 9 feet (Table 5).

Recurrence of the deformity was encountered in 2 feet (5.5%) and couldn't be correlated statistically with either the shape of the metatarsal head or the congruence of the 1st MTP.

## 4. Discussion

Surgical correction of symptomatic hallux valgus deformity aims at relieving the symptoms and improving the alignmentin the current study, the most affected age group (44%) was between 60 and 69 years old, with those under 60 years old being the least affected (20%). This was consistent with the findings of Hylton B. Menz and fellows [13], who studied the incidence and progression of hallux valgus. They included 1482 participants, 739 women and 743 men; the mean age was 62.9 ± 8.1 years.

The majority of patients were females (88%), and only 3 patients (12%) were males. This is common in the literature; Christopher G. Lenz and his colleagues [14] found that 94 patients (89%) of their study sample were women. Also, Jonathan Larholt and his fellows [15] included there were 24 females (89%) out of 27 patients in their study.

In this study, 10 patients were affected bilaterally (40%), and also 10 patients (40%) operated on the left side only, and only 5 patients (20%) had the operation on their right foot. Michael J. Coughlin *et al.* [16] studied hallux valgus demographics and etiology, finding that 87 of 108 patients (84%) had bilateral bunions.

Our patients were followed up after surgery more than 12 months in 18 patients (72%), (6 - 12 months) in 4 patients (16%), and in less than 6 months) in 3 patients (12%). A.-K. Nilsdotter and his colleagues [17] did study outcomes after hallux valgus surgery, and follow-up after surgery was from 6 months to 2 years.

Our results showed that, according to radiological measures, the angle of hallux valgus significantly shifted to the normal range. The mean hallux valgus angle has improved from 36.2 before surgery to 16.9 one year after the procedure. The inter-metatarsal angle had also shifted to the normal range. The mean inter-metatarsal angle has been reduced from 19.4 before the operation to 9.5 one year after the correction. Both changes were statistically significant (P value < 0.05).

**Table 5.** Postoperative metatarsal cascade.

| Metatarsal Cascade | R | | L | |
|---|---|---|---|---|
| | N | % | N | % |
| Disturbed (short first metatarsal) | 4 | 25.0 | 5 | 25.0 |
| Normal | 12 | 75.0 | 15 | 75.0 |
| Total | 16 | 100.0 | 20 | 100.0 |

Ignacio Martínez Garrido and his fellows [18], in their study of 30 patients (37 feet) with moderate to severe hallux valgus deformity, performed scarf and Aikin osteotomies and found in their post-operative radiological assessment of a significant improvement ($P < 0.001$) of the Hallux valgus angle (mean reduction 17.4 degrees). In the inter-metatarsal angle, they found a mean reduction of 5.8 degrees. Christopher G. Lenz and his colleagues [14] had enrolled 106 patients (118 feet) and assessed patients' pre-operative and postoperative measurements of Hallux valgus and inter-metatarsal angles on weight-bearing X-ray images. They found that the Hallux valgus angle was reduced significantly by an average of 18.7 degrees and the inter-metatarsal angle by 7.8 degrees. Our series' average reductions in the mean Hallux valgus and inter-metatarsal angles were 19.2 and 9.9 degrees, respectively. These findings were compared with the results of the above studies.

It is still debatable if the first metatarsal (MT) head shape and the hallux valgus deformity are related. In the current study, the postoperative shape of the 1st MT head was rounded at 16 feet, intermediate at 6 feet, and marginal at 14 feet. The first metatarsal head's lateral edge was investigated by Okuda and his colleagues [19] as a potential risk factor for hallux valgus recurrence and concluded that there was a significant association between a round-shaped first metatarsal head and the risk of hallux valgus recurrence.

Moreover, Satoshi Yamaguchi *et al.* examination of the first metatarsal head's lateral edge [20] discovered a high correlation between greater first metatarsal pronation and a positive round sign on the dorsoplantar radiograph of the first metatarsal head's foot. With hallux valgus surgery, the negative round sign may be utilized to demonstrate the successful correction of first metatarsal pronation.

The congruence of the first metatarsophalangeal (MTP) joint after the surgical correction is important in predicting the recurrence of deformity. Several researches have demonstrated a strong correlation between postoperative MTP joint incongruence and hallux valgus recurrence. In our study, the postoperative incongruence of the metatarsophalangeal joint was encountered in 7 joints, and 28 joints were congruent. Yan Li *et al.* [21] included 245 feet and evaluated the congruence of the first metatarsophalangeal joint after hallux valgus surgery. They claimed that the MTP joint congruency joint may be evaluated quantitatively using the MTP joint angle and congruence index (CI), and that the MTP joint congruency should be taken into account when selecting surgical techniques for various levels of hallux valgus.

In this study we also evaluated the postoperative alignment of metatarsal cascade. It was found disturbed (short first metatarsal) in 9 feet and normal in 27 feet. Following treatment of hallux valgus, Christopher G. Lenz and his colleagues [14] reassessed the post-operative metatarsal cascade and came to the conclusion that the first metatarsal had significantly shrunk. Furthermore, according to Ahmet Kaptanetalstudy [22]'s the first metatarsal length drastically decreased from preoperative measurements.

Finally, our study shows that surgical correction of hallux valgus using a scarf and akin osteotomies significantly improves radiological measures. This is supported by Ignacio Martínez Garrido and his fellows [18] in their study of 30 patients (37 feet) with moderate to severe hallux valgus deformity. They used a scarf and Akin procedures and realized that these procedures have value in obtaining predictable correction of moderate to severe hallux valgus deformities.

## 5. Conclusion

Surgical management of moderate and severe hallux valgus deformity with a combination of scarf and akin osteotomies provides satisfactory radiological outcomes. This was reflected by restoring the normal values of the hallux valgus angle and inter-metatarsal angle in most patients. However, the metatarsal cascade and the length of the 1st metatarsal can be affected after the procedure. The results of this study couldn't correlate the shape of the 1st metatarsal head with the recurrence of the deformity.

## Acknowledgements

First and foremost, we thank Allah for lighting our path and allowing us to finish this work. We are grateful to our colleagues who contributed to bringing this work to light. We are grateful to our families for devoting themselves at this time to provide various forms of assistance. Thank you very much.

## Ethics Approval and Consent to Participate

We declare that we have:

- Written permission was obtained from the administrative authority of Future hospital.
- Confidentiality was considered intentional, and data was used anonymously by using code Numbers instead of names to participants' identities and keep secure, and information was used for research purposes only.

## Authors' Contributions

S. N: Orthopaedics surgeon, conceptualization, methodology, resources, project administration, writing original draft.

M. H: Orthopedic resident, conceptualization, data collection, methodology, assist in writing original draft.

A. K: Orthopedic resident, conceptualization, assist in data collection, writing original draft.

H. A: Orthopedic surgeon, data curation, resources, validation, review and editing.

M. F: Orthopedic surgeon, resources, visualization, validation, and assisting in analysis & editing.

O. G: House officer, data curation, formal analysis, software, and assisting in writing original draft.

The manuscript has been read and approved by all the authors.

## Conflicts of Interest

The authors declare that they have no competing interests.

## References


[1] Coughlin, M.J. (1996) Hallux Valgus. *Journal of Bone and Joint Surgery—American Volume*, **78**, 932-966. https://doi.org/10.2106/00004623-199606000-00018

[2] Easley, M.E. and Trnka, H.J. (2007) Current Concepts Review: Hallux Valgus Part 1: Pathomechanics, Clinical Assessment, and Nonoperative Management. *Foot & Ankle International*, **28**, 654-659. https://doi.org/10.3113/FAI.2007.0654

[3] Nix, S., Smith, M. and Vicenzino, B. (2010) Prevalence of Hallux Valgus in the General Population: A Systematic Review and Meta-Analysis. *Journal of Foot and Ankle Research*, **3**, Article No. 21. https://doi.org/10.1186/1757-1146-3-21

[4] Perera, A.M., Mason, L. and Stephens, M.M. (2011) The Pathogenesis of Hallux Valgus. *Journal of Bone and Joint Surgery—American Volume*, **93**, 1650-1661. https://doi.org/10.2106/JBJS.H.01630

[5] Easley, M.E. and Trnka, H.J. (2007) Current Concepts Review: Hallux Valgus Part II: Operative Treatment. *Foot & Ankle International*, **28**, 748-758. https://doi.org/10.3113/FAI.2007.0748

[6] Robinson, A.H. and Limbers, J.P. (2005) Modern Concepts in the Treatment of Hallux Valgus. *Journal of Bone and Joint Surgery—British Volume*, **87**, 1038-1045. https://doi.org/10.1302/0301-620X.87B8.16467

[7] Gallentine, J.W., Deorio, J.K. and Deorio, M.J. (2007) Bunion Surgery Using Locking-Plate Fixation of Proximal Metatarsal Chevron Osteotomies. *Foot & Ankle International*, **28**, 361-368. https://doi.org/10.3113/FAI.2007.0361

[8] Trnka, H.J., Parks, B.G., Ivanic, G., Chu, I.T., Easley, M.E., Schon, L.C. and Myerson, M.S. (2000) Six First Metatarsal Shaft Osteotomies: Mechanical and Immobilization Comparisons. *Clinical Orthopaedics and Related Research*, **381**, 256-265. https://doi.org/10.1097/00003086-200012000-00030

[9] Jones, S., Al Hussainy, H.A., Ali, F., Betts, R.P. and Flowers, M.J. (2004) Scarf Osteotomy for Hallux Valgus: A Prospective Clinical and Pedobarographic Study. *Journal of Bone and Joint Surgery—British Volume*, **86**, 830-836. https://doi.org/10.1302/0301-620X.86B6.15000

[10] Lipscombe, S., Molloy, A., Sirikonda, S. and Hennessy, M.S. (2008) Scarf Osteotomy for the Correction of Hallux Valgus: Midterm Clinical Outcome. *The Journal of Foot and Ankle Surgery*, **47**, 273-277. https://doi.org/10.1053/j.jfas.2008.02.021

[11] Lorei, T.J., Kinast, C., Klarner, H. and Rosenbaum, D. (2006) Pedographic, Clinical, and Functional Outcome after Scarf Osteotomy. *Clinical Orthopaedics and Related Research*, **451**, 161-166. https://doi.org/10.1097/01.blo.0000229297.29345.09

[12] Kristen, K.H., Berger, C., Stelzig, S., Thalhammer, E., Posch, M. and Engel, A. (2002) The SCARF Osteotomy for the Correction of Hallux Valgus Deformities. *Foot & Ankle International*, **23**, 221-229. https://doi.org/10.1177/107110070202300306

[13] Thomas, M.J., Roddy, E., Rathod, T., Marshall, M., Moore, A., Menz, H.B. and Peat, G. (2015) Clinical Diagnosis of Symptomatic Midfoot Osteoarthritis: Cross-Sectional Findings from the Clinical Assessment Study of the Foot. *Osteoarthritis and Cartilage*, **23**, 2094-2101. https://doi.org/10.1016/j.joca.2015.06.010

[14] Lenz, C.G., Niehaus, R., KarimEid, I. and Borbas, P. (2021) Scarf Osteotomy for Hallux Valgus Deformity: Radiological Outcome, Metatarsal Length and Early Complications in 118 Feet. *Foot and Ankle Surgery*, **27**, 20-24. https://doi.org/10.1016/j.fas.2020.01.002

[15] Larholt, J. and Kilmartin, T.E. (2010) Rotational Scarf and Akin Osteotomy for Correction of Hallux Valgus Associated with Metatarsus Adductus. *Foot & Ankle International*, **31**, 220-228. https://doi.org/10.3113/FAI.2010.0220

[16] Coughlin, M.J. and Jones, C.P. (2007) Hallux Valgus: Demographics, Etiology, and Radiographic Assessment. *Foot & Ankle International*, **28**, 759-777. https://doi.org/10.3113/FAI.2007.0759

[17] Nilsdotter, A.-K., Cöster, M.E., Bremander, A. and Cöster, M.C. (2019) Patient-Reported Outcome after Hallux Valgus Surgery—A Two Year Follow Up. *Foot and Ankle Surgery*, **25**, 478-481. https://doi.org/10.1016/j.fas.2018.02.015

[18] Garrido, I.M., Rubio, E.R., Bosch, M.N., González, M.S., Paz, G.B. and Llabrés, A.J. (2008) Scarf and Akin Osteotomies for Moderate and Severe Hallux Valgus: Clinical and Radiographic Results. *Foot and Ankle Surgery*, **14**, 194-203. https://doi.org/10.1016/j.fas.2008.02.003

[19] Okuda, R., Kinoshita, M., Yasuda, T., Jotoku, T., Kitano, N. and Shima, H. (2007) The Shape of the Lateral Edge of the First Metatarsal Head as a Risk Factor for Recurrence of Hallux Valgus. *The Journal of Bone and Joint Surgery*, **89**, 2163-2172. https://doi.org/10.2106/00004623-200710000-00010

[20] Yamaguchi, S., Sasho, T., Endo, J., Yamamoto, Y., Akagi, R., Sato, Y. and Takahashi, K. (2015) Shape of the Lateral Edge of the First Metatarsal Head Changes Depending on the Rotation and Inclination of the First Metatarsal: A Study Using Digitally Reconstructed Radiographs. *Journal of Orthopaedic Science*, **20**, 868-874. https://doi.org/10.1007/s00776-015-0749-x

[21] Li, Y., Tao, X. and Tang, K. (2022) Radiographic Evaluation of Congruency of the First Metatarsophalangeal Joint in Hallux Valgus. *Journal of Orthopaedic Surgery and Research*, **17**, Article No. 144. https://doi.org/10.1186/s13018-022-03028-1

[22] Kaptan, A.Y., Çavuşoğlu, A.T., Tokgöz, M.A., Elma, T. and Yapar, A. (2020) Distal Oblique Metatarsal Osteotomy Technique in Hallux Valgus Deformity: Clinical and Radiological Results. *Joint Diseases and Related Surgery*, **31**, 88-94. https://doi.org/10.5606/ehc.2020.71298

## Appendix

The radiological outcome of surgical correction of hallux valgus using combined scarf and akin osteotomies

**Questionnaire**

**Serial No: _____**

**PR number: _____**

**1) Age (years): _____**

**2) Gender:**

Male ☐ Female ☐

**3) The side of operation:**

Right ☐ Left ☐ Bilateral ☐

**4) The duration of follow-up (months): _____**

**5) Hallux valgus angle:**

Pre-operative ☐ Post-Operative ☐

**6) Inter-metatarsal angle:**

Pre-operative ☐ Post-Operative ☐

**7) Meta-tarsal cascade:**

Normal ☐ Disturbed ☐

**8) The shape of the first meta-tarsal head:**

Rounded ☐ Intermediate ☐ Marginal ☐