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Original Article

Forefoot width correction in patients with hallux valgus after rotational scarf osteotomy

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Abstract

Objective: Our objective was to compare foot width (bony and soft tissues) in radiological images pre- vs. post-corrective scarf osteotomy in patients with hallux valgus.

Methods: We retrospectively performed measurements of forefoot width (both bony diameter and total diameter including soft tissues) on anterior-posterior standard radiographs of 30 patients, totaling 42 feet, pre- and postoperatively, at three months. These measurements were performed by two evaluators and their reliability was calculated.

Results: Radiologically, preoperative mean of the 1-5 metatarsal bony width was 89.30mm (SD ± 5.8), reduced to 80.42mm postoperatively (SD ± 3.5; p<0.001). Regarding the soft tissue width, preoperative mean was 102.45mm (SD ± 6.4) and postoperative, 98.3mm (SD ± 5.1; p<0.001). The interclass correlation coefficient between both observers was excellent in most measurements (range, 0.884-0.973).

Conclusion: We report an objective reduction in forefoot width, in both bony and soft tissue diameter, finding means of 8.88 mm (10%) and 4.12mm (4.1%), respectively, after scarf-Akin osteotomy.

Level of Evidence IV; Case Series.

Keywords: Forefoot, human; Hallux valgus; Osteotomy.

Introduction

Hallux valgus is a progressive deformity represented by a valgus deviation of the hallux, a medial deviation of the first metatarsal, and pronation of the longitudinal axis of the metatarsal, being clinically characterized by an increase in forefoot width[1,2]. This pathology affects 2 to 4% of the general population, with a higher prevalence in females and adults[3].

For the patient, the most important concerns regarding hallux valgus postoperative outcomes are: to reduce pain over the bunion, improve walking, and restore the unrestricted ability to wear a range of shoe fashions. The physiological goal of hallux valgus corrective surgery is to perform a morphological correction of the foot by realigning the first ray, thus achieving pain relief for the patient by reducing friction between bony prominences and regular footwear. This should not only aim to improve radiographic measurements, but also prioritize comfort, since it plays an important role in the success of the surgery and patient satisfaction[4]. Medical objectives are often not necessarily aligned with patient expectations, resulting in a high percentage (25-33%) of patients who remain dissatisfied, even when radiological results are those desired by the surgeon. This is directly related to the impossibility of wearing a smaller shoe size or pointed shoes[1,2,5,6]: only 41-62% of patients can wear shoes with high and narrow heels after hallux valgus surgery[7].

A quick, simple method to better correlate medical objectives with patient satisfaction would be to measure the forefoot width[8]. The relevance of this study lies in elucidating if a metatarsal osteotomy, such as a scarf osteotomy, would decrease forefoot width, as a decrease in this measure represents a predictor of comfort in meeting patient expectations[5,9].

Study performed at the Clínica Universidad de los Andes, Santiago, Chile.

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Scarf osteotomy is one of the most popular techniques to correct hallux valgus, its main advantage being the great lateral translation of the diaphysis, which enables the correction of large deformities, preservation of joint congruence, and metatarsophalangeal (MTP) mobility, further allowing the metatarsal to descend and its length to be controlled, associated with a rigid and stable compression at the osteotomy site[10,11]. Its results are very predictable and it also makes it possible to perform corrections in both the axial and coronal planes[10,12-14].

Our objective was to compare foot width (bony and soft tissues) in radiological images pre- vs. post-corrective scarf osteotomy in patients with hallux valgus.

Our hypothesis predicts an objective reduction in forefoot width after scarf osteotomy, different from that seen in the previous literature, where no significant reduction in foot width is reported[15].

Methods

We performed a comparative retrospective study where forefoot width (bony and soft tissue) was radiographically measured by two evaluators (A.B. and F.M.) using the Enterprise Imaging XERO Viewer 8.1.2 (Agfa HealthCare N.V., Mortsel, Belgium) in patients who underwent scarf osteotomy for hallux valgus from May 2018 to June 2019 in procedures performed by two independent fellowship-trained foot and ankle surgeons with over 20 years' experience. All patients gave their informed consent, and our institutional review board approved the study. Bony foot width (BW) was measured on anterior-posterior (AP) weight-bearing radiographs of the foot, by recording the maximal distance from the medial border of the first metatarsal head to the lateral border of the fifth metatarsal head, as previously described by Jung et al.[4]. Forefoot soft tissue width (STW) was measured from the most medial soft tissue shadow to the most lateral soft tissue shadow, bisecting the level of the first metatarsal head. Both BW and STW measurements were made pre- and postoperatively, at three months (Figure 1).

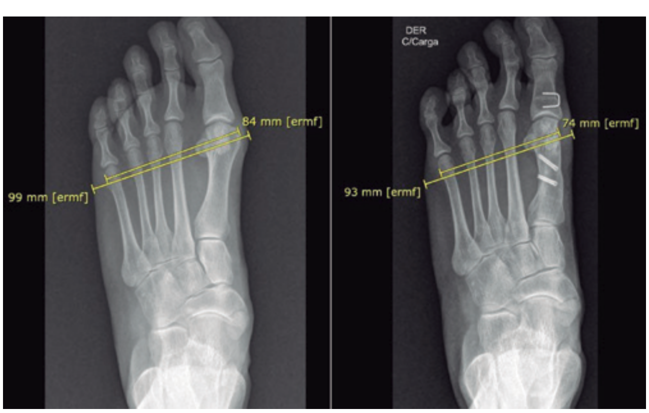

Figure 1. Pre-(left) and postoperative (at three months, right) measurements of bony foot width (BW) and forefoot soft tissue width (STW) on anterior-posterior weight-bearing radiographs of the foot.

Although these measurements were not calibrated, they were recorded by radiology technicians exclusively assigned to foot and ankle pathologies in a consistent manner.

Inclusion criteria were patients older than 18 years treated with scarf osteotomy for hallux valgus having weight-bearing AP radiographs pre- and postoperatively, at three months. Exclusion criteria were patients with additional surgery on the fifth metatarsal or lesser metatarsal, use of a different technique for the correction of hallux valgus, musculoskeletal inflammatory diseases, neurovascular deficits, history of previous foot and ankle surgery on the same foot, active local infection, radiological signs of MTP osteoarthritis, and hallux valgus associated with another acquired deformity, such as progressive collapsing foot deformity, pes cavus etc. As additional procedures, such as hammertoes correction, could eventually affect outcomes, especially soft tissue forefoot width, we looked for any association.

During the target time frame for our study, 81 hallux valgus surgeries were performed. Of these, 39 feet were excluded due to the use of non-scarf osteotomy or for requiring further corrective surgeries for the fifth metatarsal.

Surgical technique

Preoperative planning should include the length of the osteotomy, the direction of the transverse cuts, and the amount of translation depending on the severity of the deformity to be corrected.

Under tight tourniquet and regional ankle anesthesia, we performed a longitudinal incision over the shaft of the first metatarsal extending to the mid-proximal phalanx, followed by blunt dissection, capsulotomy, and subperiosteal dissection. At this stage, a bunionectomy provided a flat surface on which to perform the scarf osteotomy. The distal transverse cut was aimed at the junction of the dorsal one-third with the plantar two-thirds of the head, 7mm proximal to the MTP joint and perpendicular to the second metatarsal if preservation of metatarsal length was desired.

The longitudinal cut was then extended. The orientation of this cut should be in a slightly plantar direction to marginally lower the metatarsal. The proximal transverse cut was made between the dorsal two-thirds and the plantar one-third of the diaphysis, parallel to the distal cut (Figure 2).

Using an elevator, the osteotomy was traversed to release the periosteum and perform lateral soft tissue release.

The desired lateral translation was made and fixed with two screws. Finally, a resection of the medial overhang of the osteotomy was performed.

Akin osteotomy was performed in accordance with the clinical discretion of the surgeons responsible when residual interphalangeal hallux valgus was present after appropriate hallux valgus angle (HVA) and intermetatarsal angle (IMA) correction.

Rotational deformity (if existent) was always corrected by supination of the first metatarsal to the point at which the sesamoids were hidden behind the first metatarsal head and its square shape.

Postoperatively, feet were placed in a rigid shoe for three weeks, allowing for partial weight bearing with two crutches. Sutures were removed at two weeks and patient transitioned to comfortable shoes as tolerated.

Statistical analysis

Data was first descriptively analyzed using measures of central tendency (means, modes, and percentages for demographic variables).

A comparative descriptive analysis of results obtained in bone and soft tissue radiological images was performed.

Distribution of data (normal/abnormal) was analyzed according to the Shapiro-Wilk test, and if normal, parametric analysis (*t*-test) was performed. If not normal, non-parametric analysis (Wilcoxon test) was utilized to establish differences between the means of each measurement.

Interclass correlation coefficients (ICC) were calculated in order to look for inter-observer agreement. In case of good or excellent ICC, the average was used, and in case of moderate or poor ICC, the measurements recorded by evaluator No. 2 were used (Table 1).

A Pearson test was performed to determine which variables demonstrated an inter-variable correlation.

Linear regression analysis was performed to calculate the predictive value of postoperative variables over the preoperative ones.

With the resulting size effect values, a post hoc analysis was carried out to establish the statistical power of results. IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY IBM Corp. was used.

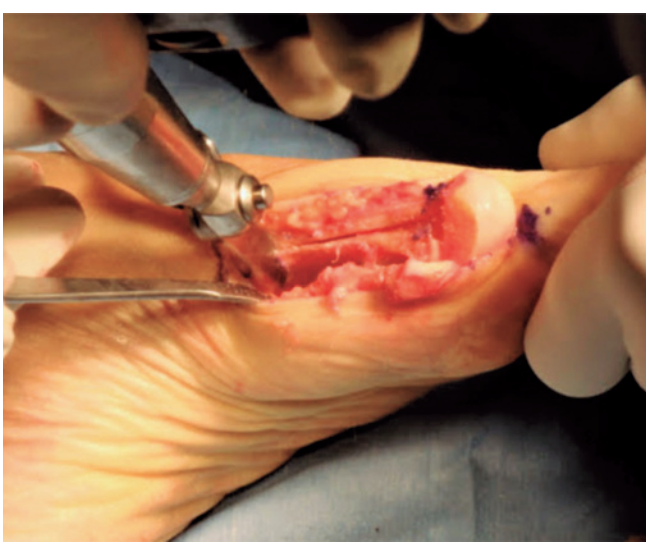

Figure 2. Extension of the longitudinal and proximal transverse cuts made between the dorsal two-thirds with the plantar one-third of the diaphysis parallel to the distal cut.

Results

Thirty patients met the inclusion criteria and underwent corrective surgery for hallux valgus using rotational scarf-Akin osteotomy in all cases, with a total of 42 feet (23 left feet, 19 right feet) included.

Demographic data are summarized in table 2.

The analysis demonstrated excellent ICC between evaluators in preoperative BW, STW, HVA, and postoperative STW (range, 0.884-0.973) and good ICC in postoperative BW (0.784). With these variables, analyses were performed using the average between both evaluators.

Pre- and postoperative mean values and standard deviation (SD) are summarized in table 3, with statistical significance between preoperative and postoperative measurements in all cases ($p<0.001$).

Table 1. Interclass correlation coefficient between both observers

ICC	Preoperative Mean (95% CI)	Postoperative Mean (95% CI)
STW	0.973 (0.95–0.986)*	0.884 (0.784–0.938)*
BW	0.966 (0.937–0.982)*	0.784 (0.599–0.884)*
IMA	0.726 (0.491–0.583)	0.479 (0.03–0.72)
HVA	0.907 (0.827–0.95)*	0.692 (0.427–0.834)

ICC: interclass correlation coefficient; CI: confidence interval; BW: bony width; STW: soft tissue width; IMA: intermetatarsal angle; HVA: hallux valgus angle. Measures marked with an asterisk were 'excellent' or 'good' and analyses were performed using the average between both evaluators.

Table 2. Demographic data (N=42)

Variable	N (%)
Sex	
Male	1 (2.4%)
Female	41 (97.6%)
Age	
Years	52.9 (range 22–74)
Side	
Right	19 (45.2%)
Left	23 (54.8%)
Hammertoes	
Yes	6 (14.3%)
No	36 (85.7%)

Table 3. Pre-and postoperative mean values and standard deviation

Average measurements (N=42)	Mean (SD) (p<0.001)
Bony width	
Preoperative	89.30mm (5.89)
Postoperative	80.42mm (3.55)
Soft Tissue width	
Preoperative	102.45mm (6.48)
Postoperative	98.33mm (5.12)
IMA	
Preoperative (Evaluator No 2)	13.01° (2.67)
Postoperative (Evaluator No. 2)	7.25° (3.07)
HVA	
Preoperative	20.8° (6.48)
Postoperative (Evaluator No. 2)	10.7° (5.56)

SD: standard deviation; IMA: intermetatarsal angle; HVA: hallux valgus angle.

A t-test was performed on preoperative vs. postoperative BW, STW, and IMA measurements. Wilcoxon test was performed on the HVA preoperative vs. postoperative measurements. Ordinal regression analysis was performed to evaluate the predictive value of hammertoe correction when performed in the same surgical procedure as hallux valgus correction and its effect on the forefoot width, and no significant predictive value was found.

Values obtained had a significance of p<0.001; values were considered statistically significant only when p<0.05. We made a post hoc analysis where the power of the study was calculated and, with the sample of 42 feet, a power of p=0.87 was achieved, validating our sample as sufficient.

The linear regression analysis performed to demonstrate predictive value by comparing the different pre- vs. postoperative variables yielded the results summarized in table 4, only reporting those with statistically significant differences (p<0.05).

Discussion

In theory, a successful hallux valgus correction surgery is achieved according to radiological parameters. Based on this concept and in our results, we were allowed to interpret that, after scarf osteotomy, the forefoot BW and STW widths could be reduced.

The greatest expectation of a patient after hallux valgus correction is to have a painless great toe able to fit into conventional shoes[16,17]. This has a direct correlation with and could be the best predictor of good results[16-18]. The severity of the deformity or the correction of radiographic measurements (HVA/IMA), alone, does not necessarily have a direct correlation with an improvement in functional scores[6,19]. Axt et al.[20] reported a 90% satisfaction among patients after Keller-Brandes operation for hallux valgus, despite 23% of the feet remaining with an altered HVA of more than 30 degrees[20]. It is possible to conclude that the ability to have a choice in footwear, unrestricted by deformity, had a positive effect on quality of life, and that is the reason why we wanted to demonstrate that, after scarf osteotomy, the decrease in forefoot width may represent the mean difference between a wide and medium shoe width size[2].

Forefoot width is a useful, objective measure of patient postoperative expectations. Tenenbaum et al.[15] previously reported a decrease in BW and STW by 5% and 2%, respectively, after scarf-Akin osteotomy and soft tissue release. However, unlike our results, in 36% of feet, the forefoot width did not change, while in 18% it increased (>5%); in our study, we demonstrated forefoot reduction in all patients. These authors concluded that patients with wider feet tended to achieve foot narrowing, while those with narrower feet had a forefoot width increase postoperatively[15].

After linear regression analysis, we were able to predict that, in a considerable percentage of cases (41.6% for BW and 59.6% for STW; p<0.001), values followed a direct correlation pattern. The wider the feet preoperatively, the wider it remained within the postoperative cohort, despite the forefoot width reduction after surgery. The same correlation for narrower feet was observed.

Similar to our results, Jung et al.[4] reported a foot width (1-5 metatarsal width) decrease of 16%, from 97.3mm to 81.3mm (mean 16mm; p<0.001) after proximal reverse chevron osteotomy associated with lateral soft tissue and Akin osteotomy on 117 feet with 14.2 months of follow-up (range, 12-25). They achieved an IMA reduction from 19 degrees (range, 9-28) to 4.5 degrees (range, -5-14.2) and an HVA reduction from 36.1 degrees (range, 16-44) to 5.4 degrees (range, -12.4-29.7)[4]. Our measurements after scarf osteotomy showed an 8.88 mm (10%) and 4.12 mm (4.1%) reduction in BW and STW, respectively. We also achieved a reduction of 5.85 degrees in IMA and 10.1 degrees in HVA.

Panchbhavi et al.[21] measured pre- and postoperative metatarsal span after chevron-Akin surgery in 52 patients, finding an 8.7mm mean reduction. This group reported no correlation between HVA and IMA correction according to metatarsal bony span. Conti et al.[8] reported a statistically significant BW reduction of 8.9mm (radiographic measurement) and 7.9mm (weight-bearing computed tomography-WBCT measurement) (p<0.001), as well as a STW of 6.9 mm (radiograph) and 6.7mm (WBCT) (p<0.001) at five months in 31 patients after a modified Lapidus, McBride, and Akin osteotomy[8]. These authors also reported a poor correlation between correction of HVA, IMA, and distal metatarsal articular angle (DMAA) and foot width reduction at the final follow-up. These results are similar to ours, since we did not find any correlation between IMA and HVA and forefoot width after scarf osteotomy (<0.3).

The present investigation has limitations. Despite having the capability to evaluate the use of WBCT within our possibilities, we did not consider WBCT measurements would offer

Table 4. Predictive value

	BW PostOp	STW PostOp (Evaluator No. 2)	IMA PostOp (Evaluator No. 2)
BW PreOp	*41.6% (p<0.001)	*58.4% (p<0.001)	-
STW PreOp	*38.8% (p<0.001)	*59.6% (p<0.001)	-
IMA PreOp (Ev. No. 2)	43.8% (p=0.033)	58.9% (p=0.048)	43.7% (p=0.013)
HVA PreOp	-	31.9% (p=0.008)	-

BW: bony width; STW: soft tissue width; IMA: intermetatarsal angle; HVA: hallux valgus angle; PreOp: preoperatively; PostOp: postoperatively. *Statistical significance between preoperative and postoperative measurements (p<0.001).

a greater precision or relevance according to our objective because our measures were unidimensional (HVA and IMA). As shown, HVA and IMA radiographic measurements are not significantly different from those obtained with WBCT[22]. On the other hand, radiographic measurements provide a greater reproducibility and external validity to our study. Another limitation to consider is that our measurement of forefoot width was always recorded using the same anatomical landmark (most medial point of first metatarsal head), which, due to potential anatomical variations among patients, might not have always been the widest point of the foot, especially after resection of the medial eminence.

Another limitation is the small sample size and the retrospective nature of this study; however, all data were obtained from a prospectively collected foot and ankle registry reviewed for consecutive patients from May 2018 to July 2019.

Finally, soft tissue width was measured according to the breadth of the foot in the radiograph. It could be more precise to make this measurement clinically, using the perimeter of the foot and a tape measure, resulting in a value closer to the actual forefoot width. Also, edema may still be present after three months of surgery, which certainly increased the STW; it may be a short postoperative time.

Conclusion

Through scarf osteotomy, we were able to demonstrate that an objective forefoot width reduction is possible and may help patients on fitting more comfortable shoes.

Author's contributions: Each author contributed individually and significantly to the development of this article: FMZ *(https://orcid.org/0000-0002-6520-9775) Conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process, data collection, statistical analysis, approved the final version; AIB *(https://orcid.org/0000-0003-4898-4259) Interpreted the results of the study, participated in the review process and approved the final version; FCR (https://orcid.org/0000-0002-3524-0624) Conceived and planned the activities that led to the study, interpreted the results of the study, performed the surgery, data collection, interpreted the results of the study, approved the final version; MPP *(https://orcid.org/0000-0002-2820-5337) Conceived and planned the activities that led to the study, statistical analysis, bibliographic review, survey of the medical records, wrote the article, participated in the review process, formatting of the article, approved the final version; GCU *(https://orcid.org/0000-0002-1993-6250) Wrote the article, performed the surgery, participated in the reviewing process, approved the final version; COM *(https://orcid.org/0000-0003-2574-9010) Conceived and planned the activities that led to the study, interpreted the results of the study, participated in the reviewing process, approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

References

1. Perera AM, Mason L, Stephens MM. The pathogenesis of hallux valgus. J Bone Joint Surg Am. 2011;93(17):1650-61.
2. Saro C, Jensen I, Lindgren U, Felländer-Tsai L. Quality-of-life outcome after hallux valgus surgery. Qual Life Res. 2007;16(5):731-8.
3. Nix S, Smith M, Vicenzino B. Prevalence of hallux valgus in the general population: a systematic review and meta-analysis. J Foot Ankle Res. 2010;3:21
4. Jung HG, Kim TH, Park JT, Shin MH, Lee SH. Proximal reverse chevron metatarsal osteotomy, lateral soft tissue release, and akin osteotomy through a single medial incision for hallux valgus. Foot Ankle Int. 2014;35(4):368-73.
5. Tai CC, Ridgeway S, Ramachandran M, Ng VA, Devic N, Singh D. Patient expectations for hallux valgus surgery. J Orthop Surg (Hong Kong). 2008;16(1):91-5.
6. Thordarson D, Ebramzadeh E, Moorthy M, Lee J, Rudicel S. Correlation of hallux valgus surgical outcome with AOFAS forefoot score and radiological parameters. Foot Ankle Int. 2005;26(2):122-7.
7. Robinson C, Bhosale A, Pillai A. Footwear modification following hallux valgus surgery: The all-or-none phenomenon. World J Methodol. 2016;6(2):171-80.
8. Conti MS, MacMahon A, Ellis SJ, Cody EA. Effect of the modified lapidus procedure for hallux valgus on foot width. Foot Ankle Int. 2020;41(2):154-9.
9. Dawson J, Coffey J, Doll H, Lavis G, Sharp RJ, Cooke P, et al. Factors associated with satisfaction with bunion surgery in women: A prospective study. Foot. 2007;17(3):119-25.
10. Aminian A, Kelikian A, Moen T. Scarf osteotomy for hallux valgus deformity: an intermediate followup of clinical and radiographic outcomes. Foot Ankle Int. 2006;27(11):883-6.
11. Barouk LS. Scarf osteotomy for hallux valgus correction. Local anatomy, surgical technique, and combination with other forefoot procedures. Foot Ankle Clin. 2000;5(3):525-58.
12. Weil LS. Scarf osteotomy for correction of hallux valgus. Historical perspective, surgical technique, and results. Foot Ankle Clin. 2000;5(3):559-80.
13. Kramer J, Barry LD, Helfman DN, Mehnert JA, Pokrifcak VM. The modified Scarf bunionectomy. J Foot Surg. 1992;31(4):360-7.
14. Molloy A, Widnall J. Scarf osteotomy. Foot Ankle Clin. 2014; 19(2):165-80.
15. Tenenbaum SA, Herman A, Bruck N, Bariteau JT, Thein R, Coifman O. Foot width changes following hallux valgus surgery. Foot Ankle Int. 2018;39(11):1272-7.
16. Schneider W, Knahr K. Surgery for hallux valgus. The expectations of patients and surgeons. Int Orthop. 2001;25(6):382-5.
17. Cody EA, Do HT, Koltsov JCB, Mancuso CA, Ellis SJ. Influence of diagnosis and other factors on patients' expectations of foot and ankle surgery. Foot Ankle Int. 2018;39(6):641-8.
18. Mann RA, Rudicel S, Graves SC. Repair of hallux valgus with a distal soft-tissue procedure and proximal metatarsal osteotomy. A long-term follow-up. J Bone Joint Surg Am. 1992;74(1):124-9.
19. Mansur H, Cardoso V, Nogueira T, Castro I. Relationship between quality of life and radiological parameters after hallux valgus correction. Acta Ortop Bras. 2020;28(2):65-8.
20. Axt M, Wildner M, Reichelt A. Late results of the Keller-Brandes operation for hallux valgus. Arch Orthop Trauma Surg. 1993;112(6):266-9.
21. Panchbhavi V, Cordova J, Chen J, Janney C. Does hallux valgus correction reduce the width of the forefoot? Foot Ankle Spec. 2020;13(2):112-5.
22. Braza S, Mansur NSB, Mallavarapu V, Carvalho KAM, Dibbern K, Nery CAS, et al. Hallux valgus measurements using weight-bearing computed tomography: what changes?. J Foot Ankle. 2021;15(3):259-64.