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Scarf osteotomy or Mau osteotomy for correction of moderate to severe hallux valgus deformity: a prospective, randomized study

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ABSTRACT

Objective. The aim of this study was to compare the clinical and radiological results of Mau osteotomy and Scarf osteotomy with a modified McBride procedure to patients with moderate to severe hallux valgus deformity. ***Methods.*** The study included 40 feet which patients were separated into 2 groups followed up for 5 months. Scarf osteotomy was applied to 20 patients including 16 females and 4 males (Scarf group)) and a Mau osteotomy to 20 patients including 17 females and 3 males (Mau group). Radiological measurements were taken preoperative, postoperative and at the final follow-up examination of the hallux valgus angle (HVA), intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), metatarsocuneiform angle (MCA), the 1st metatarsophalangeal joint congruity, 1st metatarsal length, fibular sesamoid subluxation rate. Clinical evaluation was made according to the American Orthopaedic Foot and Ankle Society (AOFAS) and the severity of pain was assessed with the visual analog scale (VAS). ***Results.*** There was no difference between the groups in term of the mean HVA, IMA, MCA and DMAA values in preoperative and postoperative measurements. A significant improvement was determined in all the angle values in Scarf and Mau group ($p<0.001$). A significant increase in DMAA and shortening in the metatarsal length were determined in Mau group compared to Scarf group ($p<0.001$). An improvement in joint congruity was seen in the goups ($p<0.001$). There was a significant improvement in term of the AOFAS and VAS values in the groups ($p<0.001$). ***Conclusion.*** Scarf and Mau osteotomies can provide the desired level of improvement in the short-term follow-up results of moderate to severe hallux valgus deformity, taking into consideration the clinical importance that complications are not formed.

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Introduction

No consensus has yet been reached on the treatment for hallux valgus and more than 130 surgical techniques have been reported [1-6]. Although successful results have been reported with a distal soft tissue procedure in the adults with mild and moderate level hallux valgus, recurrence of hallux valgus deformity has been reported in up to 11% of patients. In moderate level deformities unsuccessful results have been reported from the distal soft tissue procedure [6-11]. The distal soft tissue procedures are important in stabilizing the joint biomechanics in the surgery of incompatible joints. These soft tissue procedure cannot be seen only as a supplementary surgical procedure in cases where the bony procedure needs additional correction, but rather is an indispensable procedure to restore the physiological situation and function of the first [12]. In patients with moderate to severe hallux valgus, to bring the intermetatarsal angle (IMA) within normal physiological limits, several metatarsal osteotomy techniques together with the distal soft tissue procedure have been described [6, 13, 14]. According to the area where it is applied, distal, diaphyseal and proximal osteotomies are applied.

As Chevron [15], Mitchell [16] and Wilson [17] distal osteotomies are generally less invasive, the recovery time of patients is shorter. Unwanted outcomes may also be observed such as insufficient correction, recurrence, avascular necrosis in the metatarsal head when applied together with the distal soft tissue procedure, shortening in the metatarsal neck in Wilson osteotomy and elevation in the metatarsal head in the Mitchell osteotomy, and these osteotomies are often used in the treatment of mild and moderate level deformities [18, 19-21]. Proximal metatarsal osteotomies are defined in several types as open wedge, closed wedge, crescentic and Chevron osteotomies [6, 22-24]. Proximal osteotomies may worsen the deformity in hallux valgus deformities compatible with a high preoperative distal metatarsal articular angle (DMAA) [25-27]. Of the metatarsal diaphyseal osteotomies, the Scarf, Mau and Ludloff are the most frequently used types.

To the best of our knowledge, there is no study in literature that has compared the clinical and radiological results of Scarf and Mau osteotomies. Therefore, the aim of this prospective, randomized study was to compare the clinical and radiological results of Scarf and Mau osteotomies applied together with a modified McBride procedure in patients with moderate to severe hallux valgus deformity.

Methods

Approval for the study was granted by the Local Ethics Committee. Patients who had a diagnosis of moderate to severe hallux valgus deformity according to Mann and Coughlin classification were taken into study [6]. There was no evidence of degenerative arthritis, the pain did not respond to conservative treatment and was over 18 years of age. Informed consent was obtained from all patients. Patients were excluded from the study if they had metatarsocuneiform laxity, had previously undergone a surgical intervention or had a history of diabetes mellitus, peripheral vascular disease, peripheral neuropathy, pes planus or inflammatory disease. A total of 40 feet of 40 patients met the study inclusion and exclusion criteria and they were randomly separated into 2 groups for surgery. All the patients were prospectively followed up postoperatively for at least 5 months.

Randomization was applied with the sealed envelope method for each patient indicating either the Scarf osteotomy together with the modified McBride procedure or the Mau osteotomy together with the modified McBride procedure. The details of the operation to be applied were explained to the patients. The patient with bilateral hallux valgus underwent a different operation on each foot at a 3-month interval. The Scarf group comprised 20 patients including 16 females and 4 males with a mean age of 41.25 ± 13 years. The Mau group comprised 20 patients including 17 females and 3 males with a mean age of 40.63 ± 15 years. The hallux valgus angle (HVA) and IMA were measured preoperatively and at 3rd week and 5th months postoperatively. All the other radiological parameters were measured and the clinical evaluations were made preoperatively and at 5th month postoperatively. The preoperative and postoperative physical examinations, and the objective and subjective measurements were undertaken by an experienced orthopaedic resident who was not involved in the study.

For the subjective evaluations, the American Orthopaedic Foot and Ankle Society (AOFAS) hallux Metatarsophalangeal-Interphalangeal (MTP-IP) Evaluation Score (AOFAS-MTPIP) [28], a Visual Analog Scale (VAS) [29], and the Subjective Foot

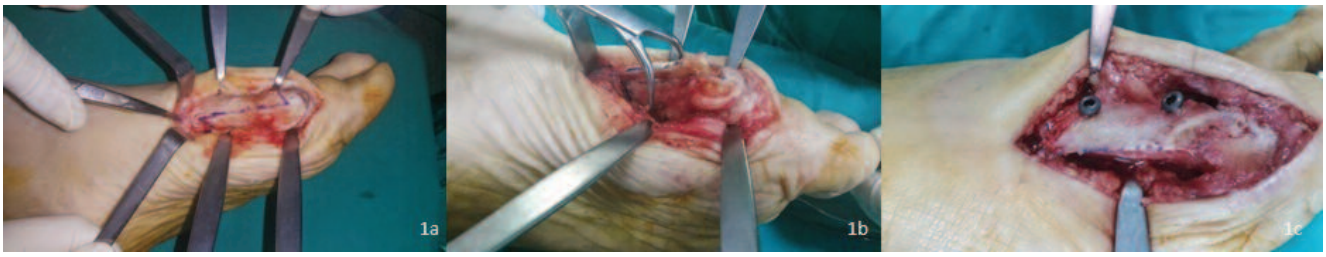

Figure 1. Scarf osteotomy planning (1a). 1st metatarsal osteotomy and fixation with mini-cannulated screw with the method described by Coetzee and Rippstein [33] (1b and 1c)

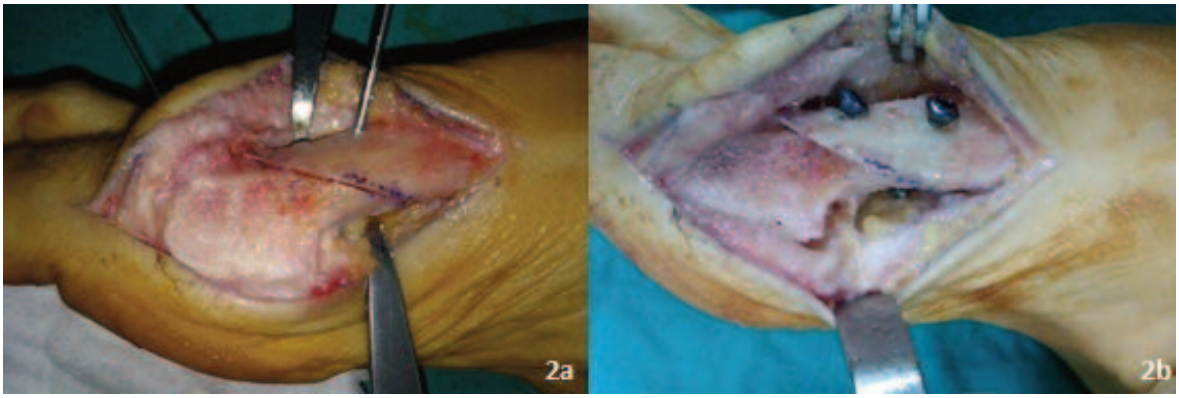

Figure 2. First metatarsal osteotomy with the Easley method [34] in cases applied with Mau osteotomy (1a) fixation with mini-cannulated screw (2b)

Evaluation Form (SFEF),as described by Haapaniemi *et al.* [30], were used. During the preoperative and follow-up examinations, standing anterior posterior and lateral radiographs were taken of all patients. For the objective evaluations, the HVA, IMA, DMAA, 1st metatarsal length [31], MTC [32], 1st metatarsophalangeal joint congruity were measured and the fibular sesamoid subluxation rate was calculated by considering the distance of the sesamoid from the metatarsal long axis [6]. All the radiological measurements were made using the Picture Archiving Communication Systems (PACS) Winsoft program on the hospital computer system.

Surgical Technique

Osteotomy was applied to the 1st metatarsal with the method described by Coetzee and Rippstein [33] in the cases applied with Scarf osteotomy (Figure 1) and with the method described by Easley *et al.* [34] in the cases applied with Mau osteotomy (Figure 2). Sutures were removed at 2nd week postoperatively and at the 3rd week the splint was removed and a hallux valgus night splint was applied. Partial weight-bearing was permitted as tolerated until union was observed.

Statistical Analysis

As the variables did not show conformity to normal distribution, comparison was made with non-parametric methods. In the comparisons between groups, the Mann Whitney U-test and the Kruskal Wallis test were used, for dependent groups the Wilcoxon test and for categorical variables, the Chi-square and Fisher tests. A value of $p<0.05$ was accepted as statistically significant.

Results

No statistically significant difference was determined between the groups in respect of the preoperative demographic characteristics (Table 1). In the Scarf group, at the final follow-up, an increase of mean 43.5 points was seen in the AOFAS criteria and a decrease of mean 3.8 points in the VAS score. A statistically significant difference was determined in the AOFAS and VAS values at the 5th month postoperatively compared to the preoperative values ($p < 0.001$, $p < 0.001$; respectively). In the Scarf group a statistically significant decrease was seen in all the measured angle values compared to preoperative values ($p < 0.001$) and the metatarsal length was seen to have shortened but to a non-significant level

Table 1. A comparison of the preoperative clinical and radiological findings of the Scarf and Mau osteotomy groups.

	Scarf group (n = 20)	Mau group (n = 20)	*p* value
Age (year)	41 ± 13 (24-63)	41 ± 15 (19-68)	0.890
HVA (º)	37.90 ± 8.2 (25-60)	35.95 ± 8.8 (23-60)	0.470
IMA (º)	16.25 ± 2.4 (13-21)	16.95 ± 3.0 (14-25)	0.460
MCA (º)	27.55 ± 4.8 (19-38)	26.35 ± 4.1 (17-34)	0.400
DMAA (º)	14.95 ± 7.8 (3-35)	12.70 ± 4.4 (3-20)	0.270
MTL (mm)	57.90 ± 4.8 (50-69)	59.20 ± 5.4 (50-70)	0.430
AOFAS score	33.50 ± 15.7 (5-60)	35.75 ± 18.3 (5-78)	0.680
VAS	6.45 ± 1.8 (3-9)	7.30 ± 1.4 (3-9)	0.200

Data are shown as mean ± standard deviation (range; min-max). HVA = Hallux valgus angle, IMA = 1-2 intermetatarsal angle, MCA = Metatarsocuneiform angle, DMJA = Distal metatarsal articular angle, MTL. Metatarsal length, AOFAS = American orthopaedic foot and ankle society, VAS = Visuel analog scale

(*p*=0.892).

In the Mau group, at the final follow-up, an increase of mean 36.1 points was seen in the AOFAS criteria and a decrease of mean 4.5 points in the VAS score. A statistically significant difference was determined in the AOFAS and VAS values at the 5th month postoperatively compared to the preoperative values ($p < 0.001$, $p < 0.001$; respectively). Compared to the Scarf group, a significant increase was seen in the DMAA in the Mau group ($p < 0.001$), a significant shortening in the metatarsal length ($p < 0.001$) and a significant decrease in the other angles ($p < 0.001$) (Table 2.) The preoperative and postoperative 5th month radiological values of the Scarf group and the Mau group are shown in (Figures 3 and 4).

In the Mau group, a significant shortening in the metatarsal length and increase in DMAA were seen at the final follow-up examination ($p < 0.001$, $p < 0.001$; respectively). In the Scarf group, a statistically significant increase was determined in the 5th month

Table 2. A comparison of the preoperative, postoperative 3th week and 5th month clinical and radiological findings of the Scarf and Mau osteotomy groups.

	n	Scarf group	*p* value	n	Mau group	*p* value
HVA (º)[a]	20	37.9 ± 8.2 (25-60)	**a-b** (< 0.001)	20	35.9 ± 8.8 (23-60)	**a-b** (< 0.001)
HVA (º)[b]	20	16.8 ± 5.7 (8-30)	**a-c** (< 0.001)	20	15.3 ± 5.6 (8-25)	**a-c** (< 0.001)
HVA(º)[c]	20	23 ± 8.6 (9-45)	**b-c** (< 0.001)	20	17.1 ± 5.2 (10-27)	**b-c** (0.199)
IMA (º)[a]	20	16.25 ± 2.4 (13-21)	**a-b** (< 0.001)	20	16.9 ± 3.0 (14-25)	**a-b** (< 0.001)
IMA (º)[b]	20	7.05 ± 2.4 (3-12)	**a-c** (< 0.001)	20	8.2 ± 2.4 (5-13)	**a-c** (< 0.001)
IMA (º)[c]	20	8.16 ± 2.1 (5-13)	**b-c** (0.003)	20	9.2 ± 2.9 (3-15)	**b-c** (0.230)
MCA (º)[a]	20	27.55 ± 4.8 (19-38)		20	26.3 ± 4.1 (17-34)	
MCA (º)[b]	20	20.95 ± 6.3 (8-33)	**a-b** (< 0.001)	20	22.0 ± 4.6 (15-30)	**a-b** (< 0.001)
DMAA (º)[a]	20	14.95 ± 7.8 (3-35)		20	12.7 ± 4.4 (3-20)	
DMAA (º)[b]	20	9.58 ± 5.8 (1-19)	**a-b**(0.003)	20	16.0 ±4.0 (1-19)	**a-b** (< 0.001)
MTL (mm)[a]	20	57.90 ± 4.8 (50-69)		20	59.2 ± 5.4 (50-70)	
MTL mm)[b]	20	57.58 ± 4.6 (49-67)	**a-b** (0.892)	20	51.6 ± 6.3 (40-67)	**a-b** (< 0.001)
AOFAS[a]	20	33.50 ± 15.7 (5-60)		20	35.7 ±18.3 (5-78)	
AOFAS[b]	20	77.00 ± 13.4 (50-95)	**a-b (**< 0.001)	20	71.8 ± 9.1 (52-83)	**a-b** (< 0.001)
VAS[a]	20	6.45 ± 1.8 (3-9)		20	7.3 ±1.4 (4-10)	
VAS [b]	20	2.63 ± 1.4 (6-14)	**a-b** (< 0.001)	20	2.8 ± 1.4 (7-13)	**a-b**(< 0.001)
AOFAS[d]	13	49.1 ± 15.6		11	37 ± 19.1	
AOFAS[e]	7	29.6 ± 20	**d-e** (0.034)	9	37.5 ± 20.2	**d-e** (0.957)
VAS[d]	13	4.4 ± 2		11	4.4 ± 1.8	
VAS[e]	7	2 ± 3.1	**d-e** (0.057)	9	4.5 ± 1	**d-e** (0.952)

Data are shown as mean ± standard deviation (range; min-max). HVA = Hallux valgus angle, IMA = 1-2 intermetatarsal angle, MCA = Metatarsocuneiform angle, DMJA = Distal metatarsal articular angle, MTL. Metatarsal length, AOFAS = American orthopaedic foot and ankle society, VAS = Visuel analog scale, n = number of patient, [a] preoperative values, [b] postoperative 3th week values, [c] postoperative 5th month values, [d] Patients under 45 years of age (subgroup A), [e] Patients over 45 years (subgroup B)

Table 3. Results of the SFEF showing distribution from satisfaction to dissatisfaction. *

Point	Scarf group	Mau group
6	7	
7	2	2
8	5	10
9		1
10	3	4
11		
12	3	3

SFEF = Subjective foot evaluation form. *The scores indicate the distribution between them as completely satisfied (6 points) and completely dissatisfied (18 points)

postoperative HVA and IMA values compared to the postoperative 3rd week values ($p < 0.00$, $p = 0.003$; respectively) (Table 2).

The results of the SFEF at the 5th month final follow-up examination of the Scarf group and the Mau group are shown in Table 3.

To evaluate the effect of patient age on the clinical results, the patients were separated categorically into two subgroups as those aged 45 years and younger in group A and those aged over 45 years in group B. This approach was previously used by Fuhrmann *et al.* [35]. It was investigated whether or not there was a difference in the preoperative and 5th month postoperative AOFAS and VAS values between the A and B groups of the Scarf and Mau groups. While the mean AOFAS values of the Scarf group A increased by 49.1 points, Group B increased by 29.6 points. The difference between the A and B groups was determined to be statistically significant ($p = 0.034$). The mean VAS points decreased by 4.46 points in group A and by 2.00 points in group B, with no significant difference determined between the groups ($p = 0.057$).

The mean AOFAS values of the Mau group A increased by 37 points and group B increased by 37.5 points, with no significant difference determined between the groups ($p = 0.950$). The mean VAS points decreased by 4.4 points in group A and by 4.5 points in group B, with no significant difference determined between the groups ($p = 0.950$) (Table 2).

The congruity of the base of the proximal phalanx with the 1st MTP joint was calculated with 2 lines drawn taking the basis of the estimated cartilage surface. In the Scarf group, preoperatively 17 (85%)

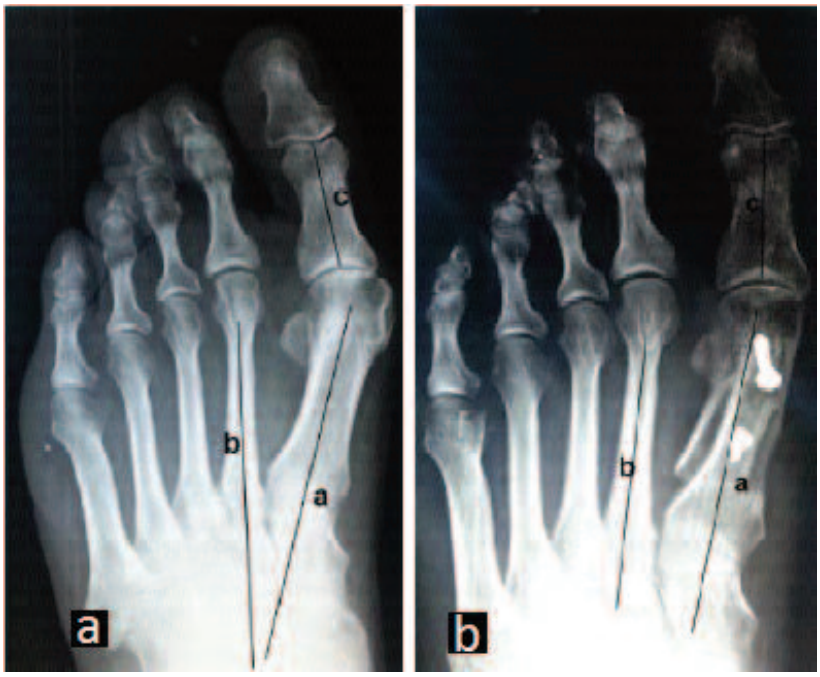

Figure 3. Scarf osteotomy. Preoperative radiograph of the foot of a 41-year old female patient with HVA 30º and IMA 16º (a). In the same patient, at postoperative 5 months, a decrease of HVA 11º and IMA 5º can be seen (b). HVA = Hallux valgus angle (HVA), IMA = Intermetatarsal angle

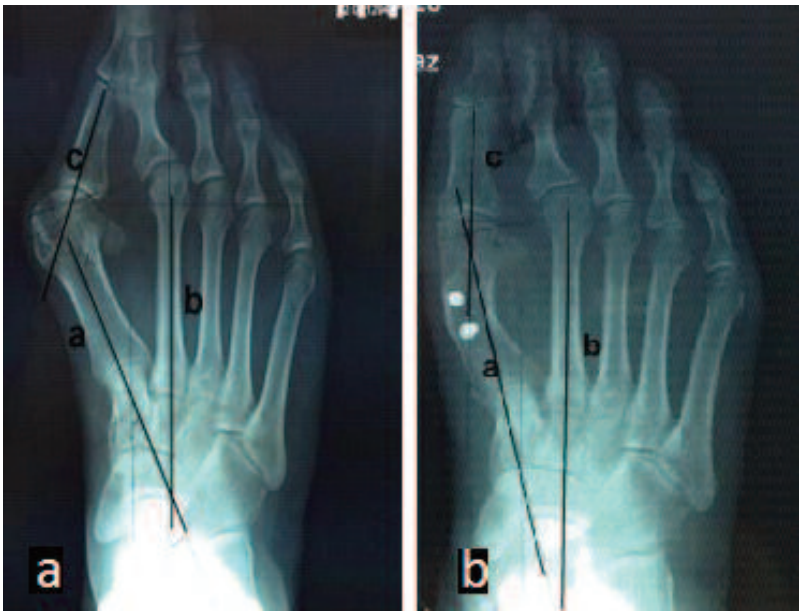

Figure 4. Mau osteotomy. Preoperative radiograph of the foot of a 41-year-old female patient with HVA 48º and IMA 25º (a) . In the same patient, at postoperative 5 months, a decrease of HVA 15º and IMA 13º can be seen (b). HVA = Hallux valgus angle (HVA), IMA = Intermetatarsal angle

feet were seen to be incongruous and 3 feet had joint congruity and postoperatively, a significant improvement was seen in 16 feet ($p < 0.001$). In the Mau group, preoperatively 18 (90%) feet were seen to be incongruous and 2 feet had joint congruity and postoperatively, a significant improvement was seen in 16 feet ($p < 0.001$). No difference was determined between the groups in respect of joint congruity ($p = 1.00$).

The fibular sesamoid subluxation rate in the Scarf group was determined as E1, in 2 patients and E2 in 18 (90%) patients preoperatively and this changed to E0 in 6 patients, E1 in 5 patients and E2 in 9 patients at the final follow-up examination. In the Mau group, 3 patients were determined as E1, 17 (85%) patients as E2 preoperatively and these changed to E0 in 4 patients, E1 in 6 patients and E2 in 10 patients at the final follow-up examination. No difference was determined between the groups in respect of fibular sesamoid subluxation rate ($p = 1.00$).

Complications such as recurrence, delayed union, 1st metatarsal elevation, insufficient correction, superficial infection, arthritis, and deep vein thrombosis were observed in 5 patients of the Scarf group and in 11 patients of the Mau group. In the Scarf group, 4 patients were admitted for a second operation to remove the screws due to skin discomfort after sufficient union in the osteotomy line was seen on radiographs taken postoperatively. In the Mau group, screws were removed from 2 patients after union was seen.

Discussion

This is the first study to have made a prospective randomized comparison of Scarf and Mau osteotomies. The results of the study showed that clinically and radiologically, similar improvements were provided in the early stage by Scarf and Mau osteotomies applied to moderate to severe hallux valgus cases. In the Scarf osteotomy, an increase which was not clinically important was determined in the HVA and IMA. In the Mau osteotomy, an increase was determined in the DMAA and the metatarsal length shortening. However, there was no change in the metatarsal length in the Scarf osteotomy, this allows the prevention of metatarsal elevation and provides balanced fixation [33, 36, 37]. In a study where Scarf osteotomy was applied to 178 feet, the mid-term retrospective results of mean 44.9-month showed that although the final follow-up mean AOFAS points were very good, excellent alignment of the 1st row was determined in only 55% of the feet. Unsatisfactory clinical results were reported to have been obtained in feet with HVA > 30° and with degenerative changes in the 1st MTP joint.

In addition, the radiological evaluation criteria

(HVA, IMA, hallux valgus interphalangeus, MTP joint congruity, arthritic findings in the 1st MTP joint) at the final follow-up examination were found to have deteriorated compared to postoperative 3th month [35]. In another prospective study which reported the mid-term results of Scarf osteotomy applied to 31 feet of 22 patients, a significant improvement was determined at the end of 12 months in the AOFAS points, and the HVA and IMA measurements. At the 5th year, a significant reduction in pain points was determined compared to the preoperative period, 90.9% of patients were satisfied with the intervention of Scarf osteotomy, the mid-term results were excellent and the method was determined to be reliable and repeatable [38].

In a study by Adam *et al.* [39], Scarf osteotomy was associated with 94% satisfactory results. They reported that complications were recurrence in 2 patients, metatarsal collapse in 3, and the need for an additional osteotomy (Akin osteotomy) in 4. In another study, Scarf and Akin osteotomies were applied to 36 feet of 35 patients, a significant improvement was determined in the AOFAS points and radiological measurements at the end of 6th month compared to the preoperative period and there was no difference in the first and 2nd metatarsal lengths in the sagittal plane. Scarf and Akin osteotomies together was recommended as a method that could be safely applied to cases with IMA ≤ 20°. The authors considered that by adding the Akin procedure to Scarf osteotomy, regardless of hallux valgus interphalangeus, the deformity could be more effectively corrected [40].

In the current study, the Akin procedure was not added to the Scarf osteotomy as there were no cases with hallux valgus interphalangeus deformity. In the 20 patients with Scarf osteotomy, we showed that the HVA, IMA and MTP joint congruity improved to an excellent degree at the end of 5th month compared to the preoperative period. In our study there was a significant increase in the AOFAS points and a significant decrease in the VAS points. When the good results obtained in the patients applied Scarf osteotomy are taken into consideration, this method can be recommended for application to cases with moderate to severe hallux valgus deformity.

During the follow-up period of some metatarsal osteotomies, including Scarf osteotomy, there may be a deterioration in the radiological criteria and there are some studies that have reported metatarsal shortening of mean 2-3.2 mm in patients applied Scarf osteotomy [35-38]. In the current study, an increase was seen in HVA and IMA without creating any clinical difference at the end of 5th month in cases applied Scarf osteotomy and a mean shortening of 0.3 mm was determined in the metatarsal length. This shortening in the metatarsal length did not create any clinical problem. Recurrence was seen in 2 patients with IMA ≥11° but as there was no problem with the patient satisfaction, no additional intervention was made. As the reason for recurrence could not be explained with the results obtained in the current study, there can be considered to be a need for further studies of more extensive series.

In a study which published the short-term objective results of Mau osteotomy, sufficient correction was obtained in the HVA and IMA, and it was emphasized that this was a method which could be safely applied in the surgical treatment of moderate to severe hallux valgus cases [13]. In the same study it was reported that revision surgery was required for recurrence in 3 cases, dorsal cortical non-union in 8 cases, insufficient correction in 5 cases and fracture during the follow-up period in 1 case [13]. In another study, the 4-month results of 24 cases applied Mau osteotomy and 10 cases applied proximal crescentic osteotomy were compared and it has been reported an significant improvement by both surgical methods. A higher rate of non-union in the osteotomy line and metatarsal elevation was reported in the cases applied proximal crescentic osteotomy and a mean shortening of 2 mm in the metatarsal length was reported in the cases applied Mau osteotomy [31].

Carr and Boyd [41] stated that shortening in the length of the 1st metatarsal of up to mean 7 mm was not clinically significant but a greater of amount of shortening could cause transfer metatarsalgia. In severe hallux valgus cases, while a high IMA is corrected in Mau osteotomy, as the DMAA could be impaired, corrective distal metatarsal closed wedge osteotomy may be necessary [42]. In our study, in the 20 cases underwent Mau osteotomy because of moderate to severe hallux valgus deformity, there was a significant improvement radiologically at the end of 5th month compared to the preoperative period. Clinically, an increase was seen in the AOFAS points and a decrease in the VAS points. A clinically non-significant shortening was seen in the metatarsal length and an increase in DMAA. No transfer metatarsalgia was observed in any patient. The shortness in the metatarsal length in the Mau osteotomy compared to the preoperative period could

have been due to the relatively lower intrinsic resistance of the distal part of osteotomy to shear forces, compared to Scarf osteotomy, but this cannot be explained with the findings obtained in this study and therefore it is recommended that further biomechanical experiments and clinical studies are made on this subject. Provided that shortening of the metatarsal length and impairment of DMAA are kept in mind, the results obtained in this study suggest that Mau osteotomy can be applied in cases of moderate to severe hallux valgus.

In biomechanical studies, distal Chevron and proximal crescentic osteotomy and Scarf osteotomy have been compared and the Scarf osteotomy has been determined to be two-fold more stable [34, 37, 43, 44]. In another biomechanical study made using plastic bone models, Mau, Ludloff and crescentic osteotomies were compared and it was reported that both Mau and Ludloff osteotomies were more resistant in fatigue tests [45]. In the same study, it was determined that Scarf, closed wedge, Mau and Ludloff osteotomies were more balanced than proximal Chevron and crescentic osteotomies. By comparing 6 different 1st metatarsal diaphyseal osteotomies in cadavers, with the exception of Ludloff, the Mau osteotomy was determined to be the most rigid osteotomy and stronger than the other diaphyseal osteotomies [46]. Consistent with all these studies, Unal *et al* [47] reached the conclusion that Mau osteotomy was the most stable shaft osteotomy. Taking all these bimechanical findings into account, both Scarf and Mau osteotomies allow early mobilization as they provide stability in the osteotomy line in the surgical treatment of hallux valgus deformity [42]. In the current study, early mobilization was encouraged in all patients and no problems were determined related to early weight-bearing. Therefore, in patients with moderate to severe hallux valgus treated with Scarf and Mau osteotomies, early weight-bearing can be applied.

In a study applied Scarf osteotomy by Fuhrmann *et al.* [35], patients were separated into 2 groups aged 50 years and younger and over 50 years. There was seen to be no difference between the groups in respect of mean preoperative and postoperative AOFAS and VAS groups. In the current study patients were evaluated in 2 age groups as older and younger than 45 years. In the cases applied Scarf osteotomy, a significant increase in AOFAS points was determined in patients aged ≤ 45 years and a non-statistically significant decrease in VAS points. In the Scarf osteotomy cases aged > 45 years and in the Mau osteotomy cases of both age groups, there was no difference in the clinical and radiological improvements. These findings suggest that better clinical results may be obtained with Scarf osteotomy in patients aged ≤ 45 years.

Recurrent hallux valgus, hallux varus, metatarsal elevation, delayed union, superficial infection, transfer metarsalgia, arthritis, and insufficient surgical correction are accepted as the most frequently seen complications in diaphyseal osteotomies [18, 35, 48-52]. In Scarf osteotomy, if the distal and proximal osteotomy fragments come to rest in the diaphyseal rather than the metaphyseal area, rotation in the metatarsal head, reduction in metatarsal height and elevation may occur because of impaction [6, 39]. Smith *et al.* [53] stated a perioperative complication rate of 6% in Scarf osteotomy. In a mid-term retrospective evaluation at mean 44.9 months after Scarf osteotomy in 178 cases, recurrence was seen in 24% and a moderate level of joint incongruity in the MTP joint in 19%. In the same study, development of hallux varus was reported in 1.6%, transfer metatarsalgia in 9 patients, arthritis in 13, metarsal fracture in 5 and reoperation in 12 patients at the final follow-up examinations. In the patients with metatarsal fracture, tomography imaging showed the reason to be metatarsal collapse [39]. In a series of 20 cases applied Scarf osteotomy, Coetzee and Rippstein [33] reported high complication rates at 6 months with metatarsal collapse in 7 feet (35%), delayed union in 5%, poor rotational union in 30%, fracture in the proximal metatarsal in 10%, infection in 5% and recurrence in 25%. In a study by Hyer et al. [31] of 24 Mau osteotomies, complications such as infection, non-union, recurrence, metatarsal elevation, insufficient correction and transfer metatarsalgia were reported to have developed.

In the current study, complications developed in 5 patients applied Scarf osteotomy and in 11 patients applied Mau osteotomy. These complications were recurrence in 7 cases, metatarsal elevation in 6 cases, superficial infection in 3, arthritis in 1, insufficient correction in 7, delayed union in 4 and deep vein thrombosis in 1. In the patient who developed thromboemboli, recovery was seen with medical treatment. A second operation to remove the screws was necessary in 2 patients in the Scarf osteotomy group. When the radiographs were examined retrospectively, the screw lengths were seen to be normal postoperatively, but at the final follow-up

examination, the screws were determind to have migrated outwards from the dorsal and plantar cortices. It was thought that this could have been due to metatarsal collapse, which is the most frequently seen complication of Scarf osteotomy. When the complications of the two osteotomies applied in this study were compared, the complication rate of the Mau osteotomy was higher but no clinical difference was determined between the two techniques.

The most important advantage of this study was that it was prospective and randomised and therefore the scientific evidence is of a high level. Other advantages are that it was conducted at a single centre, all operations were performed by a single surgeon and there was no loss of data due to patients withdrawing from follow-up.

The Limitation of the Study

Limitations of the study could be said to be the low number of cases and the relatively short follow-up period. The long-term results of a greater number of cases operated on by the same surgeon would make a greater contribution to literature.

Conclusions

In conclusion, the short-term results obtained in this study were observed to be satisfactory. When it is considered that no complications of clinical importance are created, the Scarf and Mau osteotomies can be recommended for use together with the modified McBride procedure in patients with moderate to severe hallux valgus deformity that have no degenerative changes in the MTP joint.

Authorship declaration

All authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors, and all authors are in agreement with the manuscript.

Conflict of interest

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