

# Sex-Related Differences in Outcomes after Hallux Valgus Surgery

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Received: March 18, 2014

Revised: May 22, 2014

Accepted: June 7, 2014

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The authors have no financial conflicts of interest.

**Purpose:** With differences between the sexes in foot bone anatomy and ligamentous laxity, there is the possibility that the results of hallux valgus surgery may also differ between the sexes. We aimed to compare the results of hallux valgus surgery between the sexes. **Materials and Methods:** The authors retrospectively reviewed 60 males (66 feet) and 70 females (82 feet) who underwent distal or proximal chevron osteotomy for the treatment of hallux valgus deformity between June 2005 and December 2011. We compared the clinical and radiologic outcomes between the sexes. **Results:** There were no statistically significant differences in demographics between the sexes. The mean American Orthopedic Foot and Ankle Society score, visual analogue scale for pain, and patient satisfaction at the last follow-up did not differ significantly between the sexes. The mean preoperative hallux valgus angle (HVA) and inter-metatarsal angle (IMA) were not significantly different between the sexes. At the last follow-up, the mean HVA was significantly greater in females ( $p=0.003$ ) than in males; mean IMA was not significantly different between the sexes. The mean correction of HVA in males was significantly greater than that in females ( $p=0.014$ ). **Conclusion:** There were no significant differences between the sexes regarding clinical outcomes after distal and proximal chevron osteotomy. However, male patients achieved greater correction of HVA than female patients. There is a possibility that sexual dimorphism of the foot may affect postoperative HVA.

**Key Words:** Hallux valgus, distal chevron osteotomy, proximal chevron osteotomy, gender

## INTRODUCTION

The prevalence of hallux valgus is reported to be higher in women than in men.<sup>1,2</sup> The predominance of hallux valgus in women may be due to their habit of wearing constricting shoes and/or differences in osseous anatomy.<sup>3-5</sup> Some studies have reported differences between foot bones in males and females. For example, the metatarsal head articular surface in female patients is more rounded and smaller, providing a less stable joint.<sup>6</sup> The female first metatarsal has a tendency to be more adducted than that in the male skeleton,<sup>5</sup> and ligamentous laxity and first ray hypermobility are more common in women.<sup>3</sup> These differences may underlie the pre-

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disposition of the female foot to develop hallux valgus and might lead to different results between male and female patients after hallux valgus surgery. However, studies have yet to compare the outcomes of hallux valgus surgery between the sexes, although one recent study<sup>4</sup> did compare demographics, etiology, and radiologic measurements on preoperative radiographs.

Accordingly, the purpose of this study was to compare the results of hallux valgus surgery between male and female patients. We hypothesized that the clinical and radiologic outcomes after hallux valgus surgery would differ between the sexes.

## MATERIALS AND METHODS

This study was approved by the hospital's Institutional Review Board. We retrospectively reviewed 167 consecutive patients (198 feet) with symptomatic hallux valgus who underwent distal or proximal chevron osteotomy between June 2005 and December 2011. All operations were performed by the same surgeon. Metatarsal osteotomy was selected on the basis of inter-metatarsal angle (IMA). Distal chevron osteotomy was indicated for hallux valgus with an IMA  $<15^\circ$ , whereas proximal chevron osteotomy was used for cases with an IMA  $\geq 15^\circ$ . We performed a distal soft tissue procedure combined with metatarsal osteotomy in patients with moderate or severe hallux valgus deformity to obtain better correction of the deformity. Akin osteotomy was performed simultaneously if any contact between the distal end of the great and second toes or pronation deformity of the hallux remained intraoperatively under load simulation test after correction by metatarsal osteotomy was noted. The inclusion criteria were painful bunion and hallux valgus deformity that was refractory to nonoperative management, difficulty in wearing shoes, and availability of dor-

so-plantar and lateral weightbearing radiographs of the feet taken preoperatively and at final follow-up. The exclusion criteria were rheumatoid arthritis, radiographic evidence of osteoarthritis of the first metatarsophalangeal (MTP) joint, instability at the first metatarsocuneiform joint, patients with a follow-up  $<24$  months, and previous foot surgery or combined lesser toe procedures performed simultaneously with the procedure for the treatment of hallux valgus. In total, 148 feet from 130 consecutive patients were finally enrolled in this study, including 66 feet of 60 male patients and 82 feet of 70 female patients. Patient demographics and procedures used for treatment of hallux valgus are shown in Table 1.

### Surgical technique

The procedures were performed with patients in the supine position under spinal anesthesia. Distal soft tissue procedures were performed at the beginning of the surgery. Through a dorsal first web space incision, the adductor hallucis tendon, lateral sesamoid metatarsal ligament, transverse metatarsal ligament, and lateral capsule were released. A medial longitudinal incision was made over the first MTP joint and a medial longitudinal capsulotomy was performed in the same plane as the incision. The medial eminence was excised 1 mm medial to the sagittal sulcus in the distal-proximal direction with a sagittal saw.

For the distal chevron osteotomy, a  $60^\circ$  V-osteotomy centered on the first metatarsal head was performed and the capital fragment was displaced laterally. The osteotomy was then fixed with a 3.0-mm cannulated screw (Barouk Screw; DePuy International, Leeds, UK). For the proximal chevron osteotomy, an osteotomy was performed on the first metatarsal shaft 10 mm distal to the metatarsocuneiform joint, and the apex of osteotomy was directed proximally with an angle of  $60^\circ$ . The distal fragment was translated and tilted laterally, and the osteotomy was secured

**Table 1.** Patient Demographics and Procedures

	Males (n=66)	Females (n=82)	p value
Mean age (yrs) (range)	66.1 (60 to 74)	64.5 (48 to 78)	0.101
Mean BMI (kg/m <sup>2</sup> ) (range)	23.7 (19.2 to 27.6)	23.4 (18.8 to 28.2)	0.415
Mean follow-up (months) (range)	31.5 (24 to 92)	33.8 (24 to 91)	0.470
Procedures (n, %)			
Distal chevron osteotomy	28 (42.4)	30 (36.6)	0.470
Proximal chevron osteotomy	38 (57.6)	52 (63.4)	
Akin osteotomy	44 (66.7)	44 (53.7)	0.109
Distal soft tissue procedure	50 (75.8)	59 (72.0)	0.601

BMI, body mass index.

with two or three medially placed 1.6-mm Kirschner wires. The Akin osteotomy was then carried out and fixed with a 3.0-mm cannulated screw. The redundant margin of a medial capsule was removed and a medial capsulorrhaphy was performed.

Both groups followed the same postoperative protocol. Patients wore an open, hard-soled postoperative shoe for a minimum of 6 weeks and were allowed to bear weight as tolerated on their heel and lateral forefoot on the first postoperative day. Once there was radiographic evidence of healing at the osteotomy site, transfer of weight to the forefoot in sneakers was advanced, typically at 6 weeks. The Kirschner wires were usually removed at 3 months postoperative.

### Evaluation

All patients were evaluated clinically before surgery and at the time of follow-up. Clinical outcomes were assessed with the American Orthopedic Foot and Ankle Society (AOFAS) forefoot-metatarsophalangeal-interphalangeal scale<sup>7</sup> and a visual analogue scale (VAS)<sup>8</sup> for pain (0, no pain; 10, worst pain). Patients were also asked to rate their satisfaction as 'very satisfied', 'satisfied', or 'not satisfied'.

Weightbearing dorso-plantar and lateral radiographs of the foot were obtained preoperatively and at the time of follow-up. Radiographic assessment was performed by one independent blinded observer. The hallux valgus angle (HVA),<sup>9</sup> IMA,<sup>10</sup> distal metatarsal articular angle (DMAA),<sup>11</sup> congruency of the first MTP joint,<sup>12</sup> and the position of the medial sesamoid<sup>13</sup> were measured on weightbearing dorso-plantar radiographs preoperatively and at final follow-up using a digital picture archiving and communication system (PACS) image system. The position of medial sesamoid was graded from 1 to 7 based on its relationship to the longitudinal bisector of the first metatarsal (1, most medial; 7, most lateral).<sup>13</sup> We categorized the shape of the first metatarsal head as a round, chevron, and flat articular surface.<sup>14</sup> On the preoperative weightbearing lateral radiographs, the first metatarsal-medial cuneiform angle (MMCA) and first metatarsal lift were measured to assess hypermobility of the first ray at the first metatarsal-medial cuneiform joint.<sup>15</sup> The MMCA is the angle subtended by the lines drawn between the superior and inferior edges of the articular surfaces of the medial cuneiform and first metatarsal. The first metatarsal lift is defined as the perpendicular distance between the inferior border of the base of the first metatarsal and a line drawn between the proximal and distal inferior border of the medial cuneiform and measures the amount of dorsal translation

in millimeters of the first metatarsal relative to the medial cuneiform. To evaluate osteotomy healing in the first metatarsal, we measured the dorsiflexion angle of the first metatarsal, shortening of the first metatarsal length, and bony callus formation at the osteotomy site. The dorsiflexion angle of the first metatarsal was measured on weightbearing lateral radiographs.<sup>16</sup> To measure shortening of the first metatarsal length we used a method previously described by Trnka, et al.<sup>17</sup> A bony callus at the osteotomy site was identified at the time of the early follow-up (6 to 8 weeks). As in previous studies,<sup>18,19</sup> we defined recurrence of hallux valgus as an HVA  $\geq 20^\circ$ . Recurrence was assessed at the final follow-up.

### Statistical analysis

All statistical analyses were performed with SPSS software for Windows version 16.01 (SPSS Inc., Chicago, IL, USA). Student's t-test was used to compare continuous variables between the sexes, and a paired t-test was used to evaluate changes between the pre- and postoperative values. The chi-squared test was used to compare nominal variables. Logistic regression analysis was performed to identify variables associated with bony callus formation. Univariate logistic regression analysis was used to determine significant associations between variables and bony callus formation. Stepwise multivariable logistic regression was performed for all independent variables that achieved a *p* value  $< 0.05$  against bony callus formation in univariate analysis. Results are presented as odds ratios (OR) with corresponding 95% confidence intervals (CI) and *p* value. A *p* value less than 0.05 was considered statistically significant. Post hoc power analyses were performed to demonstrate true differences in the clinical and radiological outcomes between the sexes using G\*Power 3.1.

## RESULTS

The demographics of the patients are shown in Table 1. There were no statistically significant differences between male and female patients in terms of age, body mass index (BMI), mean follow-up, and procedure used for hallux valgus treatment.

The clinical results are presented in Table 2. The mean AOFAS score and VAS improved significantly in both groups (all *p*  $< 0.001$ ). However, there were no significant differences in pre- and postoperative AOFAS scores and VAS between the two groups. Regarding satisfaction, 54/66 cases

**Table 2. Clinical Outcomes**

	Males (n=66)	Females (n=82)	<i>p</i> value
VAS for pain*			
Preoperative	6.3±1.3	6.4±1.1	0.548
Postoperative	1.6±1.5	2.1±1.7	0.113
<i>p</i> value	<0.001	<0.001	
AOFAS score*			
Preoperative	50.9±15.9	51.6±11.0	0.778
Postoperative	84.8±11.4	87.8±7.0	0.093
<i>p</i> value	<0.001	<0.001	
Satisfaction (n, %)			0.075
Very satisfied	32 (48.5)	52 (63.4)	
Satisfied	22 (33.3)	24 (29.3)	
Not satisfied	12 (18.2)	6 (7.3)	

VAS, visual analogue scale; AOFAS, American Orthopaedic Foot and Ankle Society.

\*Data was expressed by mean (standard deviation).

(81.8%) in the male group and 76/82 cases (92.7%) in the female group were satisfied or very satisfied with the overall outcome of the surgery ( $p=0.075$ ). In contrast, 12.2% of all cases (18/148 cases) were not satisfied with the outcome for the following reasons: recurrence of hallux valgus (8 cases), pain around the first MTP joints (6 cases), first MTP joint stiffness (2 cases), and new transfer metatarsalgia with a plantar keratosis under the second metatarsal head (2 cases).

The radiological results are shown in Table 3. The mean preoperative HVA was not significantly different between the groups ( $p=0.864$ ), whereas the mean HVA at the last follow-up in the female group was significantly greater than that in the male group ( $p=0.003$ ). The mean correction of HVA was significantly greater in the male group than in the female group ( $p=0.014$ ). The mean HVA had decreased significantly at the last follow-up in both groups. The mean pre- and postoperative IMA did not differ between the two groups ( $p=0.378$  and  $p=0.965$ , respectively). The mean IMA decreased significantly at the last follow-up in both groups, and there was no significant difference between the groups regarding the mean correction of IMA ( $p=0.405$ ). The mean pre- and postoperative DMAA were not significantly different between the groups ( $p=0.492$  and  $p=0.121$ , respectively). The mean DMAA did not change significantly after surgery in both groups ( $p=0.270$  and  $p=0.867$ , respectively). The mean grade of the positions of the medial sesamoid improved significantly in both groups. There were no significant differences between the groups in terms of mean pre- and postoperative grade of the medial sesamoid positions and correction of the grade ( $p=0.119$ ,  $p=0.097$ , and  $p=0.923$ , respectively).

The first MTP joint was preoperatively incongruent in all

of our cases. At the last follow-up, incongruity of the first MTP joint was observed in 17/66 feet (25.8%) in the male group and in 19/82 feet (23.2%) in the female group ( $p=0.715$ ). The mean pre- and postoperative dorsiflexion angle of the first metatarsal revealed no significant differences between the groups ( $p=0.160$  and  $p=0.317$ , respectively), and the mean difference between preoperative and last follow-up values did not differ between the two groups ( $p=0.537$ ). There were no significant changes in pre- and postoperative dorsiflexion angles of the first metatarsal in both groups ( $p=0.336$  in the male group,  $p=0.127$  in the female group). No statistically significant difference was found with respect to mean first metatarsal shortening between the two groups ( $p=0.233$ ).

Recurrence of hallux valgus was observed in 5/66 feet (7.6%) in the male group and 12/82 feet (14.6%) in the female group ( $p=0.181$ ). Among 17 patients with hallux valgus recurrence, four complained of contact between the distal end of the great toe and second toe, two had intermittent pain around the first MTP, one reported new transfer metatarsalgia under the second metatarsal head, and the remainder had no symptoms.

In regards to the shape of the first metatarsal head, a rounded articular surface was more common in the female group (66/82 feet, 80.5%) than the male group (40/66 feet, 60.6%) ( $p=0.008$ ). The MMCA and first metatarsal lift were greater in the female group than male group ( $p=0.001$  and  $p=0.011$ , respectively).

A bony callus formation was seen at the osteotomy site by 6 to 8 weeks in 20/66 feet (30.3%) in the male group and 18/82 feet (22.0%) in the female group ( $p=0.698$ ). At the last follow-up, all of these feet had union of the osteoto-

**Table 3. Radiological Outcomes**

	Males (n=66)	Females (n=82)	<i>p</i> value
Hallux valgus angle (degrees)*			
Preoperative	35.5±10.2	35.2±8.3	0.864
Last follow-up	12.8±9.0	16.9±7.6	0.003
<i>p</i> value	<0.001	<0.001	
Correction <sup>†</sup>	22.7±10.0	18.3±11.2	0.014
First intermetatarsal angle (degrees)*			
Preoperative	15.7±2.9	15.2±4.1	0.378
Last follow-up	10.3±3.7	10.4±4.0	0.965
<i>p</i> value	<0.001	<0.001	
Correction <sup>†</sup>	5.4±3.8	4.8±4.0	0.405
Distal metatarsal articular angle (degrees)*			
Preoperative	11.4±4.9	10.5±5.7	0.492
Last follow-up	13.1±5.9	10.7±6.5	0.121
<i>p</i> value	0.270	0.867	
Medial sesamoid position grade*			
Preoperative	5.9±1.1	5.6±1.4	0.119
Last follow-up	3.9±1.0	3.6±1.2	0.097
<i>p</i> value	<0.001	<0.001	
Correction <sup>†</sup>	2.1±1.5	2.0±1.5	0.923
Congruity of the first metatarsophalangeal joint (n, %)			
Preoperative			0.707
Congruent	12 (18.2)	13 (15.9)	
Incongruent	54 (81.8)	69 (84.1)	
Last follow-up			0.610
Congruent	50 (75.8)	65 (79.3)	
Incongruent	16 (24.2)	17 (20.7)	
Dorsiflexion angle of first metatarsal (degrees)*			
Preoperative	18.6±3.9	19.9±6.4	0.160
Last follow-up	17.8±6.3	18.8±5.6	0.317
<i>p</i> value	0.336	0.127	
Difference <sup>‡</sup>	1.1±6.3	1.5±7.3	0.537
First metatarsal shortening (mm)*			
Preoperative	3.6±5.2	2.4±6.5	0.233
Bony callus formation (n, %)			
Preoperative	20 (30.3)	18 (22.0)	0.698
Recurrence (n, %)			
Preoperative	5 (7.6)	12 (14.6)	0.181
Shape of the first metatarsal head (n, %)			
Preoperative			0.008
Round-type	40 (60.6)	66 (80.5)	
Chevron or flat-type	26 (39.4)	16 (19.5)	
First metatarsal-medial cuneiform angle (degrees)*			
Preoperative	2.1±1.5	3.2±2.1	0.001
First metatarsal lift (mm)*			
Preoperative	2.1±1.3	2.8±1.7	0.011

\*Data was expressed by mean (standard deviation).

<sup>†</sup>Difference between pre-operative and last follow-up value.

<sup>‡</sup>Positive value means that pre-operative value was greater than last follow-up value.

my site, and resorption of the callus was observed in 31/38 feet (81.5%). A comparison of demographics and radiological outcomes for patients with and without bony callus is presented in Table 4. There were no significant differences between patients with and without bony callus regarding mean age, BMI, follow-up, and metatarsal osteotomies used for the correction of hallux valgus. The mean preoperative

HVA and IMA in patients with bony callus were significantly greater than those of patients without bony callus ( $p=0.009$  and  $p<0.001$ , respectively), and the mean postoperative HVA and IMA did not differ between the two groups ( $p=0.432$  and  $p=0.191$ , respectively). The mean correction of HVA and IMA in patients with bony callus was significantly greater than that in patients without bony callus ( $p=$

**Table 4.** Comparison of Demographics and Radiological Outcomes for the Patients with and without Bony Callus

	Callus (n=38)	No callus (n=110)	p value
Mean age (yrs) (range)	66.6 (59 to 77)	64.8 (48 to 78)	0.061
Mean BMI (kg/m <sup>2</sup> ) (range)	22.9 (19.1 to 27.3)	23.7 (20.6 to 27.9)	0.174
Mean follow-up (months) (range)	32.9 (24 to 83)	32.7 (24 to 91)	0.969
Metatarsal osteotomies (n, %)			0.134
Distal chevron osteotomy	11 (28.9)	47 (42.7)	
Proximal chevron osteotomy	27 (71.1)	63 (57.3)	
Hallux valgus angle (degrees)*			
Preoperative	38.7 (8.1)	34.2 (9.2)	0.009
Last follow-up	14.4 (7.1)	15.4 (8.9)	0.432
Correction <sup>†</sup>	24.5 (7.5)	18.8 (11.4)	0.001
First intermetatarsal angle (degrees)*			
Preoperative	18.1 (4.0)	14.5 (3.1)	<0.001
Last follow-up	11.2 (4.6)	10.1 (3.6)	0.191
Correction <sup>†</sup>	6.9 (3.5)	4.4 (3.9)	0.001
Dorsiflexion angle of first metatarsal (degrees)*			
Preoperative	18.7 (4.8)	19.5 (5.4)	0.426
Last follow-up	18.7 (5.8)	18.2 (6.0)	0.618
p value	0.972	0.07	
Difference <sup>‡</sup>	0.8 (5.9)	1.5 (7.2)	0.610
First metatarsal shortening (mm)*	3.5 (4.1)	2.7 (6.5)	0.522

\*Data was expressed by mean (standard deviation).

<sup>†</sup>Difference between pre-operative and last follow-up value.

<sup>‡</sup>Positive value means that pre-operative value was greater than last follow-up value.

0.001 and  $p=0.001$ , respectively). Significant differences were not observed between the two groups with regard to mean pre- and postoperative dorsiflexion angle of the first metatarsal ( $p=0.426$  and  $p=0.618$ , respectively) and the difference between pre- and postoperative values ( $p=0.610$ ). There were no significant changes in pre- and postoperative dorsiflexion angle of the first metatarsal in either group ( $p=0.972$  in patients with bony callus,  $p=0.07$  in patients without bony callus). In univariate logistic regression, variables associated with bony callus with a  $p$  value  $<0.05$  included preoperative HVA and IMA ( $p=0.011$  and  $p<0.001$ , respectively) and correction of HVA and IMA ( $p=0.006$  and  $p=0.001$ , respectively). Among these variables, only preoperative IMA was significantly associated with bony callus formation in multivariate logistic regression [OR, 1.34 (95% CI 1.14 to 1.57);  $p<0.001$ ].

Complications other than the recurrence of hallux valgus are shown in Table 5. There were six cases of superficial wound infections that were resolved with antibiotic therapy, six cases of reversible hypoesthesia in the region of the wound, two cases of transfer metatarsalgia under the second metatarsal head, and two cases of the first MTP joint stiffness. No revision procedures were necessary.

A post hoc power analysis was performed to demonstrate

**Table 5.** Complications

Complication	Males (n=66)	Females (n=82)
Total (n, %)	8 (12.1)	8 (9.7)
Superficial wound infection	4	2
Hypoesthesia	2	4
Transfer metatarsalgia	0	2
First metatarsophalangeal joint stiffness	2	0

the existence of true differences in the postoperative HVA and correction of HVA between male and female patients. The mean postoperative HVA was  $12.8\pm 9.0$  degrees in the male group and  $16.9\pm 7.6$  degrees in the female group ( $p=0.003$ ). The power is 0.84 at a significance level of 0.05. The mean correction of HVA was  $22.7\pm 10.0$  degrees in the male group and  $18.3\pm 11.2$  degrees in the female group ( $p=0.014$ ). The power is 0.70 at a significance level of 0.05.

## DISCUSSION

In our study, the mean preoperative HVA did not differ significantly between male and female patients, whereas the mean HVA at the last follow-up was significantly greater in

the female group than in the male group. The mean correction of HVA was also significantly greater in the male group than in the female group. The recurrence rate of hallux valgus in the female group was also higher than that of the male group, although this was not statistically significant. The mean pre- and postoperative IMA was not significantly different between the groups.

Sexual dimorphism of the foot has been described in the literature. Based on measurements of articular surfaces, Ferrari, et al.<sup>5</sup> suggested that female bones had the potential for more movement to occur in the direction of adduction, possibly resulting in greater adduction of the first metatarsal in females than in males. Women have more rounded and smaller metatarsal articular surfaces, compared with men, and a rounder metatarsal head is associated increased hallux valgus deformity.<sup>6</sup> Women have much greater ligamentous laxity than men,<sup>20</sup> and first ray hypermobility is also more common in women.<sup>21</sup> In our study, a rounded articular surface of the first metatarsal head was more common in female patients, and two parameters for assessing the first ray hypermobility showed that the first metatarsal-medial cuneiform joint is more lax in female patients than in male patients. Such differences between the sexes may underlie the predisposition of the female foot to develop hallux valgus deformity and may also be the reason why the mean postoperative HVA was significantly greater in female patients in our study. Women are more likely to wear high-heel shoes postoperatively than men. This may also be another reason why the mean HVA correction of the male patient group was significantly greater than that of the female patient group.

We compared dorsiflexion angle of the first metatarsal, shortening of the first metatarsal length, and bony callus formation at the osteotomy site to investigate differences in osteotomy healing between the sexes. None of these differed significantly between the sexes, indicating no difference between the sexes with respect to osteotomy healing and suggesting no difference in loss of IMA correction over time between the sexes. This probably explains why there was no significant difference in the mean postoperative IMA between the two groups.

A bony callus formation at the osteotomy site was observed in a total of 38/148 feet (25.6%) at the time of the early follow-up. We compared demographics and radiological outcomes for the patients with and without bony callus because we suspected that these might differ between the two groups. The mean preoperative values of HVA and IMA

and the correction of HVA and IMA were significantly greater in patients with a bony callus than in patients without a bony callus. The results of multivariate logistic regression analysis demonstrated that preoperative IMA was associated with bony callus formation. Therefore, we speculate that a bony callus might occur more frequently in patients with larger IMA because motion at the osteotomy site is more likely to occur with a greater correction of IMA. Trnka, et al.<sup>17</sup> reported that the mean age of patients with bony callus at the osteotomy site was significantly greater than that of patients without bony callus after Ludloff osteotomy; however, there were no significant differences between the groups regarding pre- and postoperative values of HVA and IMA. They stated that osteopenia and less rigid fixation of the osteotomy site might contribute to bony callus formation and recommended additional immobilization and protected weight bearing for patients who developed a callus at the osteotomy site. However, we applied the same postoperative protocol, regardless of bony callus formation, and the mean correction of HVA and IMA was significantly greater in patients with bony callus at the last follow-up. Therefore, our data suggest that patients with a bony callus at the early follow-up may not need additional immobilization and protected weight bearing.

There are few comparisons of radiologic measurements of hallux valgus deformity between the sexes. Ferrari and Malone-Lee<sup>6</sup> reported that HVA was significantly greater in women than in men ( $p=0.001$ ) in a study that included patients under 40 years of age with and without hallux valgus deformity. In contrast, Nery, et al.<sup>4</sup> analyzed 31 males and 31 females with diagnosed hallux valgus deformity who had received operative treatment and reported that the preoperative HVA and DMAA were significantly higher in males. Our results showed no significant differences in the preoperative HVA and DMAA between male and female patients. It should be noted that men and women might feel differently about the need for hallux valgus surgery. Therefore, a comparative study of patients who undergo hallux valgus surgery might not accurately reflect gender-related differences in the severity of hallux valgus deformity in the general population. The power about no differences in the preoperative HVA and DMAA between the sexes is 0.99 and 0.17, respectively, at a significance level of 0.05. Thus, a study of a large number of patients is needed to identify the difference of DMAA between the sexes.

The present study is limited by its retrospective design. However, we could not find another study that compared

the results of hallux valgus surgery between the sexes in the literature. Thus, our study has value because it is the first to compare clinical and radiological results after hallux valgus surgeries performed by a single surgeon between male and female patients.

In conclusion, this study demonstrated that clinical outcomes and radiological parameters reflecting osteotomy healing after distal and proximal chevron osteotomy were not significantly different between the sexes. However, the male patient group achieved greater correction of HVA than the female patient group. There is a possibility that sexual dimorphism of the foot may affect postoperative HVA.

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