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Distal Oblique Metatarsal Osteotomy for Hallux Valgus Deformity: A Clinical Analysis

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ABSTRACT

We compared the outcomes of the distal oblique metatarsal (DOM) osteotomy, which is parallel to the articulation surface of the proximal phalanx, with those of the chevron osteotomy and evaluated whether displacement and shortening of the first metatarsal have any effect on the incidence of metatarsalgia and patient satisfaction. Patients treated with the DOM osteotomy (n = 30) or distal chevron osteotomy (n = 31) were evaluated retrospectively. The chevron and DOM osteotomies both provided significant improvement in the first intermetatarsal angle ($p < .001$), hallux valgus angle ($p < .001$), distal metatarsal articular angle ($p < .001$), range of first metatarsophalangeal joint motion ($p < .001$), American Orthopaedic Foot and Ankle Society score ($p < .001$), and sesamoid position ($p < .001$), without any significant differences between the 2 groups. Patient satisfaction and metatarsalgia also were not different between the study groups. The DOM osteotomy group had higher plantar displacement (0.1 ± 0.1 mm versus 1.0 ± 0.1 mm; $p < .001$) and absolute shortening of the first metatarsal (1.0 ± 0.4 mm versus 6.8 ± 1.0 mm; $p < .001$). In conclusion, the DOM osteotomy is an alternative treatment method for mild and moderate hallux valgus.

Hallux valgus is the most common foot deformity and affects approximately 30% of the population to some degree, causing pain and/or discomfort (1). Although the exact etiology of hallux valgus is not known, a number of factors, inherent or acquired, play a combined role in the pathogenesis (2,3). Because it is a progressive disorder, surgery is indicated for cases in which nonoperative treatment does not decrease the pain. Many surgical procedures (i.e., metatarsal osteotomy and arthrodesis) have been described to correct hallux valgus (1,4–9); however, no consensus has yet been reached on which surgical technique is the most appropriate (9–11).

The common complications of hallux valgus surgery include transfer metatarsalgia, recurrence, avascular necrosis, hallux varus, non- or malunion of metatarsal osteotomies, and decreased range of motion (12). The ideal osteotomy for hallux valgus should correct the first intermetatarsal angle (IMA) and hallux valgus angle (HVA), without other undesired changes in the anatomy of the first metatarsal that could lead to transfer metatarsalgia (13).

Chevron, which is a distal osteotomy, is the most preferred technique for hallux valgus surgery (4). Chevron osteotomy is accepted as a reliable procedure for mild and moderate hallux valgus cases without degeneration at the first metatarsophalangeal (MTP) articulation (14–21). Chevron osteotomy with the distal soft tissue release technique has also been reported as successful in severe hallux valgus cases (HVA >40° and IMA >20°) (21–23). However, the distal chevron osteotomy might be related to avascular necrosis of the metatarsal head and a decrease in passive range of motion (ROM) of the first MTP joint, both of which can be prevented by shortening the distal metatarsal (24–26).

The Wilson osteotomy, the first osteotomy described, is also 1 of the preferred techniques for hallux valgus surgery (27). It is an oblique osteotomy of the first metatarsal with lateral transpositional displacement of the distal bone fragment, resulting in correction of the deformity and shortening of the first metatarsal (27,28). However, metatarsalgia secondary to shortening is the main complication of the Wilson osteotomy.

In the present study, we suggest a distal metatarsal osteotomy as a modification of the Wilson osteotomy, with the aim of decreasing the

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amount of shortening and incidence of metatarsalgia and improving the outcomes. Our technique is a distal oblique metatarsal (DOM) osteotomy that is parallel to the articulation surface of the proximal phalanx and has angle values specific for each patient. We hypothesized that the modified DOM osteotomy would provide an effective correction of the deformity and that the amount of metatarsal shortening with the DOM osteotomy would not cause metatarsalgia. Therefore, the DOM osteotomy might be an alternative surgical technique for mild to moderate hallux valgus.

To test this hypothesis, we compared the functional and radiologic outcomes of the DOM osteotomy, which is parallel to the articulation surface of the proximal phalanx, and modified chevron osteotomy—the most commonly applied surgical technique for hallux valgus deformity. We also evaluated whether plantar displacement and shortening of the first metatarsal due to the DOM osteotomy would have any effect on the incidence of metatarsalgia and patient satisfaction.

Patients and Methods

We performed a retrospective comparative study. The data from 68 patients who underwent the DOM osteotomy by an orthopedic surgeon with 8 years of experience (O.G.) or distal chevron osteotomy by another orthopedic surgeon with 8 years of experience (B.Y.) from 2009 to 2012 were evaluated retrospectively. The included patients were 16 to 60 years old and had an HVA of $<40^\circ$ and IMA of $<15^\circ$ between first and second metatarsal (mild and moderate). Also, they were required to have no radiologic evidence of degenerative MTP arthritis, persistent symptoms despite conservative treatment such as shoe wear modifications and nonsteroidal anti-inflammatory drugs, and a follow-up period of $\geq$12 months. The exclusion criteria were severe hallux valgus deformity (1 patient), the impracticability of radiologic examinations for measurement (3 patient), discontinuous follow-up visits (2 patients), degenerative arthritis of the first MTP joint (1 patient), previous surgery on the affected foot, diabetes mellitus, peripheral vascular disease, peripheral neuropathy, rheumatoid arthritis, other inflammatory diseases, and the absence of preoperative radiographs. Seven patients were excluded from the present study.

The institutional ethics committee approved the present study, which was performed in accordance with the Declaration of Helsinki (code of ethics of the World Medical Association). All patients provided written informed consent for surgery as a part of routine clinical practice.

Operative Technique

In the modified chevron osteotomy (13), a 60° V-shaped osteotomy with a 1- to 1.3-cm distance between its apex and subchondral bone was performed using a power saw (length 40 mm, thickness 0.4 mm, and width 9 mm; Linvatec, ConMed Corp., Utica, NY) after bunionectomy. The capital fragment was shifted 4 to 6 mm laterally and fixed with 4-mm headless cannulated compression screws. The medial projection of the proximal fragment was excised.

For the DOM osteotomy (27), a dorsomedial approach over the distal part of the first metatarsal was used. The skin incision was straight and medial to the extensor hallucis longus tendon. Before opening the MTP joint capsule, a Kirschner wire was inserted through the shaft–neck junction, parallel to the articular surface of the proximal phalanx. The osteotomy was performed using a Kirschner wire for guidance. After dissecting the joint capsule in a Y-shape, the periosteum on the upper and lower surface of first metatarsal was opened minimally, and the retractors were placed to protect the sesamoid bones. The dissection was extended to the bone, and the saw blade (length 40 mm, thickness 0.4 mm, and width 9 mm) was aligned halfway between the perpendicular long axis of the first metatarsal and the plantar aspect of the foot. The osteotomy was performed in a distal medial to proximal lateral direction at the shaft–neck conjunction of the metatarsals and just parallel to the articulation surface of the proximal phalanx (Fig. 1). The distal fragment was then displaced laterally, and specific attention was given for slight plantarization, approximately 1 mm (Fig. 2). The amount of lateral displacement was determined by the correction required and was as much as 6 to 10 mm. Lateral displacement was performed until the longitudinal axes of the first metatarsal and the proximal phalanx were parallel on fluoroscopic imaging. In necessary cases, derotation was performed manually at the distal site of the osteotomy to correct any pronation, which is a rotational deformity on the axial plane. The distal fragment was fixed with a 4-mm headless cannulated compression screw (Figs. 3–5). The residual

Fig. 1. Anteroposterior fluoroscopic image of a 35-year-old female patient standing on her right foot. A Kirschner wire can be seen from the head–neck junction of first metatarsal to the proximal articular surface of the proximal phalanx.

Fig. 2. Anteroposterior fluoroscopic image showing transient fixation of the Kirschner wire after lateralization and plantarization of the distal fragment after distal oblique metatarsal osteotomy.

medial bony prominence of the proximal fragment was excised. Adductor tenolysis was not performed. All the patients underwent medial capsular plication and bunionectomy.

Postoperative Care

The dressing and sutures were removed at 15 to 21 days postoperatively, and the use of a toe spacer was advised. Full weightbearing, as tolerated with a protective shoe, was permitted at 6 weeks after surgery.

Radiologic and Clinical Parameters

Preoperative and postoperative loadbearing radiographs were obtained. An anteroposterior radiograph was taken with the beam tilted 15° posteriorly; the lateral radiograph was focused perpendicularly on the base of the third metatarsal (29).

All radiographs were taken from a distance of 1 m. The HVA and 1-2 IMA were calculated using the method described by Mitchell et al (30). To measure the distal metatarsal articular angle, we used the method described by Richardson et al (31). The range of motion of the first MTP joint was evaluated using a 5-point scale: 0° to 15°, 1 point; 16° to 35°, 2 points; 36° to 55°, 3 points; 56° to 75°, 4 points; and >75°, 5 points.

The American Orthopaedic Foot and Ankle Society (AOFAS) scoring system scale, ranging from 0 to 100 points, was also calculated preoperatively and after 1 year postoperatively. The scoring system includes both subjective and objective factors, such as pain, functional capacity, and hallux alignment (32).

The degree of the patient satisfaction with their foot cosmesis and the location and degree of metatarsalgia were also scored using a 5-point scoring system (Table 1) (9,29). The sesamoid position was determined on anteroposterior radiographs obtained from the patient in the standing position according to the relationship between the axis of the first metatarsal and the sesamoids (Table 1) (29).

Shortening of the first metatarsal was expressed in millimeters. To measure the relative first metatarsal length, a line from the distal-most portions of the first and third metatarsal heads was drawn. The distance from this line as it crossed the second metatarsal shaft to the most distal portion of the second metatarsal head was used to evaluate first metatarsal shortening as related to the second metatarsal length. This method was developed to determine whether the rotational correction of the first metatarsal altered the measured shortening relative to the second and third metatarsals (Fig. 6) (6).

Fig. 3. Anteroposterior fluoroscopic image showing fixation with 4-mm headless screw of the proximal and distal fragments.

Fig. 4. Anteroposterior radiograph of 37-year-old female patient's foot while standing at postoperative day 15.

Absolute shortening of the first metatarsal was evaluated by measuring the distance from the subchondral bone at the proximal articular surface to the subchondral bone distally at the first and second metatarsal heads (Fig. 7). The difference in the lengths measured (second metatarsal length minus the first metatarsal length) from the preoperative to the postoperative radiographs was determined as the absolute amount of shortening. In all cases, the measurements were taken over the lines drawn to evaluating the IMA to reduce variability. This method was used such that shortening was assessed relative to another metatarsal to minimize any magnification error (6).

Plantar displacement of the distal first metatarsal was determined using the method described by Tóth et al (29) and expressed in millimeters. Lateral displacement of the distal first metatarsal is the range of lateralization of the metatarsal distal to the osteotomy. It was calculated as the ratio of the distance between the lateral sides of the distal and proximal metatarsals to the distal mediolateral length of the proximal metatarsal and expressed as a percentage (Fig. 8).

Statistical Analysis

The study data were summarized using descriptive statistics (mean, range, and standard deviation for continuous variables and frequency and percentage for categorical variables). The categorical variables were compared using the χ^2 or Fisher exact test. To compare the continuous variables of the 2 groups, the Student *t* test and Mann-Whitney *U* test was used for normally or not normally distributed data, respectively. To compare the paired data from 2 groups, the paired sample *t* test or Wilcoxon signed

Fig. 5. Lateral radiograph of 37-year-old female patient's foot standing at postoperative day 15. *Arrow* indicates plantar displacement of the distal metatarsal fragment.

Table 1
Scores for patient satisfaction, degree of metatarsalgia, and sesamoid position

Patient Satisfaction Scoring System (9)	Degree of Metatarsalgia (29)	Sesamoid Position (29)
1, Poor	1, Very severe pain	1, Normal, with the axis of first metatarsal between the 2 sesamoids
2, Satisfactory	2, Severe pain	2, Lateral part of the medial sesamoid is in contact with the axis of the first metatarsal
3, Good	3, Moderate pain	3, Axis of the first metatarsal halves the medial sesamoid
4, Very good	4, Mild pain	4, Medial part of the medial sesamoid is still in contact with the axis of the first metatarsal
5, Excellent	5, Pain free	5, Medial sesamoid is laterally beyond the axis of the first metatarsal

rank test was used for the normally and not normally distributed data, respectively. For comparisons of >2 groups, the Friedman test, followed by post hoc analysis with the Mann-Whitney *U* test for significant results, was performed. Spearman's correlation analysis was used to evaluate the correlation between displacement or shortening of the first metatarsal caused by the osteotomy and the development of metatarsalgia and patient satisfaction.

The statistical level of significance was set to $p < .05$. Bonferroni's correction was used to adjust the *p* value for the post hoc multiple comparisons ($p = .05$/number of comparisons). Statistical analysis was performed using MedCalc Software, version 12.7.7 (MedCalc Software bvba, Ostend, Belgium).

Results

Study Groups

A total of 61 patients (31 who underwent the chevron osteotomy and 30 who underwent the DOM osteotomy) were included in the present study. The chevron osteotomy and DOM osteotomy groups were similar in terms of age, gender, hospitalization, and follow-up duration (Table 2). The mean follow-up period was 45.5 (range 12 to 72) months in the chevron group and 43.3 (range 12 to 56) months in the DOM group.

Clinical and Radiologic Efficacy of the Chevron and DOM Osteotomies

In both the chevron osteotomy and the DOM osteotomy groups, the HVA, IMA, distal metatarsal articular angle, and sesamoid position scores decreased and the AOFAS scores increased significantly after surgery (Table 3). However, no significant difference was found between the preoperative and postoperative values of the first MTP joint ROM ($p = .734$) in the chevron and DOM groups ($p = .734$ and $p = .125$, respectively). No significant differences were found between the chevron osteotomy and DOM osteotomy groups for any of these variables.

The incidence of postoperative metatarsalgia, which was defined as a metatarsalgia score of 1 to 4, was similar in the chevron and DOM groups for the second ray (19.4% versus 20.0%; $p = .808$), third ray (16.1% versus 16.7%; $p = .523$), fourth ray (9.7% versus 10.0%; $p = 1.00$), and fifth ray (9.7% versus 6.7%; $p = 1.00$). The metatarsalgia score, lateral displacement of the first metatarsal, and patient satisfaction did not show any differences between the 2 study groups. In contrast, plantar displacement, absolute and relative shortening of the first metatarsal, and postoperative ROM of the first MTP joint were

Fig. 6. Measurement of the relative first metatarsal length: the distance *(red line, point A to point B,* in millimeters) from the line between the distal-most portions of the first and third metatarsal heads *(blue line)* to the most distal portion of the second metatarsal head.

Fig. 7. Measurement of the first and second metatarsal lengths: the distance *(black lines,* in millimeters) from the subchondral bone at the proximal articular surface to the subchondral bone distally at the first and second metatarsal heads.

Fig. 8. Measurement of the lateral displacement of the distal first metatarsal. It was calculated as the ratio of the distance between the lateral sides of the distal and proximal metatarsals *(point A to point C)* to the distal mediolateral length of the proximal metatarsal *(point A to point B)*, expressed as a percentage.

significantly greater in the DOM osteotomy group than in the chevron osteotomy group (Table 3).

Complications of Chevron and DOM Osteotomy

No differences were found between the chevron and DOM groups in terms of complication rates. Only 2 complication (6.5%) in the chevron osteotomy group and 1 complication (3.3%) in the DOM osteotomy group were recorded ($p = 1.00$). One patient in each group developed a superficial soft tissue infection, which healed with debridement and antibiotic treatment. In the chevron group, 1 patient experienced asymptomatic delayed union, with union complete at 4.5 months.

No fixed mallet toe deformity (requiring surgery) was found during the follow-up period. At the final follow-up examination, no patient in either group had evidence of hallux varus, nonunion, or osteonecrosis.

Table 2
Demographic and clinical patient characteristics

Characteristic	Chevron Osteotomy (n = 31)	DOM Osteotomy (n = 30)	*p* Value*
Gender (n)			.849
Female	21	21	
Male	10	9	
Age (yr)			.275
Mean ± standard deviation	41.8 ± 9.1	40.4 ± 6.7	
Range	21 to 55	29 to 52	
Hospitalization duration (days)			.789
Mean ± standard deviation	1.4 ± 0.6	1.3 ± 0.5	
Range	1 to 3	1 to 3	
Follow-up duration (mo)			.390
Mean ± standard deviation	45.4 ± 13.2	43.3 ± 9.2	
Range	12 to 72	12 to 56	

Abbreviation: DOM, distal oblique metatarsal.
* Mann-Whitney *U* test.

Correlation Between Clinical and Radiologic Data

The shortening (absolute or relative) or displacement (plantar or lateral) of the first metatarsal did not correlate with second to fifth ray metatarsalgia or patient satisfaction after the osteotomies (Table 4). In contrast, changes in the HVA correlated negatively with the absolute and relative shortening in both the chevron ($r = -0.839$, $p < .001$ and $r = -0.867$, $p < .001$, respectively) and the DOM ($r = -0.881$, $p < .001$ and $r = -0.678$, $p < .001$, respectively; Table 4) groups.

A negative correlation was found between the alterations in the HVA and lateral displacement alterations in both techniques (chevron group, $r = -0.386$, $p = .032$; DOM group, $r = -0.636$, $p < .001$). However, no correlation was found between the HVA and plantar displacement alterations.

In both groups, the sesamoid position alteration did not correlate significantly with metatarsalgia, shortening (relative or absolute) or displacement (plantar or lateral) of the first metatarsal, alterations in the AOFAS score, or patient satisfaction (Table 4). Similarly, the MTP joint ROM alteration did not correlate significantly with metatarsalgia, shortening (relative or absolute), or displacement (plantar or lateral) of the first metatarsal (Table 4).

A statistically significant positive correlation was found between lateral displacement and shortening (relative or absolute) (chevron group, $r = 0.426$, $p = .022$ and $r = 0.411$, $p = .022$; DOM group, $r = 0.580$, $p = .001$ and $r = 0.718$, $p < .001$, respectively). However, no correlation was detected with plantar displacement.

Discussion

The aim of the surgical treatment of hallux valgus is to correct the deformity and improve patient symptoms with few to no complications (9). Although >100 operative techniques have been suggested for hallux valgus deformity, no consensus has yet been reached for any of the techniques. Thus, many approaches are available to correct hallux valgus, and largescale comparative studies are still needed (9,14).

Transfer metatarsalgia, which is pain around the MTP joints, is a common complication of hallux valgus surgery and has multifactorial etiology. Its rate and severity change with the osteotomy technique applied and the experience of the surgical team (33,34). Some studies have reported that first metatarsal shortening causes transfer metatarsalgia, which can be decreased by displacing the distal fragment in a plantar direction (8,35–38).

In the present study, we reported a modified osteotomy technique for the treatment of mild to moderate hallux valgus deformity: DOM osteotomy, which is parallel to the articulation surface of the proximal phalanx, and is a modification of the Wilson osteotomy (6,27–38). In our technique, we modified the Wilson osteotomy by decreasing the surgical angle to the metatarsal shaft to obtain minimum shortening of the first metatarsal and, thus, a lower incidence of metatarsalgia. Yildirim et al (39) reported a positive correlation between the first metatarsal distal osteotomy angle increment and first metatarsal shortening in their study. We compared the outcomes of our technique with that of the modified chevron osteotomy, which theoretically produces minimal shortening.

Table 3
Clinical and radiologic efficacy of chevron and distal oblique metatarsal osteotomies

Variable	Chevron Osteotomy (n = 31)	DOM Osteotomy (n = 30)	*p* Value[*]
HVA (°)			
Preoperative	34.7 ± 3.4 (24 to 39)	33.4 ± 3.3 (25 to 40)	.092
3-wk Postoperative	8.4 ± 0.9 (7 to 10)	8.5 ± 0.9 (7 to 11)	.945
Last postoperative follow-up	9.9 ± 1.1 (8 to 12)	9.6 ± 1.0 (8 to 12)	.304
p Value[†]	<.001[‡,§]	<.001[‡,§]	
IMA (°)			
Preoperative	12.3 ± 1.1 (11 to 15)	12.7 ± 1.3 (10 to 15)	.094
3-wk Postoperative	5.7 ± 0.7 (5 to 7)	5.7 ± 0.7 (5 to 7)	.776
Last postoperative follow-up	6.8 ± 0.7 (6 to 8)	6.7 ± 0.8 (5 to 8)	.408
p Value[†]	<.001[‡,§]	<.001[‡,§]	
DMMA (°)			
Preoperatively	15.5 ± 2.8 (10 to 22)	14.3 ± 2.2 (10 to 21)	.076
Postoperatively	7.4 ± 1.4 (5 to 10)	6.9 ± 1.4 (5 to 9)	.187
p Value[§]	<.001[§]	<.001[§]	
Sesamoid position (1 to 5)			
Preoperatively	4.4 ± 0.5 (4 to 5)	4.3 ± 0.5 (4 to 5)	.478
Postoperatively	1.3 ± 0.5 (1 to 2)	1.3 ± 0.5 (1 to 2)	.929
p Value[§]	<.001[§]	<.001[§]	
First MTP joint ROM (1 to 5)			
Preoperative	4.6 ± 0.5 (4 to 5)	4.7 ± 0.5 (4 to 5)	.665
Postoperative	4.6 ± 0.4 (4 to 5)	4.8 ± 0.4 (4 to 5)	.017
p Value[‖]	.734	.125	
AOFAS score (0 to 100)			
Preoperatively	76.1 ± 5.7 (63 to 85)	76.0 ± 5.5 (63 to 86)	.688
Postoperatively	92.9 ± 4.1 (80 to 95)	93.9 ± 4.5 (80 to 99)	.155
p Value[‖]	<.001[§]	<.001[§]	
Metatarsalgia (1 to 5)			
Second ray	4.6 ± 0.9 (2 to 5)	4.7 ± 0.7 (2 to 5)	.950
Third ray	4.7 ± 0.6 (3 to 5)	4.8 ± 0.5 (3 to 5)	.955
Fourth ray	4.9 ± 0.4 (3 to 5)	4.9 ± 0.3 (4 to 5)	1.00
Fifth ray	4.9 ± 0.30 (4 to 5)	4.9 ± 0.3 (4 to 5)	.671
p Value[†]	.001[¶]	.004[#]	
Lateral displacement of first metatarsal (%)	30.7 ± 3.6 (25 to 40)	31.6 ± 2.8 (27 to 38)	.267[**]
Plantar displacement of first metatarsal (mm)	0.1 ± 0.1 (0.1 to 0.4)	1.0 ± 0.1 (0.5 to 2.1)	<.001[§]
Absolute shortening of first metatarsal (mm)	1.0 ± 0.4 (0.4 to 1.2)	6.8 ± 1.0 (5.2 to 8.2)	<.001[§]
Relative shortening of first metatarsal (mm)	0.5 ± 0.4 (0.2 to 1.0)	3.1 ± 0.5 (2.3 to 3.9)	<.001[§]
Patient satisfaction (1 to 5)	4.6 ± 0.6 (3 to 5)	4.6 ± 0.7 (3 to 5)	.753

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society; DMMA, distal metatarsal articular angle; DOM, distal oblique metatarsal; HVA, hallux valgus angle; IMA, intermetatarsal angle; MTP, metatarsophalangeal.
Data are presented as mean ± standard deviation (range).
* Mann-Whitney *U* test.
† Friedman test.
‡ $p < .001$ for preoperatively versus 3 weeks postoperatively, preoperatively versus last postoperative follow-up examination, and 3 weeks postoperatively versus last postoperative follow-up examination (Wilcoxon signed rank test); statistical significance level was set to .017 ($p = .05/3$) after Bonferroni correction.
§ Statistically significant.
‖ Wilcoxon signed rank test.
¶ $p = .046$ for second versus third, $p = .023$ for second versus fourth, $p = .024$ for second versus fifth, $p = .046$ for third versus fourth, $p = .025$ for third versus fifth, and $p = .317$ for fourth versus fifth (Wilcoxon signed rank test); statistical significance level was set to .0083 ($p = .05/6$) after Bonferroni correction.
# $p = .083$ for second versus third, $p = .034$ for second versus fourth, $p = .020$ for second versus fifth, $p = .083$ for third versus fourth, $p = .046$ for third versus fifth, and $p = .317$ for fourth versus fifth (Wilcoxon signed rank test); statistical significance level was set to .0083 ($p = .05/6$) after Bonferroni correction.
** Student's *t* test.

The modified chevron osteotomy is an effective procedure for correcting hallux valgus deformity and sesamoid bone position and is commonly applied in orthopedic clinics (4,13,16,17,19,22,40). Mann and Donatto (26) reported distal chevron osteotomy as an effective technique for correction, cosmesis, and function in 23 mild and moderate hallux valgus feet. In 4 of these patients, avascular necrosis of the metatarsal head without collapse and a 22% incidence of arthrofibrosis were detected. Bai et al (22) reported that distal chevron osteotomy combined with distal soft tissue release is an effective technique that provides low complication rates and high patient satisfaction in those with mild and moderate hallux valgus. In their study, Lee et al (40) compared the patients who had and had not received distal lateral soft tissue release with distal chevron osteotomy. Although no statistically significant difference was found between the 2 groups in surgical correction or AOFAS scores, the postoperative ROM restriction was greater in the lateral soft tissue release group (40). Similarly, in our study, distal chevron osteotomy without distal soft tissue release was an effective technique with significant surgical correction, sesamoid bone position correction, high patient satisfaction, and AOFAS scores, without first MTP ROM restriction.

A large number of studies have compared distal metatarsal chevron osteotomy (horizontally directed 60° V-osteotomy modification) (13) with other distal metatarsal osteotomies (10,16,17,41–43). In a comparative study, Saro et al (10) suggested that patients who underwent a Lindgren-Turan osteotomy showed clinical outcomes similar to those who underwent the chevron osteotomy but better radiographic correction. In a study by Lambers Heerspink et al (16), although, radiologically, the correction was better with the Mitchell osteotomy than with the modified chevron osteotomy for mild and moderate hallux valgus, the shortening of the first metatarsal was greater with the Mitchell osteotomy. However, no statistically significant difference was detected in patient satisfaction or the incidence of metatarsalgia (16). In a study by Kinnard and Gordon (42), no

Table 4
Spearman's correlation coefficient, *r* (*p* value), for correlation between first metatarsal shortening/displacement and metatarsalgia and patient satisfaction

Variable	Study Group	Displacement and Shortening of First Metatarsal After Osteotomy			
		Plantar Displacement	Lateral Displacement	Absolute Shortening	Relative Shortening
Second ray metatarsalgia	Total	0.043 (.740)	0.128 (.326)	−0.065 (.620)	−0.037 (.777)
	Chevron	0.116 (.534)	0.186 (.317)	−0.110 (.557)	−0.091 (.627)
	DOM	−0.013 (.849)	0.049 (.798)	−0.178 (.346)	−0.087 (.646)
Third ray metatarsalgia	Total	0.037 (.775)	0.028 (.833)	−0.105 (.420)	−0.070 (.594)
	Chevron	0.123 (.509)	0.077 (.681)	−0.151 (.418)	−0.210 (.256)
	DOM	−0.036 (.849)	−0.055 (.773)	−0.304 (.102)	−0.091 (.631)
Fourth ray metatarsalgia	Total	0.010 (.942)	−0.027 (.836)	−0.072 (.582)	−0.069 (.599)
	Chevron	0.019 (.918)	0.071 (.704)	−0.034 (0.855)	−0.158 (.395)
	DOM	−0.007 (.972)	−0.175 (.356)	−0.264 (0.159)	−0.116 (.542)
Fifth ray metatarsalgia	Total	0.045 (.731)	−0.002 (.990)	0.007 (0.959)	−0.015 (.907)
	Chevron	0.019 (.918)	0.080 (.670)	−0.037 (0.844)	−0.153 (.410)
	DOM	−0.057 (.766)	−0.171 (.366)	−0.139 (0.463)	−0.093 (.626)
Patient satisfaction	Total	0.019 (.885)	−0.074 (.570)	−0.144 (0.269)	−0.170 (.190)
	Chevron	−0.210 (.258)	−0.023 (.902)	−0.267 (0.218)	−0.366 (.088)
	DOM	0.163 (.390)	−0.190 (.313)	−0.245 (0.191)	−0.341 (.065)
Alteration in HVA	Chevron	−0.018 (.923)	−0.386 (.032)	−0.839 (<0.001)	−0.867 (<.001)
	DOM	0.119 (.531)	−0.636 (<.001)	−0.881 (<0.001)	−0.678 (<.001)
Alteration in IMA	Chevron	0.125 (.504)	0.067 (.712)	−0.037 (0.844)	0.150 (.422)
	DOM	0.307 (.099)	−0.071 (.708)	−0.122 (0.521)	−0.053 (.780)
Alteration in AOFAS score	Chevron	0.146 (.432)	0.273 (.138)	0.171 (0.358)	0.387 (.142)
	DOM	−0.040 (.835)	0.221 (.240)	0.269 (0.151)	0.258 (.168)
First MTP joint ROM	Chevron	−0.189 (.309)	0.302 (.101)	0.204 (0.271)	0.305 (.096)
	DOM	0.005 (.977)	0.135 (.476)	0.021 (0.904)	0.021 (.913)
Sesamoid alteration	Chevron	0.181 (.331)	−0.153 (.411)	−0.264 (0.144)	−0.291 (.230)
	DOM	0.068 (.720)	−0.195 (.302)	−0.011 (0.952)	−0.021 (.912)

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society; DOM, distal oblique metatarsal; HVA, hallux valgus angle; IMA, intermetatarsal angle; MTP, metatarsophalangeal; ROM, range of motion.

statistically significant differences were found between the modified chevron osteotomy and Mitchell osteotomy for deformity correction, first metatarsal shortening, or patient satisfaction. In another study, Radwan and Mansour (17) described an alternative percutaneous transverse distal osteotomy for mild and moderate hallux valgus and reported greater patient satisfaction than with the distal chevron osteotomy. Lechler et al (43) compared combined distal chevron-Akin osteotomy with only chevron osteotomy for mild and moderate hallux valgus. Although similar correction was provided by both techniques, patient satisfaction was greater and hallux valgus deformity correction more effective in the combined group. In our study, no statistically significant differences were found between the 2 groups in terms of deformity correction, lateral displacement, sesamoid bone position correction, AOFAS scores, and patient satisfaction.

In some studies, decreased transfer metatarsalgia rates were achieved by preserving the length of the first metatarsal (4,9,33). Therefore, the osteotomy should aim to decrease the hallux valgus angle with minimum shortening of the first metatarsal. Nevertheless, even in osteotomies that are perpendicular to the first metatarsal longitudinal axis and shortening is not expected, shortening does occur rather frequently (26,44,45). However, the exact amount of shortening that causes metatarsalgia is not known. In contrast, in some studies, displacement of the distal part of the metatarsal in a plantar direction has been advocated for decreasing the occurrence of metatarsalgia (33,46,47). Repositioning of the sesamoid bones plays an important role in restoration of the weightbearing capacity of the first metatarsal (8,13,33,47). Although it was reported that the shortening is minimal with distal chevron osteotomy, the shortening was 2.0 to 4.4 mm in some cases (16,26,44,48,49). Mann and Donatto (26) reported a 96% patient satisfaction rate and 2-mm shortening of the first metatarsal in patients treated with the distal chevron osteotomy. Shortening of the first metatarsal was 3.0 to 7.0 mm with the Mitchell osteotomy (1,46). Tóth et al (29) applied the Wilson osteotomy as modified by Lindgren and Turan in 240 patients with hallux valgus deformity and reported shortening of the first metatarsal of 3.8 mm. Additionally, they reported that the increment of first metatarsal shortening was related to the increment of metatarsalgia risk and decreased patient satisfaction rates. Tóth et al (9) analyzed the relationship between the length of the first metatarsal and postoperative metatarsalgia retrospectively in 87 cases after the Wu subcapital cross osteotomy. In their study, a negative correlation was found between lengthening of the first metatarsal and the occurrence of metatarsalgia at rays 2 and 3, because changes in the HVA correlated positively with the level of patient satisfaction with the foot cosmesis (9). In the study by Lambers Heerspink et al (16), the mean shortening was 4.4 mm with the modified chevron osteotomy and 6.6 mm with the Mitchell osteotomy in those with mild and moderate hallux valgus. No statistically significant difference was detected in the metatarsalgia rates of the patients. However, the mean shortening value was 9.6 mm in patients with metatarsalgia and 6.8 mm in patients without metatarsalgia. In our study, the mean absolute metatarsal shortening was 1 mm and 6.8 mm and the relative metatarsal shortening was 0.5 mm and 3.1 mm for the chevron and DOM osteotomies, respectively. We found no correlation between shortening (absolute or relative) or displacement of the distal fragment (plantar or lateral) of the first metatarsal, alterations in sesamoid bone position, MTP joint ROM, alterations in AOFAS scores, second to fifth ray metatarsalgia, and patient satisfaction after both chevron and DOM osteotomies. In our study, the low rate of metatarsalgia and high patient satisfaction resulted from different reasons in the chevron and DOM osteotomies. We speculate that the reason for not finding any correlations, unlike other studies, was the limited shortening in the chevron group and plantar displacement of the distal fragment of the first metatarsal in the DOM group. We believe that the sagittal saw blade-related bone loss caused the shortening of the first metatarsal in the chevron osteotomy.

In the prospective randomized study by Klosok et al (38), the distal chevron and Wilson osteotomies were compared. The mean shortening was 10 mm for the Wilson osteotomy and 6 mm for the distal chevron osteotomy. No significant correlation was seen between the amount of shortening and the metatarsalgia rates due to displacement of the distal fragment of the first metatarsal in the Wilson osteotomy. Additionally, in the Wilson osteotomy group, the increase in ROM at the first MTP joint caused shortening in the first metatarsal (38). Their results led us to believe that the shortening of the first metatarsal in the DOM osteotomy group might have caused the ROM increase in the first MTP joint.

In the study by Yildirim et al (39), the correlation between shortening of the first metatarsal and alterations in the HVA was statistically significant in the distal oblique metatarsal osteotomy (mean angle 22.5°, range 10° to 34°). However, the correlation with lateral displacement was not statistically significant. In our study, the absolute and relative shortening and alteration in HVA correlated with the lateral displacement in both groups.

The major limitation of the present study was its retrospective design and small sample size, resulting in a high type 2 statistical error rate, which precluded us from reaching more definitive conclusions. Larger series with the suggested osteotomy technique are needed to show its benefit compared with chevron osteotomy for hallux valgus. Another limitation was that no randomization was performed, because the 2 distinct surgical techniques were performed according to the subjective preferences of 2 different surgeons. The wide age interval of the patients and nonblinded clinical and radiologic evaluations were additional limitations of the study.

In conclusion, the DOM osteotomy is an oblique osteotomy that is parallel to the proximal surface of proximal phalanx and causes shortening at the first metatarsal. However, this technique provides plantar displacement of the distal fragment of the first metatarsal to compensate for shortening of the metatarsal. Although the DOM osteotomy results in greater absolute and relative shortening and plantar displacement of the first metatarsal than does the chevron osteotomy, these changes were not related to the occurrence of postoperative metatarsalgia and patient satisfaction. The DOM osteotomy, which is a modification of the Wilson technique, is an alternative surgical technique for mild and moderate hallux valgus. The shortening and displacement of the first metatarsal resulting from the DOM osteotomy requires further, largescale, comparative studies to draw a final conclusion regarding the advantages or disadvantages of this technique compared with other osteotomies.

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