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ORIGINAL ARTICLE

Double osteotomy in recurrence cases with distal metatarsal articular angle increase after hallux valgus distal surgery

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ABSTRACT

Objectives: The aim of this study was to evaluate the clinical and radiological results of the combined use of distal closed wedge and proximal open wedge osteotomies in cases of recurrent hallux valgus (HV) with an increased distal metatarsal articular angle (DMAA).

Patients and methods: Between January 2019 and December 2022, a total of 10 female patients (mean age: 48.8±10.8 years; range, 28 to 63 years) who underwent surgical treatment for recurrent HV with an increased DMAA were retrospectively analyzed. Pre- and postoperative anterior-posterior and lateral radiographs of the patients were taken. The intermetatarsal angle (IMA), DMAA, and HV angle (HVA) were measured and compared before and after surgery. The clinical outcomes of the patients were evaluated using the American Orthopaedic Foot & Ankle Society (AOFAS) score, Manchester-Oxford Foot Questionnaire (MOXFQ) score, and Maryland Foot Score (MARYLAND).

Results: The median follow-up was 33.1 (range, 24 to 78) months. Seven (70%) of the patients underwent surgery on the right side and three (30%) of the patients underwent surgery on the left side. The median time to recovery of osteotomies was 8 (range, 6 to 10) weeks. There was no loss of correction at minimal two years of follow-up. None of the patients developed postoperative infections. The postoperative HVA, IMA, DMAA values of the patients were statistically significantly lower than the preoperative values ($p<0.05$). The AOFAS and MARYLAND scores of the patients at six and 24 months after surgery were statistically significantly higher compared to the baseline ($p<0.05$). Considering the MOXFQ scores, the scores at six months and 24 months after surgery were statistically significantly lower than the scores before surgery ($p=0.005$ for both). Similarly, MOXFQ scores at 24 months after surgery were statistically significantly lower than those at six months ($p=0.013$), indicating that the clinical improvement obtained at six months continued to increase until 24 months.

Conclusion: The combination of distal closed wedge and proximal open wedge osteotomies for HV recurrence seems to be an effective surgical technique for correction of the deformity. Plate and screw fixation can increase the rate of bone union and accelerate postoperative mobilization of the patients. Further large-scale, long-term studies are needed to provide more comprehensive findings on the effectiveness of HV surgery and elucidate the effects of postoperative rehabilitation processes on recovery in order to optimize the treatment protocols.

Keywords: Distal metatarsal articular angle, double osteotomy, hallux valgus, revision.

Hallux valgus (HV) is one of common deformities of the forefoot and may result in severe pain, forefoot deformity, and impaired quality of life.[1] The etiology is not known exactly. In the literature, wearing narrow shoes, hindfoot pronation, pes planus, Achilles contracture, the first metatarsocuboid joint hypermobility, neuromuscular diseases, female sex, and familial genetic factors have been reported to be effective in the development of the deformity.[2,3] Although HV causes pain in patients, less frequently it may lead to balance disorders and increased risk of falls in elderly individuals.[4] It affects approximately 23% of adults between the ages of 18 and 65 and is 15 times more common in women than in men.[5,6] Patients with mild deformities are usually managed conservatively, whereas patients with symptomatic moderate to severe deformities

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require surgical intervention. Although more than 130 surgical techniques have been described in the literature, no surgical technique has been proven to be significantly superior to other techniques.[7]

The main goal of HV surgery is to anatomically correct the existing deformity, eliminate the pain complaints of the patients and prevent future recurrences. The most common complication of HV surgery is recurrence, followed by complications such as infection and hallux varus. The etiology of recurrence is not fully understood; however, anatomical factors, the type of shoe worn, patient compliance after the first surgery and factors related to surgical technique are thought to be effective in the development of recurrence.[8,9] In the diagnosis of HV recurrence, the reappearance of the deformity, the patient having chronic pain and worsening of the outcome scores are among the important indicators.[10]

In the present study, we hypothesized that, in recurrent HV cases with an increased distal metatarsal articular angle (DMAA), correction of the DMAA could be achieved through a distal closed wedge osteotomy, and the resected wedge could be utilized to perform a simultaneous proximal open wedge osteotomy to correct the recurrent deformity and this combined approach would provide the patient with a well-aligned, pain-free great toe, enabling comfortable ambulation without any difficulty. We, therefore, aimed to evaluate the clinical and radiological results of the combined use of distal closed wedge and proximal open wedge osteotomies in cases of recurrent HV.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Health Sciences University, Bakırkoy Dr Sadi Konuk Health Aplication and Reseach Center, Department of Orthopedics and Traumatology between January 2019 and December 2022. Patients between the age of 18 and 65 years who underwent surgical treatment for recurrent HV were evaluated. Inclusion criteria were as follows: prior distal osteotomy for HV; increased DMAA (>10°) and increased HVA (>20°); and persistent pain and discomfort during walking. Exclusion criteria were as follows: follow-up time shorter than two years; any surgeries for HV besides distal osteotomy; any foot and ankle surgeries besides HV; traumatic cases; and revision HV cases without DMAA increase. Finally, a total of 10 female patients (mean age: 48.8±10.8 years; range, 28 to 63 years) who were diagnosed with HV and met the inclusion criteria were recruited. A written informed consent was obtained from each patient. The study protocol was approved by the institutional review board (IRB) of the clinic where the study was conducted due to its retrospective design (date: 13.12.2024) The study was conducted in accordance with the principles of the Declaration of Helsinki.

Radiological evaluation

Pre- and postoperative bilateral anterior-posterior and lateral radiographs of the patients included in the study were taken. After evaluating the conformity of the images, intermetatarsal angle (IMA), DMAA and HV angle (HVA) were measured as described by Coughlin and Jones[2] and compared before and after surgery.

Clinical evaluation

Demographic data of the patients, smoking and comorbidities, which were thought to cause union problems at the osteotomy sites applied in their first surgery, were questioned. The preoperative and at six and 24 months postoperatively clinical outcomes of the patients were evaluated using the American Orthopaedic Foot & Ankle Society (AOFAS) score, Manchester-Oxford Foot Questionnaire (MOXFQ) score, and Maryland Foot Score (MARYLAND).[11-13]

Surgical procedure

Following standard anesthesia, sterilization, and draping procedures, a long incision of approximately 8 cm was made on the dorsomedial aspect of the metatarsal metatarsal and the folds were duly crossed (Figure 1). After performing a Y capsulotomy, the existing implant from the previous surgery was removed. Under the fluoroscopic guidance, a closed wedge osteotomy was performed distal to the first metatarsal and the DMAA was corrected. Fixation was achieved with one headless cannulated screw (Headless canulated compression screw, Tasarım Medical, İstanbul, Türkiye). Then, an open wedge osteotomy was performed proximal to the first metatarsal to address the existing valgus deformity. The wedge graft removed from the distal closed osteotomy was placed in the proximal open wedge osteotomy site and fixed with one mini-plate and screw (Mini plate screw fixation system, Deva Medical Instruments, İstanbul, Türkiye). After fluoroscopy and stability checks, bleeding was controlled and the folds were closed properly. A short leg splint was applied. The patients' short leg splint application was terminated after two weeks and the patients were followed with HV shoes till bony healing with weight-bearing as tolerated.

FIGURE 1. Images of a 26-year-old female patient. **(a)** AP and lateral radiographs taken before surgery. **(b)** Perop surgical images of the patient. Increased DMAA and dorsiflexion deformity after the first surgery are seen. **(c)** Early postop AP and Lateral images of the foot. **(d)** Sixth month control foot AP and lateral radiographs.
AP: Anterior-posterior; DMAA: Distal metatarsal articular angle.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 26.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. The normal distribution of numerical variables was evaluated using the Shapiro-Wilk test. The Friedman test and Dunn-Bonferroni *post-hoc* tests were used to analyze the data containing more than two repeated measurement scores that did not meet the normality assumption. The change between the means of two dependent measurements was analyzed with the Wilcoxon test. A p value of <0.05 was statistically significant.

RESULTS

The median follow-up was 33.1 (range, 24 to 78) months. Seven (70%) of the patients underwent surgery on the right side and three (30%) of the patients underwent surgery on the left side (Table I). The median time to recovery of osteotomies was

TABLE I
Demographic and clinical characteristics (n=10)

	n	%	Mean±SD	Median	Min-Max
Age (year)			48.8±10.8		28-63
Time after surgery (month)				33.1	24-78
Surgical aspect					
Right	7	70			
Left	3	30			
Smoking					
+	44	40			
–	6	60			

SD: Standard deviation.

TABLE II
Radiologic features (n=10)

	Preoperative		Postoperative	
	Mean±SD	Min-Max	Mean±SD	Min-Max
HVA	32.40±9.07	13-44	14.60±2.31	9-17
IMA	12.00±4.42	6-20	7.50±1.84	3-9
DMAA	19.30±5.98	8-28	9.70±1.16	7-11

HVA: Hallux valgus angle; IMA: Intermetatarsal angle; DMAA: Distal metatarsal articular angle.

TABLE III
Examination of the differences between preoperative and postoperative values of the related parameters

		Ranks	n	Mean rank	Sum of ranks	z	*p**
HVA	Preoperative-postoperative	Negative ranks	10	5.50	55.00	–2.807	**0.005**
		Positive ranks	0	0.00	0.00		
		Equal	0				
		Total	10				
IMA	Preoperative-postoperative	Negative ranks	7	5.00	35.00	–2.383	**0.017**
		Positive ranks	1	1.00	1.0		
		Equal	2				
		Total	10				
DMAA	Preoperative-postoperative	Negative ranks	10	5.50	55.00	–2.805	**0.005**
		Positive ranks	0	0.00	0.00		
		Equal	0				
		Total	10				

HVA: Hallux valgus angle; IMA: Intermetatarsal angle; DMAA: Distal metatarsal articular angle; Wilcoxon signed-rank test; * p<0.05.

8 (range, 6 to 10) weeks. There was no loss of correction at minimal two years of follow-up. None of the patients developed postoperative infections.

The pre- and postoperative HVA, IMA, and DMAA values of the patients are shown in Table II. The postoperative HVA, IMA, DMAA values of the patients were statistically significantly lower than the preoperative values (p<0.05) (Table III).

There was a statistically significant difference between the AOFAS, MARYLAND, and MOXFQ scores of the patients before surgery and at six and 24 months after surgery (p<0.05) (Table IV). The AOFAS and MARYLAND scores of the patients at six and 24 months after surgery were statistically significantly higher compared to the preoperative scores (p<0.05). However, there was no statistically significant difference between the scores at six months and 24 months after surgery (p=0.116 and p=0.051, respectively). Considering the MOXFQ scores, the scores at six months and 24 months after surgery were statistically significantly lower than the scores before surgery (p=0.005 for both). Similarly, MOXFQ scores at 24 months after surgery were statistically significantly lower than those at six months (p=0.013), indicating that the clinical improvement obtained at six months continued to increase until 24 months.

DISCUSSION

In the present study, we evaluated the radiological and clinical outcomes of cases of combined distal closed wedge and proximal open wedge osteotomies for recurrent HV cases. The clinical and radiological results showed a change with a significant improvement at six and 24 months during follow-up.

The most common complication after HV surgery is recurrence of the deformity. In a recent meta-analysis, the recurrence rate after HV surgery was found to be approximately one-fourth.[7] In the evaluation of HV recurrence, it is critical to detect

TABLE IV
Examination of preoperative and postoperative differences between AOFAS, MARYLAND and MOXFQ scores

	Measurement time point	Mean±SD	Median	25th-75th percentiles	Mean rank	χ^2	W	*p*	z	*p**
	Preoperative	49.40±19.8	44.00	36.00-65.50	1.10				–2.701	**0.007b**
AOFAS	Postoperative 6th month	90.40±13.2	95.00	84.25-100.0	2.20	14.889	0.744	**0.0005a**	–2.805	**0.005c**
	Postoperative 24th month	96.40±5.44	98.50	94.25-100.0	2.70				–1.572	0.116d
	Preoperative	45.70±14.47	43.50	38.00-48.75	1.00				–2.805	**0.005b**
MARYLAND	Postoperative 6th month	90.10±12.61	95.00	84.75-100.0	2.25	17.568	0.878	**0.0001a**	–2.807	**0.005c**
	Postoperative 24th month	96.10±4.72	98.50	91.50-100.0	2.75				–1.947	0.051d
	Preoperative	39.60±8.70	39.00	36.00-46.00	3.00				–2.807	**0.005b**
MOXFQ	Postoperative 6th month	10.00±7.71	6.50	5.75-13.25	1.90	18.200	0.910	**0.0001a**	–2.809	**0.005c**
	Postoperative 24th month	6.00±3.33	5.00	3.00-9.00	1.10				–2.489	**0.013d**

SD: Standard deviation; AOFAS: American Orthopaedic Foot & Ankle Society; MOXFQ: Manchester-Oxford Foot Questionnaire; MARYLAND: Maryland Foot Score a: Friedman test; b, c, d: Wilcoxon signed-rank test; b: Postoperative 6th month-preoperative; c: Postoperative 24th month-preoperative; d: Postoperative 24th month-postoperative 6th month; W: Kendall's W; * p<0.05.

the deformity on physical examination and imaging studies. In addition, the presence of pain in the first metatarsal head or adjacent metatarsals is the primary indication for revision surgery.[14] In the current study, surgical necessity was determined by evaluating the pain and functionality of the patients. Also, inadequate and inappropriate initial surgeries performed in HV and surgeries performed by surgeons without sufficient experience are critical factors in terms of recurrence.

Although HV recurrence is multifactorial, it has been shown to be associated with many potential factors such as preoperative HVA and IMA values and postoperative HVA and sesamoid position.[10] The main goal of surgery is to correct varus deviation of the metatarsal. However, it has been suggested that inadequate correction of metatarsal pronation as a result of inadequate evaluation may be at least partially responsible for some recurrence cases in patients with increased HVA or IMA.[15] Since HV occurs more frequently in the female population, some studies on recurrence have included only female patients.[16,17] Female sex is considered to be an important predisposing factor for the development of HV.[2,18] This study was performed in female patients who developed HV recurrence.

In 1993, Peterson and Newman[19] attempted to correct bunion deformity in 15 adolescent feet with proximal and distal osteotomy. According to the technique described, a bone fragment obtained from the distal closed wedge osteotomy was placed as a graft in the proximal open wedge osteotomy site, fixed with Kirschner wire (K-wire) and a short leg cast was applied. At the end of six weeks, they removed the cast and K-wire and applied a walking cast for a total of five weeks. In our study, we used the osteotomy described by Peterson and Newman[19] to correct the deformity, but we preferred plate and screw fixation for fixation to increase stability.[20] With the bone graft placed, it was aimed to increase the union rate and to obtain more satisfactory functional results in the earlier period[21] and complete union was observed in all patients. In our study, the splint period of the patients was determined as two weeks, as the fixation was more stable. By using a screw for distal osteotomy, and plate-screw for proximal osteotomy we avoided using a K-wire passing through interphalangeal and metatarsophlangeal joints without a second surgical intervention to remove K-wire. This situation enabled patients to mobilize earlier. Peterson and Newman[19] achieved a good correction by this technique, but they were all primary adolescent cases, and they could not point out the utilization of this technique for correcting increased DMAA with recurrent adult cases.

Review of the literature reveals a variety of definitions of HV recurrence. However, HVA ≥20 degrees is accepted as the threshold for diagnosing HV recurrence.[22,23] In our study, the median HVA value was 32.4 and all patients had symptoms leading to functional limitation. Of note, DMAA has been shown to be an important factor for HV recurrence. Inadequate DMAA correction or inadequate evaluation of DMAA/joint compatibility before surgery may eventually lead to recurrence.[24] The main goal of distal closed wedge osteotomy performed as described in the surgical procedure is to reduce DMAA and provide joint congruence. The normal value of DMAA is accepted as <10 degrees.[2] In the current study, the median DMAA was found to be 19.30 preoperatively and 9.70 postoperatively, indicating a statistically significant change before and after surgery.

In the conventional HV classification, HVA 20 to 40 and IMA 11 to 16 degrees indicate moderate deformity, while HVA >40 and IMA >16 degrees indicate severe deformity.[25] In cases with high IMA, it is commonly accepted to prefer proximal osteotomies. In addition to studies recommending proximal osteotomy in HV cases with IMA >15 and HVA >35 degrees, there are also studies indicating that proximal osteotomy should be performed in moderate-to-severe HV cases.[3,26] In this study, we attempted to obtain a stronger correction power by approaching the center of the deformity with proximal osteotomy. Radiographic measurements showed a significant improvement in HVA and IMA values before and after surgery.

Mathew et al.[27] performed similar double metatarsal osteotomy in 10 patients and reported that there was no residual deformity, excellent correction was achieved, and it was a reliable method that could be used safely in advanced HV cases. Compared to our cohort, the patient number is the same but with a shorter median follow-up period (13.4 months *vs.* 33.1 months). Similar to Peterson and Newman,[19] the authors could not address the use for increased DMAA and used a K-wire for fixation with aforementioned disadvantages.

In another study, Edmonds et al.[28] compared proximal single proximal single distal and double osteotomy in cases of juvenile HV and showed that double osteotomy provided a higher rate of DMAA correction compared to single osteotomy. In our study, we observed that the use of double osteotomy technique improved the deformity by providing a significant change in HVA IMA and DMAA and we did not detect any recurrence after two years of follow-up.

In the current study, a significant improvement was observed in the AOFAS and MARYLAND scores of the patients at six months after surgery compared to the preoperative period. However, no significant change was detected from the sixth to the 24th month after surgery. This finding indicates that clinical improvement reaches its maximum level within the first six months and, thus, the first six-month period plays a critical role in achieving clinical improvement. Previous studies support our findings and indicate that patients can reach the highest recovery levels in the first few months after surgery.[29] The fact that the recovery follows a stable course in the period after the first six months and the condition of the patients does not worsen emphasizes the effectiveness of the surgery and the sustainability of the general condition of the patients. This finding is of utmost importance for the long-term follow-up of patients in clinical practice.[30]

On the other hand, a significant improvement in MOXFQ scores was observed both at six months and 24 months after surgery compared to the baseline, and a significant improvement continued from six months to 24 months. Sustained significant improvements in the MOXFQ scores at 24 months indicate the long-term effects of surgery. This reveals that surgery is critical not only for short-term results, but also for long-term patient satisfaction.[31]

The main limitation to this study is its small sample size. In future studies, research with larger patient groups may increase the generalizability of the results and help to obtain more robust data. In addition, the patients were evaluated at the latest 24 months after surgery. However, studies with longer follow-up periods may provide more reliable information about its long-term effects and to better understand the recurrence and complication rates. The postoperative rehabilitation process after HV surgery may also affect the rate of recovery and complication rates. In future studies, the effects of different rehabilitation protocols can be studied. Future studies on quality of life and functional recovery after HV surgery are warranted to examine not only the physiological, but also the psychological and social effects of surgical treatment.

In conclusion, the combination of distal closed wedge and proximal open wedge osteotomies for HV recurrence seems to be an effective surgical technique for correction of the deformity. Plate and screw fixation can increase the rate of bone union and accelerate postoperative mobilization of the patients. Further large-scale, long-term studies are needed to provide more comprehensive findings on the effectiveness of HV surgery and elucidate the effects of postoperative rehabilitation processes on recovery in order to optimize the treatment protocols.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data, final approval of the version to be published: E.B., M.U.Ç., M.G.K.; Drafting the article or revising it critically for important intellectual content: E.B., M.U.Ç.

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