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Clinical Outcomes of Proximal Opening-Wedge Osteotomy and Distal Chevron Osteotomy in the Treatment of Moderate Hallux Valgus Deformity

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Abstract
Introduction: *Hallux valgus (HV) deformity is a condition with gradually increasing prevalence, often accompanied by cosmetic deformity. The change in pain and functional levels of patients after surgery directly affects the clinical outcomes in moderate hallux valgus deformities.*
Aim: *The aim of this study was to compare the clinical outcomes of proximal opening-wedge osteotomy and distal chevron osteotomy in the treatment of moderate hallux valgus deformity.*
Materials and Methods: *37 patients aged between 55 and 65, who were diagnosed with moderate hallux valgus deformity between March 2015 and December 2017 in Ankara Yıldırım Beyazit University Yenimahalle Training and Research Hospital were enrolled in this study. Patients who underwent proximal opening-wedge osteotomy (POWO) were assigned to Group 1 (n=19) and patients who underwent distal chevron osteotomy (DCO) were assigned to Group 2 (n=18). There was no difference between the groups in terms of age, duration of follow-up, demographic and radiological parameters. Visual Analogue Scale (VAS) and American Orthopedic Foot and Ankle Score (AOFAS) systems were used to compare the preoperative period with months 3, 6 and 12.*
Results: *There was a significant difference between the two groups in terms of VAS and AOFAS scores at months 3 and 6 in favor of Group 2 ($p<0.001$). According to the follow-up at month 12, the change in VAS ($p=0.518$) and AOFAS ($p=0.119$) measurements was not statistically significant for any of the groups. Both groups exhibited a statistically significant increase in the scores at months 3 and 6 as compared to the preoperative period.*
Conclusion: *Proximal opening-wedge osteotomy was found to be more effective than distal chevron osteotomy in terms of short-term pain and functional scores in the treatment of moderate hallux valgus deformity. On the other hand, it was seen in follow-ups that both methods alleviated pain and provided similar improvement from the functional aspect.*
Keywords: *Hallux valgus, distal osteotomy, proximal osteotomy.*

Introduction

Hallux valgus (HV) deformity is a progressive bone and soft tissue disorder with gradually increasing prevalence, accompanied by cosmetic problems and it negatively affects the daily activities and quality of life of the patients unless treated appropriately. The deformity manifests with subluxation of the first metatarsophalangeal joint due to medial deviation of the first metatarsal bone, the lateral deviation of the large toe and internal rotation of the large toe along the longitudinal axis[1,2]. As the deformity progresses, a relative bone protrusion called a "bunion" is observed in the medial aspect of the head of the first metatarsal bone. Patients also have coexisting soft tissue pain. Its etiology has not been clearly revealed yet and it is though that intrinsic and extrinsic factors play a role in its etiology[2,3].

The gold standard method to assess the severity of HV deformity, the treatment plan that will be implemented and the improvement status during follow-up is to measure the angle[4,5]. The measurement is carried out by determining the abduction angle of the first MTP joint from posterior-anterior X-rays of the foot (Hallux valgus angle – HVA)[6,7]. In addition, a radiologic measurement of the intermetatarsal angle (IMA) is frequently performed to determine the changes in the deformity[8]. As a result of the radiologic measurements, the deformity is then classified as mild, moderate and severe HV deformity[2, 3, 9]. Mild hallux valgus deformity is defined by an IMA equal to or less than 11 degrees and an HVA of less than 20 degrees. A moderate hallux valgus deformity is defined by an HVA of 20 to 40 degrees and a first IMA of less than 16 degrees, while a severe deformity is defined by an HVA of more than 40 degrees and a first IMA equal to or more than 16 degrees[3,10].

Numerous surgical methods have been described for the treatment of this deformity. Surgical techniques can be classified in general as soft tissue procedures, metatarsal and phalangeal osteotomies or combinations thereof. It is possible to divide the metatarsal procedures into two groups, i.e. distal and proximal osteotomies[11]. The hallux valgus angle, intermetatarsal angle, arthritis of the first metatarsophalangeal (MTP) joint, hypermobility of the first tarsometatarsal joint, position of sesamoids, musculo-tendinous balance, and congruity of the first metatarsophalangeal joint are among the considerations for technical choice[2,3,9]. Among distal osteotomies, DCO is commonly preferred for deformities of mild to moderate severity as it is a simple method[12-14]. However, it also has some disadvantages. It is possible to correct only a relatively small amount of deformity with this technique and it involves post-operative shortening of the first metatarsal with a risk of avascular necrosis of the metatarsal head[15-17]. Proximal osteotomies are commonly preferred in the treatment of moderate and severe hallux valgus deformities. As for the disadvantages of POWO, it may cause some metatarsal lengthening and require grafting as it leads to strain on the medial structures. Therefore, the risk of developing stiffness is high in this technique[18].

A lack of correlation between the angular severity of bone deformities and functional limitations or the actual complaints of the patient can be frequently observed. The current literature involves the use of the scale developed by the American Orthopedic Foot and Ankle Society (AOFAS) in order to determine the level of the functional problem[19].

In this study, it was aimed to compare the changes in the clinical outcomes in patients who underwent POWO and DCO throughout the follow-up period.

Materials and Methods

37 patients who fulfilled the inclusion criteria among 75 patients aged between 55 and 65, who were diagnosed with moderate hallux valgus deformity (HV angle 20 to 40 degrees, IMA < 16 degrees) and underwent an operation in the orthopedics and traumatology outpatient clinic of Ankara Yıldırım Beyazit University Yenimahalle Training and Research Hospital between March

2015 - December 2017 were enrolled in this study. The indications for surgery consisted of patient history, physical examination findings, forefoot pain, and progressive deformity. For the diagnosis of moderate hallux valgus deformity, the hallux valgus (HV) angle and 1-2 intermetatarsal angles (IMA) were measured from anterior and lateral weight-bearing foot radiographs during the preoperative and postoperative assessment. A single reviewer evaluated all radiographs. Surgery and follow-up dates, age, gender, body mass index and radiologic measurement findings were recorded for all patients from the follow-up forms filled out during the first examination.

37 patients who had moderate hallux valgus deformity were retrospectively evaluated. Patients who underwent proximal opening-wedge osteotomy (POWO) were assigned to Group 1 (n=19) and patients who underwent distal chevron osteotomy (DCO) were assigned to Group 2 (n=18). Visual Analogue Scale (VAS) and American Orthopedic Foot and Ankle Score (AOFAS) systems were used to compare the preoperative period with months 3, 6 and 12.

Patients who had signs of arthrosis of the metatarsophalangeal joint, rheumatoid arthritis or similar inflammatory arthritis, history of fractures and dislocation on the side of and aroundthe affected foot, and history of cancer; patients who were diagnosed with fibromyalgia or hallux rigidus; patients who were previously diagnosed with and received any treatment for HV and patients who were lost to follow-up throughout the study period were excluded from the study.

Surgical Technique

Considering the common surgical steps before the POWO and DCO procedures, 1 g IV cefazolin sodium was administered to the patients in both groups for prophylaxis before surgery. Patients were put under general or spinal anesthesia according to the anesthesiologist's recommendation. The surgeries were routinely performed by one surgeon (MA) using a pneumatic tourniquet and by placing the patients in supine position. A sterile surgical drape exposing the part under the knee and distal aspect thereof was placed on the lower limb in accordance with the orthopedic methods following proper surgical skin disinfection. A 5-6 cm long longitudinal incision was made extending from the base of the first metatarsal to the middle phalanx. Blunt dissection was carried down through the skin and subcutaneous tissues. The dissection was extended while preserving the dorsomedial cutaneous nerve. Then, a U-shaped opening facing the distal aspect was made on the joint capsule, and the first metatarsophalangeal joint was opened after dissection. The joint was examined in terms of degenerative changes. This was followed by removing the medial protrusion (bunion) using a motor saw on the same axis as the metatarsal medial cortex, starting from 1-2 mm medial to the sagittal sulcus.

Proximal Opening-Wedge Osteotomy

After completion of the common surgical steps, the periosteum was scraped up to the point 1 cm distal to the metatarsocuneiform joint on the base of the metatarsal bone. This was followed by creating a line by drilling the medial and superior aspect of the metatarsal bone using a 2.7 mm drill bit in order to determine the osteotomy line. Osteotomy was performed by joining the drill grooves using a motor saw while leaving the lateral cortex of the metatarsal bone intact. The osteotomy line was opened using an opener device while keeping the lateral cortex intact and the bone graft obtained from the medial protrusion was placed in the osteotomy line. Then, fixation was performed using locking screws and mini plates designed for proximal opening-wedge osteotomy and the operation was finished (Figure 1).

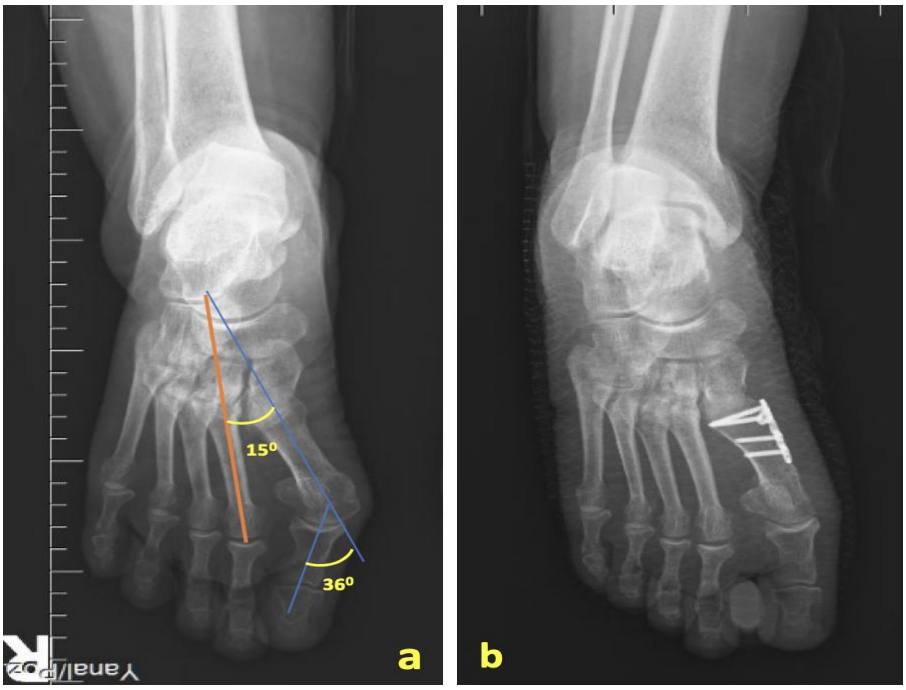

Figure 1: Pre-operativeradyologicalmeasurement of HVA and IMA (a), post-operative X-ray of POWO technique

Distal Chevron Osteotomy

After completion of the common surgical steps, a 60-degree V-shaped osteotomy line was marked using a surgical marking pen on the distal metatarsal medial area on which bunionectomy was applied. Then, complete osteotomy was carried outfrom the medial to the lateral aspect using a cutter driven by a motor. This was followed by manual lateral translation of the capital fragment without exceeding 50% of the width of the metatarsal head, and then compression and stabilization with two headless screws (Figure 2).

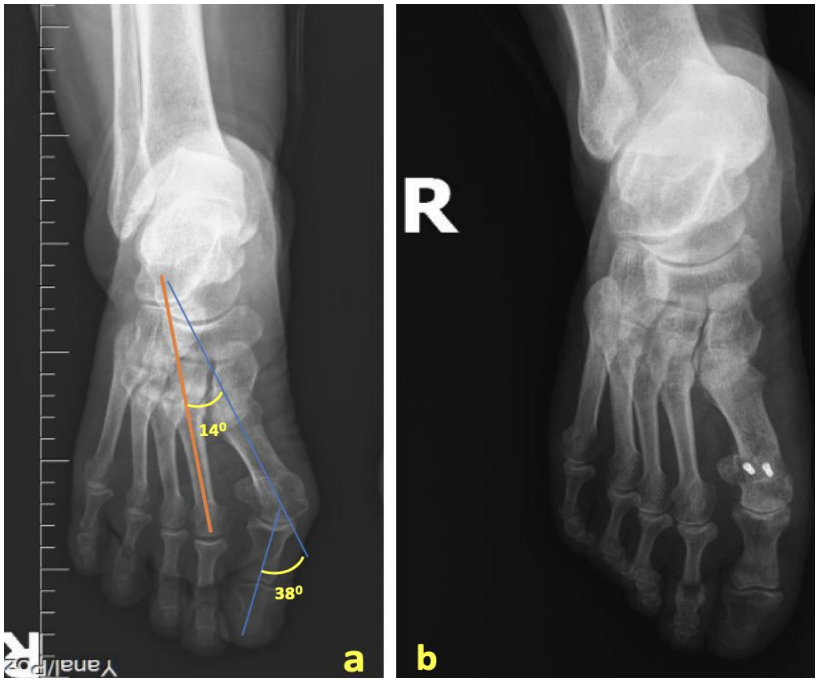

Figure 2: Pre-operativeradyologicalmeasurement of HVA and IMA (a), post-operative X-ray of DCO technique

A short leg cast was applied to the patients and weight bearing was not allowed until the end of week 2 following surgery in both patient groups. Then, the casts were removed and full weight bearing was allowed as tolerated by the patients.

Statistical Analysis

SPSS 17.0 software package was used in the statistical analysis of data. Categorical variables were summarized with numbers and percentages, whereas continuous variables were summarized with mean and standard deviation values (median and minimum-maximum, where necessary). Chi-square test was used in comparing the categorical variables. Distributions were analyzed in order to compare continuous variables between the groups, wherein Student's T test was used for variables with a parametric distribution and Mann Whitney U test for those without a parametric distribution. A p value of 0.05 was considered statistically significant for all tests.

Results

The mean age of the patients included in the study was 57.62±5.33 in Group 1 and 58.31±4.17 in Group 2. 68.42% (n=13) and 77.77% (n=14) of the patients were female in Group 1 and Group 2, respectively. It was found that the Body Mass Index (BMI) (kg/m^2) was 29.78±2.46 and 27.81±2.78 in Group 1 and Group 2, respectively. Demographic characteristics of the patients and distribution of these characteristics by groups are provided in Table 1.

Table 1: Demographic characteristics and distribution of the patients

	Group 1 (n=19)		Group 2 (n=18)		Total (n=37)		p
	n	%	n	%	n	%	
Gender							
Female	13	68,42	14	77,77	27	72,97	0,116
Male	6	31,57	4	22,22	10	27,02	
Age (Mean±SD)	57,62±5,33		58,31±4,17		57,96 ±4,75		0,194
BMI (kg/m2) (Mean±SD)	29,78±2,46		27,81±3,10		28,79±2,78		0,495

n: Number of patient , BMI: Body Mass Index, SD: Standard Deviation

Comparison of the functional scores between the two groups revealed that there was a statistically significant difference between the two groups in terms of VAS and AOFAS scores at months 3 and 6 in favor of Group 2 (POWO) ($p<0.001$). According to the follow-up at month 12, the change in VAS ($p=0.487$) and AOFAS ($p=0.605$) measurements was not statistically significant for any of the groups. Both groups exhibited a statistically significant increase in the scores at months 3 and 6 as compared to the preoperative period. The change in functional scores according to the follow-up periods is provided in a detailed manner in Tables 2 and 3. These tables indicate that the mean VAS score of the patients in Group 1 was 67.87±9.32 in the preoperative period, and30.08±11.12 at postoperative month 12. The same values were 65.13±7.90 and 28.53±7.11, respectively in Group 2. The mean AOFAS score in Group 1 was 43.22±9.74 in the preoperative period and 73.87±10.6 at postoperative month 12. The same values were 42.29±9.44 and 78.70±6.45, respectively in Group 2.

Table 2: Variation in Visual Analog Scale (VAS) scores and analysis between groups

Follow-up	Group 1 (Mean±SD)	Group 2 (Mean±SD)	Total (Mean±SD)	p
Preoperative	67,87±9,32	65,13±7,90	66,5±8,61	0,152
Postoperative 3 monthslater	42,28±6,92	25,83±9,39	34,05±8,15	**<0,001**
Postoperative 6 monthslater	38,18±8,09	21,31±5,88	29,74±6,98	**<0,001**
Postoperative 12 monthslater	30,08±11,12	28,53±7,11	29,30±9,11	0,487

SD: Standard Deviation

Table 3: American Foot and Ankle (AOFAS) scores in thefollow-upperiodandtheanalysis

Follow-up	Group 1 (Mean±SD)	Group 2 (Mean±SD)	Total (Mean±SD)	p
Preoperative	43,22±9,74	42,29±9,44	42,74±9,49	0,340
Postoperative 3 monthslater	57,59±12,3	71,69±7,19	64,64±9,74	**<0,001**
Postoperative 6 monthslater	61,20±11,2	76,68±4,39	68,94±7,79	**<0,001**
Postoperative 12 monthslater	73,87±10,6	78,70±6,45	76,3±8,50	0,605

SD: Standard Deviation

Conclusion

This study was carried out in order to compare two different methods for the treatment of moderate HV deformity, which is gradually becoming more and more prevalent and negatively affects the quality of life of patients due to pain, difficulty walking, problems in wearing shoes and cosmetic problems. It was demonstrated that both surgical methods were effective in terms of functional recovery. On the other hand, it was found that this recovery was statistically significant in the early period, whereas a superiority of POWO and DCO on each other could not be demonstrated in the long-term. It is apparent that both treatment approaches are effective in the treatment of moderate HV.

The effectiveness of conservative and surgical methods used in the treatment of this disease, which is very common according to the literature, has been demonstrated in numerous studies[1-4]. Surgical treatment is preferred in cases with moderate and severe hallux valgus deformity, when conservative treatment fails to succeed. Metatarsal osteotomy applications, which encompass various distinct surgical procedures, can be classified in two groups, i.e. proximal and distal osteotomies. Oravakangas et al. performed proximal metatarsal opening-wedge osteotomy for moderate hallux valgus deformity in a case series consisting of 35 patients and reported high success and low complication rates according to the mid-term outcomes[5]. Wester et al. compared two different proximal osteotomies (opening-wedge versus crescentic) in their study conducted in 2016 and showed that both techniques had similar, successful outcomes and they were not superior over one another[6].

There are many studies in the literature concerning chevron osteotomy, which is a very frequently used method among distal osteotomies [20-22]. Distal metatarsal chevron osteotomy performed using many different implants is commonly preferred by surgeons due to the ease of application. According to the literature, Brogan et al. compared minimally invasive and open distal chevron osteotomies, and reported that they observed successful outcomes in both techniques [23]. Although DCO is frequently performed, several complications of DCO have been reported in the literature. Baiget al. investigated K-wire fixation in distal chevron osteotomy in their prospective study and reported high complication rates[10]. Kaufmann et al. conducted a study with a large case series consisting of 524 patients and demonstrated that there was correction loss after month 3 following chevron osteotomy[24]. In a recent study conducted on 36 patients, Braitoet al. applied POWO and DCO procedures together and they reported high complication rates although this approach was highly successful in correcting the deformity[25].

One of the strengths of this study was the comparison of patients included in the study in accordance with the inclusion and exclusion criteria with patients who had similar demographic and clinical characteristics. The fact that this study was not double-blind in terms of the surgery for moderate hallux valgus deformity, did not include scheduling and different fixation protocols, and had a short follow-op period constituted the weaknesses of our study.

Proximal and distal metatarsal osteotomies are practiced by many surgeons in the treatment of moderate hallux valgus deformity. Various soft tissue surgeries included in treatment procedures

in addition to different fixation methods were shown to be effective in restoring foot functions and relieving pain. However, studies provide different results as to which approach is more effective. There is no consensus or an internationally accepted algorithm for this deformity. Therefore, patient-based approaches should also be considered in determining the surgical protocol.

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