Correction of More Hallux Valgus Pathologic Disorders with a Single Distal Osteotomy

A New Surgical Technique

Mehmet Ümit Çetin, MD*
Atilla Sancar Parmaksızoğlu, MD†
Fırat Fidan, MD‡
Mehmet Kılıç, MD§
Ahmet Aybar, MD||
Yaşar Mahsut Dinçel, MD*

Background: Hallux valgus, one of the most common deformities of the great toe, may cause pain, dysfunction, and impaired gait pattern. In this retrospective study we report the results of a new type of distal metatarsal osteotomy combined with distal soft-tissue release in patients with mild-to-moderate hallux valgus deformity.

Methods: This new technique was used in the management of 32 feet of 31 patients (eight men and 23 women) with mild-to-moderate hallux valgus. Hallux valgus angle, intermetatarsal angle, and distal metatarsal articular angle were measured on preoperative, early postoperative (6–8 weeks), and late (1 year) postoperative radiographs. American Orthopaedic Foot and Ankle Society hallux metatarsophalangeal score was calculated. Sesamoid position, by considering medial sesamoid position, and metatarsal shortness were also measured.

Results: Statistically significant differences were detected between the preoperative and late postoperative measurements of the hallux valgus angle, distal metatarsal articular angle, intermetatarsal angle, and sesamoid position parameters in patients operated on with this technique. Improvement was 14° for the hallux valgus angle, 4° for the distal metatarsal articular angle, and 4° for the intermetatarsal angle. Sesamoid position was also improved, and the mean American Orthopaedic Foot and Ankle Society score was significantly improved. Metatarsal shortness greater than 2 mm was observed in two patients without resulting in any clinical discomfort.

Conclusions: This new technique was easy, safe, and promising in patients diagnosed as having mild-to-moderate hallux valgus deformity. (J Am Podiatr Med Assoc 111(4): 1-9, 2021)

Hallux valgus is one of the most common deformities of the great toe, which may cause pain, dysfunction, and impaired gait pattern.[1,2] The main goals of treatment are pain relief and functional improvement, in addition to correction of the deformity. Obtaining and maintaining radiologic and clinical improvement are crucial in hallux valgus surgery.[3] Various distal metatarsal osteotomy techniques, such as chevron osteotomy, have been described in hallux valgus surgery.[4] Promising results with the modified McBride technique without performing metatarsal osteotomy in the management of mild-to-moderate hallux valgus have been published.[5-7]

*Orthopedics and Traumatology Department, Tekirdağ Namık Kemal University, Tekirdağ, Turkey.

†Orthopedics and Traumatology Department, Türkiye Gazetesi Hospital, Istanbul, Turkey.

‡Orthopedics and Traumatology Department, Sancaktepe Şehit İlhan Varank Training and Research Hospital, Istanbul, Turkey.

§Orthopedics and Traumatology Department, Arnavutköy Hospital, Istanbul, Turkey.

||Orthopedics and Traumatology Department, Gaziosmanpasa Taksim Training and Research Hospital, Istanbul, Turkey.

Corresponding author: Mehmet Ümit Çetin, MD, Orthopedics and Traumatology Department, Tekirdağ Namık Kemal University, Tekirdağ, 59030 Turkey. (E-mail: drumitcetin@gmail.com)

In this retrospective study, we report the results of a newly described distal metatarsal osteotomy that may be an alternative to chevron osteotomy for mild-to-moderate hallux valgus deformity. This new osteotomy enables distal metatarsal articular angle (DMAA) correction by giving a closed wedge effect to distal osteotomy in patients with a high DMAA. Furthermore, complications of distal osteotomy can be reduced with this safe technique.

Methods

Between June 1, 2010, and September 30, 2014, thirty-two feet of 31 patients (eight men and 23 women) underwent distal metatarsal osteotomy and a distal soft-tissue procedure for hallux valgus deformity. The mean patient age was 44.18 years (range, 17–64 years). All of the operations were performed by two different surgeons (ASP, AA). Patients who remained symptomatic with hallux valgus deformity and painful bunion despite conservative treatment were included in this study. All of the patients were mature in terms of skeletal development and were followed up for at least 1 year after surgery. The exclusion criteria were serious medial or posterior foot pathologic disorders (Achilles tendon enthesopathy, posterior tibial tendon rupture with arch collapse, tarsal tunnel syndrome, midtarsal osteoarthritis, cuboid subluxation syndrome), anterior foot pathologic disorders other than Freiberg disease and mallet finger, tibialis posterior tendon failure, rheumatoid arthritis, post-traumatic deformity, neuromuscular disease, progressive osteoarthritis of the foot or ankle, previous unsuccessful surgery, and severe hallux valgus deformity (hallux valgus angle [HVA] $>40°$; intermetatarsal articular angle [IMA] $>20°$). Patients who were lost during follow-up were also excluded from the study.

The medical history, complaints, expectations, daily activity level, occupation, and athletic performance of the patients were recorded. Physical evaluation included paresthesia and dermal pathologic conditions. Smoking, alcohol, and narcotic drug habits were recorded. To evaluate clinical outcomes of patients before and after surgery, we used the hallux metatarsophalangeal-interphalangeal scoring system of the American Orthopaedic Foot and Ankle Society.

Anteroposterior and lateral radiographs in the standing position were obtained for all of the patients before and after surgery. With the aid of a digital assessment system (Infinitt, Phillipsburg, New Jersey), these images were used to measure the HVA, the IMA of the first and second metatarsals, the DMAA, and the first metatarsophalangeal joint compliance. Preoperative and postoperative lengths of the first metatarsal were measured by the method of Lee et al.[8] Postoperative evaluation of the patients included data from the early postoperative (week 6–8) control visits before loading and from the late postoperative control visit in month 12. Medial sesamoid position was examined on these images and assessed by a 7-point system (from 1 to 7) described by Hardy and Clapham[9] (Table 1).

During follow-up, patients were observed for limitation of first metatarsophalangeal joint range of motion ($<30°$), delayed reunion or non-reunion of the osteotomy line (no improvement within 6 months), avascular necrosis, recurrence of the deformity, deep infection, stress fracture, Sudeck atrophy, and osteoarthritic changes in the joint.

Statistical analysis included descriptors such as means, standard deviations, minimum and maximum values, frequencies, and percentages. Comparisons among preoperative, early postoperative, and late postoperative measurements were made by repeated-measures analysis of variance. Multiple comparisons were made by Bonferroni test. Comparisons between preoperative and postoperative American Orthopaedic Foot and Ankle Society and sesamoid position variates were made by paired-samples t test. Two-way significance level was adjusted to a $P < .05$. All of the analyses were

Table 1. General Characteristics of the Patient Group

Characteristic	Mean ± SD	Range
Age (years)	44.18 ± 12.37	17–64
Follow-up (months)	26.71 ± 11.39	12–54
Preop HVA (°)	28.59 ± 4.44	20–40
Early postop HVA (°)	11.59 ± 4.82	3–19
Late postop HVA (°)	13.65 ± 3.58	6–20
Preop IMA (°)	13.90 ± 1.57	11–16
Early postop IMA (°)	7.25 ± 2.12	2–11
Late postop IMA (°)	9.31 ± 1.61	6–12
Preop DMAA (°)	16.15 ± 7.26	4–31
Early postop DMAA (°)	10.46 ± 4.27	4–22
Late postop DMAA (°)	11.93 ± 3.81	6–20
Preop SP	4.75 ± 1.24	3–7
Postop SP	2.75 ± 1.21	1–5
Preop AOFAS MTP-IP	65.81 ± 8.68	47–77
Postop AOFAS MTP-IP	95.15 ± 4.99	85–100
Metatarsal shortness (mm)	2.28 ± 2.75	0–9

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society; DMAA, distal metatarsal articular angle; HVA, hallux valgus angle; IMA, intermetatarsal angle; MTP-IP, metatarsophalangeal-interphalangeal score; postop, postoperative; preop, preoperative; SP, sesamoid position.

performed with a statistical software program (NCSS 10; NCSS Statistical Software, Kaysville, Utah).

A 4- to 5-cm dorsomedial skin incision is made starting 1 cm distal to the first metatarsophalangeal joint to the diaphyseal midline on the surgical foot (Fig. 1). The joint capsule is exposed by sparing the neurovascular structures (Fig. 2). The joint is exposed by an L-shaped capsulotomy (Fig. 3). The same incision is used to enter the joint space, and lateral release is performed by the technique of Parmaksızoğlu and colleagues.[10] Briefly, the joint is medially dislocated by taking the metatarsophalangeal joint lateral rim as the pivotal point. Then, the capsule, adductor tendon, metatarsosesamoid ligament, and intermetatarsal ligament are cut in the joint space with a No. 12 scalpel (Fig. 4). For osteotomy planning, medial eminence is found under fluoroscopy, and a Kirschner wire (0.062 mm) is sent on the medial-to-lateral line parallel to the first metatarsal joint cartilage (Fig. 5). A second wire is sent at the anteroposterior plane with a 45° angle. The second wire intersects the first Kirschner wire in the middle part of the metatarsal shaft (Fig. 6). Then a third wire is sent parallel to the second wire. The third wire intersects the first wire on the distal margin of the metatarsal (Fig. 7).

In patients with a high DMAA, the third wire can be sent with an angle to form a closed wedge osteotomy effect medially rather than parallel to the second wire. This modification leads to a greater improvement in the DMAA. Metatarsal osteotomy is performed on the line defined by Kirschner wires using a micro-oscillation saw (Fig. 8). The osteotomy fragment is excised (Fig. 9); the distal part is impacted to the proximal part (Fig. 10). The distal and proximal parts are fixed by a headless screw inserted from distal medial to proximal lateral (Fig. 11). After osteotomy and correction, toe movements are checked and correction is strengthened by medial capsulorrhaphy. The position is secured by placing a sponge between the first and second toes until postoperative day 15 (suture removal). For a schematic representation of osteotomy, see Fig. 12.

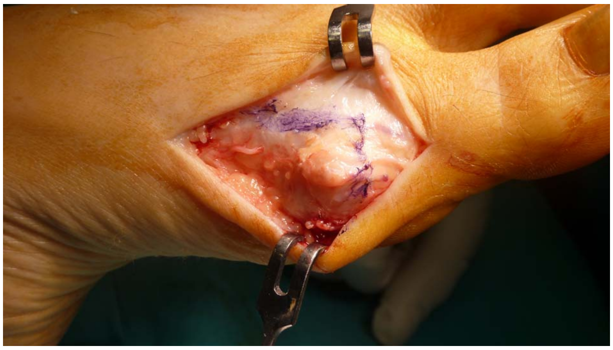

Figure 2. Planning of capsular incision.

The early postoperative period included the 6 to 8 weeks after the operation. The patients were encouraged to walk by using a surgical shoe or slipper, but partial weight was allowed only on the heel. No other orthoses or splints were used. Metatarsophalangeal joint motion was started on postoperative day 1. Most of the patients were discharged on postoperative day 2. The remaining few patients who felt better were discharged on postoperative day 1. All of the patients were seen 3 days after discharge to change the dressings and control the wound healing. The stitches were removed 15 days after the operation. After that, follow-up occurred in postoperative week 6, month 3, and month 6 and at 1 year. Full weightbearing was permitted around week 6 to 8 because radiologic full reunion was expected during this period. For the preoperative and postoperative radiographs, see Figs. 13 and 14.

Figure 1. Surgical Incision.

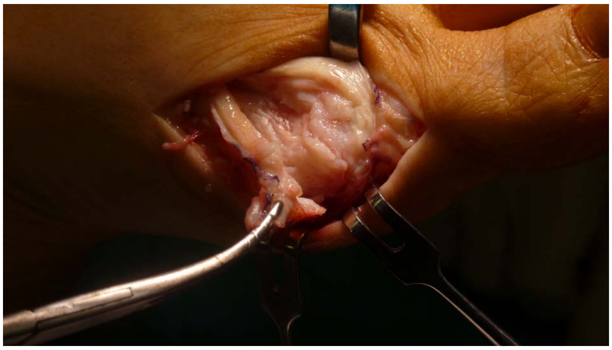

Figure 3. L-shaped capsulotomy.

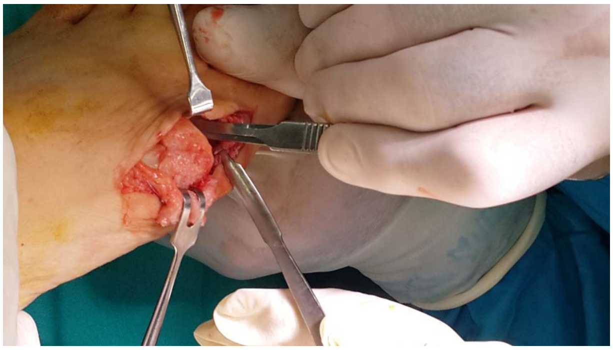

Figure 4. Releasing of lateral structures.

Results

Mean follow-up was 26.71 months (range, 12–54 months). Two patients had asymptomatic Freiberg disease and three patients had second toe mallet deformity. No additional intervention was performed for these pathologic conditions. Preoperative versus postoperative comparison of DMAA, IMA, and HVA values showed significant improvement (standard error [SE] = 1.59, .43, and .96, respectively) (Table 2). Similarly, comparison of early versus late postoperative DMAA, IMA, and HVA values showed significant differences ($P = .25$, .22, and .32, respectively) (Table 2). Furthermore, preoperative versus late postoperative comparisons for final outcome showed significant differences in DMAA, IMA, and HVA values ($P = 1.41$, .35, and .84, respectively) (Table 2). In addition, on average, 2-mm (range, 0- to 9-mm) metatarsal shortness was found in all of the patients. Considering the sesamoid position, preoperative and postoperative

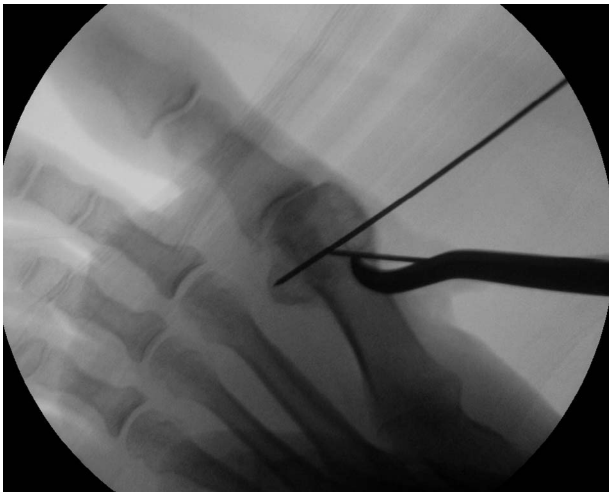

Figure 6. Sending of second Kirschner wire.

comparisons showed that each patient had an improvement of 1.4° (0°–4°) (Table 1). In only two patients, preoperative and postoperative sesamoid positions were comparable. None of the patients had a worse sesamoid position after surgery.

Considering complications, none of the patients had secondary hallux varus, recurrence of the deformity requiring revision surgery, avascular necrosis, delay in reunion or non-reunion, Sudeck atrophy, deep infection, limitation of the metatarsophalangeal joint, or arthrosis. However, two patients showed metatarsal shortness (>2 mm) (Table 1). These patients were asymptomatic and required no additional surgery. One patient developed superficial wound infection and recovered without any treatment.

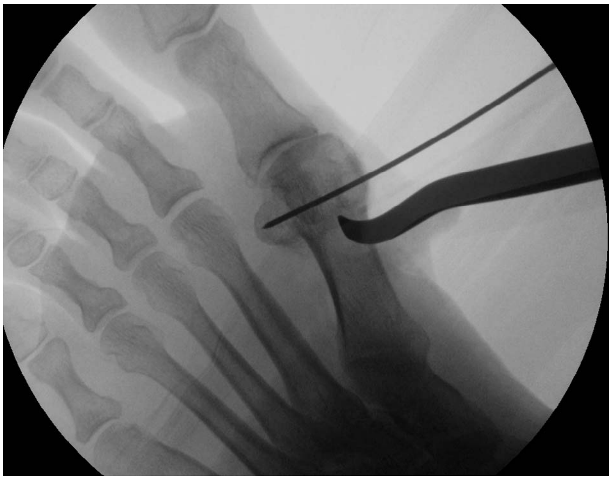

Figure 5. Sending of the first Kirschner wire.

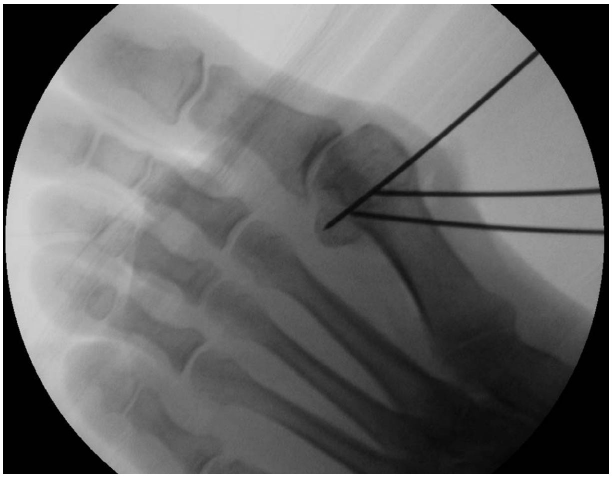

Figure 7. Sending of third Kirschner wire.

Discussion

More than 100 surgical techniques have been used for hallux valgus.[3] The goals of surgical treatment are to correct deformity, improve functional status, and reduce pain. In hallux valgus surgery, it is important to obtain and maintain radiologic and clinical correction. Therefore, choosing an adequate surgical method may help achieve these goals.[3] Distal metatarsal osteotomy is used to correct mild-to-moderate deformities, and chevron osteotomy is a commonly used method.[4] Unlike other contemporary distal osteotomy techniques, the present approach may provide DMAA correction with one osteotomy, and because it permits partially controlled translation, the rate of severe complications such as avascular necrosis and hallux valgus may reduce. This technique also improves sesamoid position through lateral soft-tissue release. Chevron osteotomy permits only translation, whereas the present approach permits both translation and rotational correction. Therefore, it is more advantageous.

Lateral soft-tissue release includes the adductor hallucis tendon, metatarsosesamoid suspensory ligament, lateral collateral ligament, deep transverse metatarsal ligament, and short lateral sesamoid ligament.[11] In a cadaveric study, it was shown that transecting the lateral metatarsosesamoid suspensory ligament was the key to a successful lateral release.[12] One of the most important points in hallux valgus surgery is the position of the sesamoids. Despite perfect angular outcomes, patient satisfaction may be lower due to pain of sesamoid origin. Without contracture release, both sesamoid bones do not release. Thus, reduction may not be at the desired level even if osteotomy is performed. If this contracture is released together with the soft-tissue procedure, sesamoid reduction may be much easier in hallux valgus.[13,14] Hardy and Clapham[9] noticed that sesamoid displacement was correlated with the severity of deformity in relation to the first metatarsal head. Johnson et al[5] compared the modified McBride procedure with distal chevron osteotomy and found that these two procedures did not provide significant improvement in medial sesamoid and led to comparable results. On the other hand, Choi et al[15] reported improvement in sesamoid position in both groups, with better improvement in the osteotomy group. Grle et al[16] compared distal osteotomy with distal osteotomy plus lateral soft-tissue release and found better results in the distal osteotomy plus lateral soft-tissue release group. Furthermore, medial sesamoid

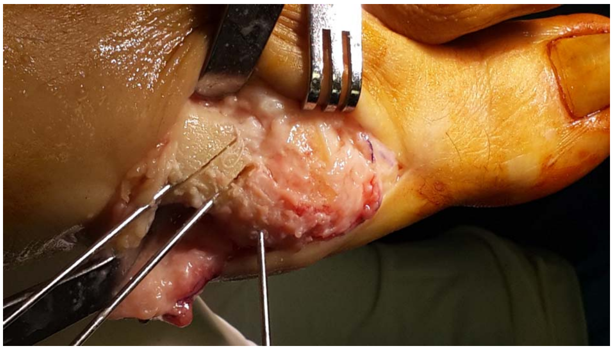

Figure 8. Safe osteotomy guided by Kirschner wires.

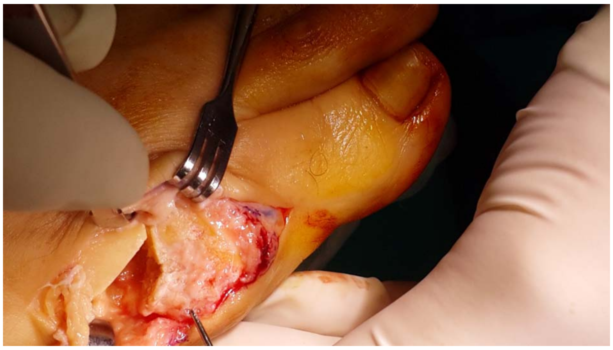

Figure 9. Excision of osteotomized fragment.

Figure 10. Relocation of first metatarsal bone.

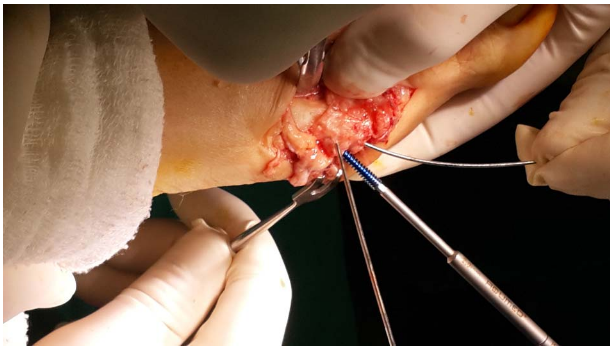

Figure 11. Fixation of osteotomy.

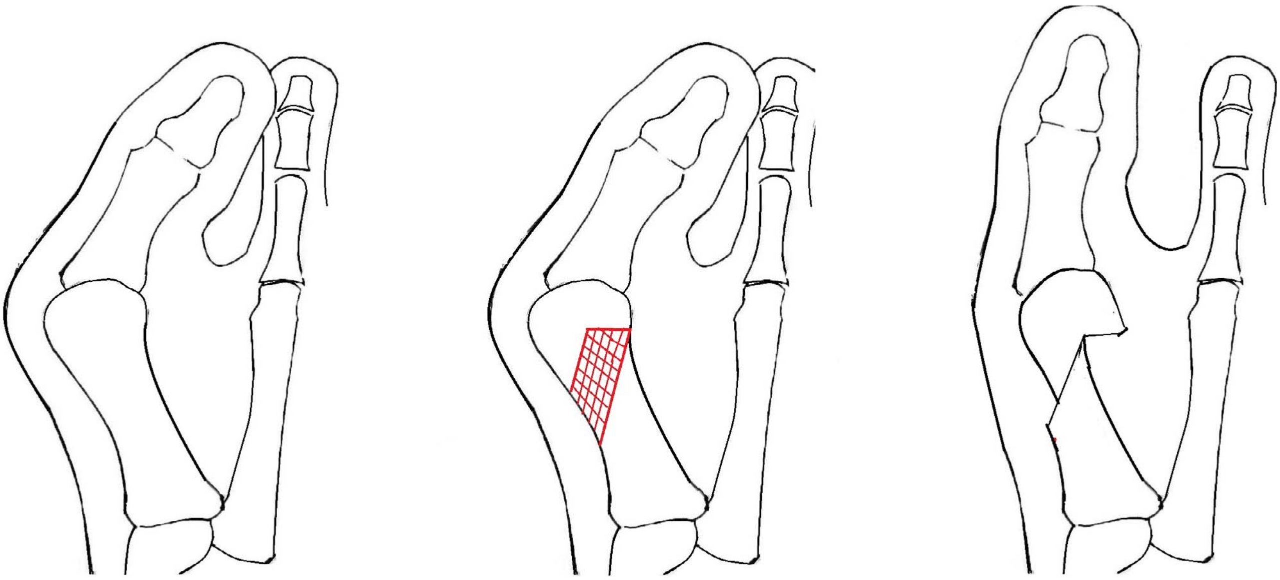

Figure 12. Schematic representation of osteotomy.

reposition was significant in the latter group.[16] The previously mentioned studies showed the importance of sesamoid position in metatarsophalangeal joint capsule release. In the present study, we observed the efficacy of intra-articular capsule, adductor ligament, and transverse ligament release in the reestablishment of sesamoid position.

Figure 13. Patient preoperative and postoperative radiographs.

It has been argued that a high preoperative DMAA has negative effects on hallux valgus surgery.[17] In patients with mild hallux valgus, the DMAA can be corrected by Akin osteotomy,[18,19] in addition to distal chevron or biplanar chevron osteotomy.[20,21] Cassinelli and colleagues[22] suggested a small closed wedge osteotomy from the medial side, in addition to chevron osteotomy in patients with a high DMAA. In their study, Coughlin and Carlson[23] recommend-

Figure 14. Patient preoperative and postoperative radiographs.

Table 2. Preoperative, Early Postoperative, and Late Postoperative Radiologic Parameters

Parameter	Mean Difference	SE	95% CI
Preop HVA–early postop HVA	17	0.96	14.54–19.45
Preop HVA–late postop HVA	14.96	0.84	12.83–17.10
Late postop HVA–early postop HVA	2.03	0.32	1.21–2.84
Preop IMA–early postop IMA	6.65	0.43	5.54–7.76
Preop IMA–late postop IMA	4.59	0.35	3.68–5.50
Late postop IMA–early postop IMA	2.06	0.22	1.50–2.61
Preop DMAA–early postop DMAA	5.68	1.52	1.81–9.57
Preop DMAA–late postop DMAA	4.21	1.41	0.64–7.78
Late postop DMAA–early postop DMAA	1.46	0.25	0.82–2.11

Abbreviations: CI, confidence interval; DMAA, distal metatarsal articular angle; HVA, hallux valgus angle; IMA, intermetatarsal angle; postop, postoperative; preop, preoperative; SE, standard error.

ed double and triple first-line osteotomy in patients with a high DMAA, and they achieved significant improvement in the DMAA. They also mentioned the corrective impact of closed wedge osteotomy (from distal to medial) on the DMAA besides correction of hallux valgus deformity.[23] In the present technique, when the angle of the third guide wire is rhomboid to the second wire rather than being parallel, it may have significant corrective effect on the DMAA by a distal closed wedge osteotomy effect in addition to corrective osteotomy. When performing this, we did not need a second osteotomy, unlike other techniques. In this way, we avoided the problems of an additional procedure. This can be seen as the most important advantage of this technique.

In hallux valgus, an HVA greater than 20°on postoperative anteroposterior standing radiographs is accepted as recurrence.[24] According to Cassinelli et al,[22] an HVA angle greater than 20° is recurrence, and the goal of treatment is to keep the HVA lower than this cutoff value during long-term follow-up. Choi et al[15] accepted an HVA angle greater than 15° as recurrence. None of the techniques defined for hallux valgus is complication-free. The most common complication is recurrence, which is reported to be 3% to 14% in various studies.[25-28] In their study, Pentikainen et al[29] reported a recurrence rate of 73% in patients with an HVA greater than 15° and stated that asymptomatic patients required no secondary intervention. In our practice, patients with an HVA greater than 20° were accepted as experiencing a recurrence during late postoperative follow-up. When we examined the results of the osteotomy operations, none of the patients had an HVA value greater than 20° during the late postoperative period. In other words, none of the patients showed recurrence or insufficient correction. These results may be due to the relative stability of osteotomy especially on the mediolateral axis and the wide contact surface.

Because of the increased DMAA, osteonecrosis and recurrence are the two potential complications of distal chevron surgery.[3] To prevent transverse metatarsalgia after surgery, these techniques should be avoided in patients in whom the first metatarsal is shorter than the second metatarsal.[8] The thickness and vibrations of the osteotomy saw may lead to 1 to 2 mm of metatarsal shortening, but lateral translocation of the distal fragment makes a small contribution to metatarsal bone length.[30] In the present patients, despite high DMAA measurements, we performed parallel osteotomy rather than establishing closed wedge effect in patients whose first metatarsal was shorter than their second metatarsal. This preference was due to the previously mentioned handicap. Eventually, we failed to obtain sufficient DMAA correction in these patients.

Cassinelli et al[22] observed varus in one patient and symptomatic shortening in another patient. Klosok and colleagues[31] compared chevron versus Wilson osteotomy and reported complications such as swelling in the early period, hallux varus, delayed wound healing, bunion recurrence, dorsal spike, third metatarsal stress fracture, dysesthesia, and/or hypoesthesia. Average metatarsal shortening was 10 mm in the Wilson osteotomy group and 6 mm in the chevron osteotomy group. Metatarsal head depression was found in three and five patients in the Wilson and chevron osteotomy groups, respectively.[31] Lee and Park[32] stated that metatarsal shortening after distal chevron osteotomy was 1.59 mm on average, whereas other studies reported 3 mm of shortening.[8] The avascular necrosis rate after distal chevron osteotomy + soft-tissue release was 0% to 40%.[33-35] In the present patient group, recurrence or loss of reduction was not observed because the osteotomy was relatively stable and capsulorrhaphy for soft-tissue repair contributed to stability. Again, hallux varus complication was not observed because the technique enabled a limited amount of correction, which was adjusted by the type of osteotomy during the operation. In this technique, translation of the metatarsal head leads to at least 50% contact, which, in turn, prevents avascular necrosis, recurrence, and overcorrection. Pochatko et al[36] stated that the lateral shift of the metatarsal head should not exceed half the width of the metatarsal head. In the present technique, the bone permits a maximal 50% shift, thus this critical threshold cannot be exceeded, which negatively affects and limits the amount of correction. However, we recommend this technique for mild-to-moderate hallux valgus deformity in which we can achieve a sufficient amount of correction. We have no experience in severe cases. Zvijac et al[37] noted the nutrient artery entered the first metatarsal at the distal third or junction of the middle and distal thirds obliquely from a proximal direction coronally; entry point and direction varied axially. Pochatko and coworkers[36] stated that sparing this artery during osteotomy may prevent this complication. Using Kirschner wires in the present operations enabled a controlled osteotomy and prevented metatarsal fracture. Furthermore, a careful intra-articular lateral release affected the metatarsal head blood supply, which prevented avascular necrosis. Again, there was no complication due to metatarsal shortening because the mean shortening was as small as 2 mm.

The strengths of this study include the limited number of surgeons (only two surgeons performed all of the operations), a relatively homogenous study group with mild-to-moderate deformity, measurements by one independent assistant, and relatively longer follow-up ($\geq$1 year). The weaknesses of this study include the retrospective study design, relatively small number of patients, only one bilateral operation, lack of a control group, and lack of biomechanical study of the technique.

Conclusions

In patients with mild-to-moderate hallux valgus, this technique led to clinical and radiologic improvement with only one osteotomy with relatively lower complication rates. As a result, this distal osteotomy technique was easy, safe, and promising in patients diagnosed as having mild-to-moderate hallux valgus deformity.

Acknowledgment: Dr. Gökhan Özkazanlı for consultation of study planning.
Financial Disclosure: None reported.
Conflict of Interest: None reported.
Dual Publication: Presented at the 25th Turkish National Congress of Orthopedics and Traumatology, October 27 to November 1, 2015, Antalya, Turkey.

References

1. Nix S, Smith M, Vicenzino B: Prevalence of hallux valgus inthe general population: a systematic review and meta-analysis. J Foot Ankle Res **3:** 21, 2010.
2. Yee G, Lau J: Current concepts review: hallux rigidus. Foot Ankle Int **29:** 637, 2008.
3. Easley ME, Trnka HJ: Current concepts review: hallux valgus: part II. Operative treatment. Foot Ankle Int **28:** 748, 2007.
4. Lee HJ, Chung JW, Chu IT, et al: Comparison of distal chevron osteotomy with and without lateral soft tissue release for the treatment of hallux valgus. Foot Ankle Int **31:** 291, 2010.
5. Johnson JE, Clanton TO, Baxter DE, et al: Comparison of chevron osteotomy and modified McBride bunionectomy for correction of mild to moderate hallux valgus deformity. Foot Ankle **12:** 61, 1991.
6. Meyer JM, Hoffmeyer P, Borst F: The treatment of hallux valgus in runners using a modified McBride procedure. Int Orthop **11:** 197, 1987.
7. Kayali C, Ozturk H, Agus H, et al: The effectiveness of distal soft tissue procedures in hallux valgus. J Orthop Traumatol **9:** 117, 2008.
8. Lee JY, Lee YS, Song KC, et al: Change in first metatarsal length after proximal and distal Chevron osteotomies for hallux valgus deformity. J Foot Ankle Surg **54:** 525, 2015.
9. Hardy RH, Clapham JC: Observations on hallux valgus: based on a controlled series. J Bone Joint Surg Br **33:** 376, 1951.
10. Parmakszoğlu A, Özer K, Yazc N, et al: Halluks valgusda distal metatarsal oblik osteotomi ve yumuşak doku girişimi ile kombinasyonu. Acta Orthop Traumatol Turc **30:** 226, 1996.
11. Schneider W: Distal soft tissue procedure in hallux valgus surgery: biomechanical background and technique. Int Orthop **37:** 1669, 2013.
12. Schneider W: Influence of different anatomical structures on distal soft tissue procedure in hallux valgus surgery. Foot Ankle Int **33:** 991, 2012.
13. LaPorta G, Melillo T, Olinsky D: X-ray evaluations of hallux abducto valgus deformity. JAPA **64:** 544, 1974.
14. Palladino SJ: "Preoperative Evaluation of the Bunion Patient: Etiology, Biomechanics, Clinical and Radiographic Assessment," in *Textbook of Bunion Surgery*, 2nd Ed, ed by J Gerbert, p 77, Futura Publishing, Mt Kisco, NY, 1991.
15. Choi GW, Kim HJ, Kim TS, et al: Comparison of the

modified McBride procedure and the distal Chevron osteotomy for mild to moderate hallux valgus. J Foot Ankle Surg **55:** 808, 2016.
16. Grle M, Vrgoc G, Bohacek I, et al: Surgical treatment of moderate hallux valgus: a comparison of distal chevron metatarsal osteotomy with and without lateral soft-tissue release. Foot Ankle Spec **10:** 524, 2017.
17. Lee KT, Park YU, Jegal H, et al: Deceptions in hallux valgus: what to look for to limit failures. Foot Ankle Clin N Am **19:** 361, 2014.
18. Mitchell LA, Baxter DE: A Chevron-Akin double osteotomy for correction of hallux valgus. Foot Ankle **12:** 7, 1991.
19. Schneider W, Aigner N, Pinggera O, et al: Chevron osteotomy in hallux valgus: ten-year results of 112 cases. J Bone Joint Surg Br **86:** 1016, 2004.
20. Chou LB, Mann RA, Casillas MM: Biplanar Chevron osteotomy. Foot Ankle Int **19:** 579, 1998.
21. Nery C, Barroco R, Ressio C: Biplanar Chevron osteotomy. Foot Ankle Int **23:** 792, 2002.
22. Cassinelli SJ, Herman R, Harris TG: Distal metatarsal osteotomy for moderate to severe hallux valgus. Foot Ankle Int **37:** 1137, 2016.
23. Coughlin MJ, Carlson RE: Treatment of hallux valgus with an increased distal metatarsal articular angle: evaluation of double and triple first ray osteotomies. Foot Ankle Int **20:** 762, 1999.
24. Shi GG, Henning P, Marks RM: Correlation of postoperative position of the sesamoids after Chevron osteotomy with outcome. Foot Ankle Int **37:** 1, 2015.
25. Coughlin MJ, Jones CP: Hallux valgus and first ray mobility: a prospective study. J Bone Joint Surg Am **89:** 1887, 2007.
26. Hirvensalo E, Bostman O, Tormala P, et al: Chevron osteotomy fixed with absorbable polyglycolide pins. Foot Ankle **11:** 212, 1991.
27. Lewis RJ, Feffer HL: Modified chevron osteotomy of the first metatarsal. Clin Orthop Relat Res **157:** 105, 1981.
28. Okuda R, Kinoshita M, Morikawa J, et al: Proximal metatarsal osteotomy: relation between 1- to greater than 3-years results. Clin Orthop Relat Res **435:** 191, 2005.
29. Pentikainen I, Ojala R, Ohtonen P, et al: Preoperative radiological factors correlated to long-term recurrence of hallux valgus following distal chevron osteotomy. Foot Ankle Int **35:** 1262, 2014.
30. Sammarco GJ, Brainard BJ, Sammarco VJ: Bunion correction using proximal chevron osteotomy. Foot Ankle **14:** 8, 1993.
31. Klosok JK, Pring DJ, Jesop JH, et al: Chevron or Wilson metatarsal osteotomy for hallux valgus: a prospective randomised trial. J Bone Joint Surg Br **75:** 825, 1993.
32. Lee JY, Park SS: Comparison of proximal and modified distal chevron osteotomy for the treatment of moderate to severe hallux valgus deformity. J Korean Foot Ankle Soc **16:** 31, 2012,
33. Donnelly RE, Saltzman CL, Kile TA, et al: Modified chevron osteotomy for hallux valgus. Foot Ankle Int **15:** 642, 1994.
34. Meier PJ, Kenzora JE: The risks and benefits of distal first metatarsal osteotomies. Foot Ankle **6:** 7, 1985.
35. Wallace GF, Bellacosa R, Mancuso JE: Avascular necrosis following distal first metatarsal osteotomies: a survey. J Foot Ankle Surg **33:** 167, 1994.
36. Pochatko DJ, Schlehr FJ, Murphey MD, et al: Distal Chevron osteotomy with lateral release for treatment of hallux valgus deformity. Foot Ankle Int **15:** 457, 1994.
37. Zvijac JE, Janecki CJ, Freeling RM: Distal oblique osteotomy for tailor's bunion. Foot Ankle **12:** 171, 1991.