Minimally invasive double-level osteotomy of the first metatarsus for treatment of severe hallux valgus

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Background Surgery for the treatment of severe hallux valgus (HV) is commenced to correct the forefoot deformity, provide metatarsalgia relief, and provide a stable biomechanically functional foot.
Many surgeons advocate moving from open surgery to minimally invasive techniques, replacing large incisions with smaller ones through which the surgeon can work. Minimally invasive techniques have been successfully used for mild to moderate HV deformities; however, controversy exists for their use in cases with more severe involvement. The aim of this prospective study was to assess the clinical and radiological outcomes of a minimally invasive technique for management of severe HV deformity.

Patients and methods Between March 2015 and August 2017, a total of 24 feet in 18 active patients, comprising 11 female and seven male patients, with six patients having bilateral involvement, met our selection criteria for symptomatic severe HV deformity and were treated with a minimally invasive double-level metatarsal osteotomy technique. The surgery is done through simple transverse osteotomy, with lateral translation, of the first metatarsus both proximally and distally combined with selective distal soft-tissue dissection. The average age of patients was 37.7 years.
Clinically, the American Orthopedic Foot and Ankle Society score and the subjective patient's satisfaction were evaluated. Radiologically, HV angle, distal metatarsal articular angle, and intermetatarsal angle and joint congruity were measured preoperatively, postoperatively, and at the end of the follow-up period. All data were statistically analyzed.

Results The mean follow-up period was 22.7 months (range, 18–30 months). Union was achieved in all osteotomies in a mean of 6.67±0.45 weeks. Each radiological and clinical parameter showed a statistically significant improvement ($P<0.001$), with negligible first-ray shortening ($P=0.547$) and a few complications. At the end of follow-up period, no patient was dissatisfied.

Conclusion Minimally invasive double-level first metatarsal osteotomy technique with selective distal soft-tissue dissection provides a simple, effective procedure, and reproducible alternative for treatment of severe HV deformity.
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Introduction

Hallux valgus (HV) is more prevalent in women and the elderly and is often associated with functional deterioration and foot pain (metatarsalgia). The pressure and pain at the head of the other metatarsals increase when patients shift their weight laterally. Orthoses and night splints do not appear to improve outcome, but surgery is reported to be beneficial [1]. HV is a common disorder of the forefoot that results from medial deviation of the first metatarsus and lateral deviation and/or rotation of the great toe (hallux), with or without medial soft-tissue enlargement of the first metatarsal head (bunion) [2]. Whether less invasive or percutaneous surgery is the preferred procedure for correction of moderate-to-severe HV deformity remains controversial. There is a growing tendency toward employing percutaneous and minimally invasive techniques in HV surgery, with the advantages of ease of surgery, reduction in operative time, less surgical dissection, and temporarily hardware fixation; this possibly results in lower incidence of complications, early weight bearing allowing bilateral surgery, and higher patient satisfaction [3].

Recently, a percutaneous minimally invasive double-metatarsal osteotomy (MIDMO) of the first metatarsus (MT-1), with proximal closing wedge and distal chevron osteotomy, has been described for severe HV deformity and showed early satisfactory results [4]. However, the procedure may be technically difficult as the arms of this osteotomy must be accurately fashioned within the safe zone of MT-1 to avoid injury of both the nutrient artery of MT-1 proximally and the first metatarsophalangeal joint (MTP-J-1) distally [5], and the routine use of Weil's osteotomy in lesser toes to overcome (MT-1) shortening after resection of a closing wedge proximally [6].

In the current study, a modified MIDMO procedure that enabled full correction of all components of severe HV deformities by a relatively simple transverse osteotomy of the MT-1 both distally and proximally, with selective distal lateral soft-tissue release (DLSTR) by small incisions was used. The distal components of the deformity were corrected distally by a subcapital MIDMO-based procedure [7], whereas the final correction of the residual varus deviation of MT-1 was completed by another simple osteotomy proximally (Figs 1–3). This can combine the dual benefits of minimal invasive nature and correction of complex deformities of severe HV.

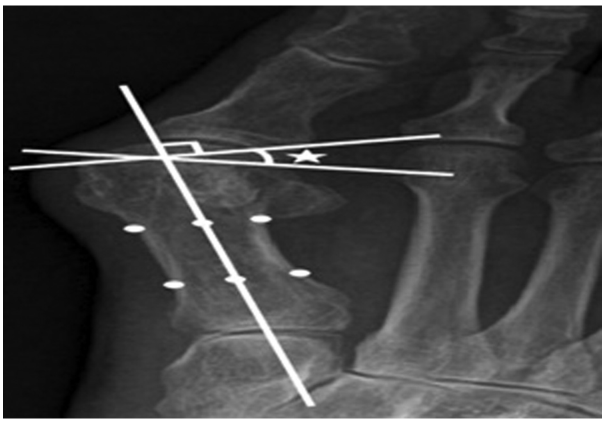
Patients and methods

Between March 2015 and August 2017, a total of 24 feet in 18 active patients comprising 11 female and seven male patients, with six patients having bilateral involvement, with hallux valgus angle (HVA) more than 40° and intermetatarsal angle (IMA) more than 18°, met our selection criteria for symptomatic severe HV deformity and were treated by a modified MIDMO technique.

Patient's selection criteria are shown in Table 1. The procedure implied simple transverse osteotomy, with lateral translation, of the first metatarsus both proximally and distally combined with selective distal soft-tissue dissection. Average patient's age was 37.7 years. Clinically, the American Orthopedic Foot and Ankle Society scale and the subjective patient's satisfaction were evaluated.

Radiologically, distal metatarsal articular angle (DMAA), HVA, IMA, and joint congruity were measured preoperatively, postoperatively, and at the end of the follow-up period. All data were statistically analyzed.

Figure 1



Distal metatarsal articular angle (asterisks) defined as the angle between a perpendicular line to the longitudinal axis of the first metatarsal and a line delineating the orientation of the metatarsal head articular surface [8].

Surgical technique

Under spinal or general anesthesia, the patient was placed in a supine position with a below-knee wedge allowing 90° knee flexion and a plantigrade position of the foot. The fluoroscopic image intensifier must be

Figure 2

Preoperatively: HVA 42°, IMA 20°. HVA, hallux valgus angle; IMA, intermetatarsal angle.

Figure 3

Paraosteally position of the Kirschner wire along the medial border of the proximal phalanx.

Table 1 Patients' selection criteria in the study

Inclusion criteria
Painful hallux valgus deformity with an increased distal metatarsal articular angle (refractory to conservative treatment for at least 3 months)
Transfer metatarsalgia (functional disability with shoe-fitting problems)
Clinically irreducible deformity, with HVA >40° and IMA >18°
Exclusion criteria
Severe degenerative changes of the first metatarsophalangeal joint (hallux valgus with rigidus)
Severe ankle and foot deformities
Failed previous HV surgeries
Generalized joint hyperlaxity and hypermobility of MT-C-J-1
Uncertain compliance

HVA, hallux valgus angle; IMA, intermetatarsal angle; MT-C-J-1, metatarso cuniform joint 1.

positioned to the patient's side and a thigh tourniquet was applied. A small 15–20-mm dorsal first web space incision was done for DLSTR. With manual correction of a pronated hallux and blunt dissection, a longitudinal small incision in the lateral MTP-J-1 capsule was made along the dorsal margin of the lateral sesamoid to release the lateral metatarso-sesamoid-suspensory ligament (LMSSL), without dissection of any capsular attachments or other lateral stabilizers.

Then, a small 15–20-mm medial skin incision (centered opposite the bunion) was done, and a capsular flap was raised for later capsulorrhaphy. Under fluoroscopic image intensifier, a MIDMO-based technique was performed with some modifications. A 2-mm Kirschner wire (K-wire) was introduced paraosteally flush to the shaft of the proximal phalanx from distal to proximal antegrade till the level of planned distal osteotomy. A transverse subcapital osteotomy was then performed at the level of the neck of the MT-1 using an electric saw with gentle penetration of the lateral cortex. The distal fragment was then displaced laterally (up to 60%) to correct HVA, by inserting a curved hook into the medullary canal of the first ray. Then the K-wire was advanced into the medullary canal to the level of the planned proximal osteotomy (2 cm from the base of MT-1). A third small 1.5-cm medial skin incision was done over the later site, and a proximal transverse osteotomy was done in the same way of the first one. The intermediate segment was then laterally displaced, to correct residual varus deviation of MT-1. Then, the K-wire was drilled in the base of MT-1 and medial cuneiform for fixation of the second osteotomy and to provide additional stability for the first one. Through the first osteotomy incision, another K-wire was then introduced flush with the intermediate fragment (paraosteally) and advanced intramedullary through the base of MT-1 till medial cuneiform to provide additional stability as it acts as a spacer preventing redisplacement at the second osteotomy. Finally, the medial capsule was closed, without over-tightening, after excising the redundant edges, while its tension was checked under fluoroscopy to confirm congruency of the MTP-J-1.

Postoperative management

(1) Full weight bearing was encouraged on the day after surgery using a postoperative flat-soled shoe.
(2) Prophylactic anticoagulant was recommended for 1 month.
(3) The great toe was securely taped for 6 weeks, changing the dressing weekly. The taping should maintain the hallux in a slight hypercorrection allowing an early removal of the K-wire and preventing recurrence of the deformity. A plantar kidney-shaped pad with its concavity surrounding the plantar aspect of the head of the first metatarsus was used to reduce weight-bearing pressure beneath the distal fragment and to prevent dorsiflexion of this distal segment.
(4) The tape and the K-wires were removed at 6 weeks following surgery, and the patients were instructed to the rehabilitation protocol taking particular care to obtain full dorsiflexion of great toe within 6–8 weeks.

Radiological assessment

Poster-anterior weight-bearing foot radiographs were done preoperatively and postoperatively to evaluate the HVA, DMAA, IMA, and tibial sesamoid position [9].

HVA is the angle between the longitudinal axis of the first metatarsus and that of the proximal phalanx. DMAA is the angle between a line perpendicular to another line connecting the distal articular margins of MTP-J-1 and the longitudinal axis of the first metatarsal (Figs 4 and 5). IMA is the angle between the longitudinal axis of the first and second metatarsals.

Figure 4

Postoperative view with double osteotomy of the first metatarsus with Kirschner wire fixation.

Figure 5

At the final follow-up with complete union, with HVA 8° and IMA 10°. HVA, hallux valgus angle; IMA, intermetatarsal angle.

Tibial sesamoid position is the position of tibial sesamoid relative to the longitudinal axis of the first metatarsus in grades 0–3 [8]. Magnification differences for MT-1 length were overcome by its ratio to the second metatarsal length. Union and length of MT-1 were also assessed.

In addition, lateral standing views were obtained for evaluation of any sagittal subluxation or malalignment.

Results

Clinical evaluation

According to the American Orthopaedic Foot and Ankle Society hallux MTP-interphalangeal scale for the clinical assessment, a mean score of 84.7±11.3 at the final follow-up was recorded.

Union was achieved in all cases, with a mean of 6.22 ±0.79 weeks (range, 6–8 weeks).

At the final follow-up, all patients restored hallux function and near-normal gait pattern. Complete pain relief was achieved in 16 patients (21 feet), whereas the other two patients (3 feet) reported subtotal pain relief owing to incomplete resolution of a preoperative metatarsalgia beneath the lesser toes. No new metatarsalgia (calluses) developed in any patient. The mean MTP-J-1 range of motion (ROM) at the final follow-up was 52.64±17.36° of dorsiflexion and 30.54±6.24° of planter-flexion. Temporarily, MTP-J-1 stiffness was observed in five noncompliant patients, but this was resolved completely after intensive physical therapy programs. There was no case of overcorrection, recurrence, avascular necrosis (AVN), or MTP-J-1 arthrosis.

Superficial pin-tract infection was detected in 5 feet (three patients) and treated by local care only. No patient was dissatisfied with the surgical outcome of the HV correction or with the surgical scars.

Radiological evaluation

The first IMA decreased from 13.7±3° (range, 10–20°) preoperatively to 5.6±1.5° (range, 4–12°) at the time of the final follow-up. The mean HVA improved to 12.4±5.4° (range, 7–23°) at the time of the final follow-up compared with31.4±10.1° (range, 29–42°) preoperatively. Mild MT-1 shortening was recorded with a mean shortening of 1.67±0.4 mm.

Discussion

During weight bearing, if the first metatarsal arch collapses, orientation of the first metatarsal axis will change toward vertical and predisposes to adduction of the first metatarsal, which initiates the deformity. Minimally invasive double-osteotomy enables a multiplanar correction in a prone, supine, or a neutral position of the metatarsal head after osteotomy.

In severe HV, orientation of the first MTP-J axis (different from the first metatarsal axis) is altered.

In this study, a MIDMO-based procedure was successfully used as a part of surgical technique to correct, with concomitant limited DLSTR, the distal components of severe HV deformity. Lateral translation of osteotomy corrects HVA deviation and narrows the forefoot. Increased DMAA is corrected by medial tilting of the distal fragment which is permitted by the direction of the osteotomy, whereas the subluxation is corrected by DLSTR. Another proximal linear osteotomy is performed to correct the residual IMA deviation which results in achieving a smooth correction of all components of the deformity. Increasing tilting of the distal fragment will, theoretically, allow correction of wide range of preexisting deformities. However, it may be so difficult to obtain full correction of all components of the deformity in severe HV presentations by this type of osteotomy alone [10].

Concomitant DLSTR is mandatory, particularly in passively uncorrectable deformity. If DLSTR remains a vital component in achieving successful correction, then coupling this release with wide displacement of osteotomy fragments carries great risks regarding damage of vascular supply to the MT-head and increases the risk of complications. We performed no more than 60% of displacement at the distal osteotomy, as extreme tilting may affect stability, healing potential, and may be injurious to the extraosseous laterally located blood supply to first metatarsal head. These structures on the lateral side are important for the blood supply of the distal fragment [11].

There were no cases of AVN of the head of the MT-1 in this series, as the procedure respects the safe zone for distal structures. The limited DLSTR with preservation of capsular insertions, the less severe bony displacements, and the careful use of the electric saw (to avoid thermal damage or over penetration of the lateral cortex) were found to minimize the risk of this complication [12].

In the current study, proximal osteotomy is proposed to be easier, and less invasive procedure as compared with the traditionally used alternative techniques [13]. Furthermore, the proximal correction depends mainly on translation, not rotation; hence, there is no negative effect on DMAA. On the contrary, traditional proximal osteotomy alone, in spite of having a high corrective power for severe first metatarsal varus deviation, can worsen preexisting increased DMAA, as it depends on lateral rotation of MT-1, hence the importance of adding a distal osteotomy to reorient metatarsal head medially [14].

In this study, complete union occurred in all cases in a mean 6.67±0.45 weeks. The average displacement of osteotomies provides good contact area for union. The use of 3-mm K-wires in the aforementioned osteotomies and protected partial weight bearing were sufficient to provide stability. There was a statistically significant improvement (<0.001) in all measured radiological angles and clinical scores.

These improvements are comparable or even better than other series [15] using different procedures for severe HV deformity.

Several procedures have been described for DLSTR ranging from simple sectioning of the LMSSL to complete fibular sesamoidectomy, with no universally accepted criteria for the technique of choice [16]. We preferred to be less invasive by weakening the lateral MTP-J-1 capsule and sacrificing only the key deforming element (LMSSL) as the patients had no severe preoperative MTP-J-1 incongruity (not severely subluxated according to inclusion criteria).

In studies of severe HV that used proximal osteotomies with a more extensive DLSTR, the recurrence rate ranged from 0 to 22.9% [17].

Using MIDMO alone, Iannò *et al.* [7] noted 16 (18.8%) deformity recurrences, nine of which were in patients with preoperative HVA more than 40°. In this study, the success in maintaining the acquired correction, may be attributed to good correction of DMAA and reduction of sesamoids, as failure of this reduction is strongly accused of under-correction or recurrence of the deformity. The lateral MTP-J-1 stabilizers were well-preserved in the current series; hence, no case of overcorrection or instability was recorded.

Detachment of these lateral supporting structures can be a potential cause of overcorrection, instability, stiffness, or AVN [18].

The unintended injury of lateral supporting structures during the indirect (blind) transarticular lateral release (TDLSTR) was associated with significantly higher overcorrection rate when compared with the direct open DLSTR [18]. This was in agreement with several reports using different reconstruction techniques [19].

First, metatarsal shortening is a common complication after double-osteotomy procedures owing to more loss of bone at each osteotomy site, which make them hardly indicated for cases with preoperative short MT-1. Incidence of 4- and 5-mm shortening was previously recorded after double-osteotomy techniques [11]. Interestingly, the mean amount of shortening in the current series was only 1.67±0.4 mm. This may be explained by the type of the osteotomy that was used and depends mainly on translation rather than closing wedge. Additionally, intraoperative adjustment could be obtained easily by slight increase in obliquity of the osteotomy or slight plantar flexion of the MT-head.

Sagittal malalignment and shortening of the MT-1 are pitfalls after HV surgery, as they may lead to metatarsalgia [20].

Incidence up to 28 and 61% of sagittal malalignment were reported after proximal osteotomies [13], and some MIDMO series [1], respectively. Tanaka *et al.* [20] documented that feet with metatarsalgia at follow-up showed a mean dorsiflexion malunion of 1.8°, whereas feet with no metatarsalgia showed plantar flexion malunion of 2.0°. This difference was significant. In the current series, there was no case of malunion as intraoperative adjustment of plantar or dorsal displacement of the capital fragment was possible by using the paraosteally placed K-wires as spacers, while their bending acts as a buttress for the displaced segment, preventing redisplacement, and adds stability by three-point fixation. However, in the current study, we encountered other minor complications including five patients: three cases had residual mild metatarsalgia which may be attributed to under-evaluation of a preoperative early arthritis in MTP-J of lesser toes and two patients (3 feet) with temporarily MTP-J-1 stiffness owing to noncompliance of the patients with rehabilitation program. However, they were totally recovered by intensive physical therapy. The carefully controlled sectioning of the MTP-J-1 capsule, less severe displacement at distal osteotomy, the extra-articular position of K-wires, gentle tightening of medial structures, and the supervised rehabilitation programs may be responsible for our satisfactory ROM results. Comparable results were reported in other series [1,12]. On the contrary, significant MTP-J-1 stiffness has been previously documented after osteotomies combined with open DLSTR as compared with TDLSTR [18].

In our preliminary experience with the aforementioned combined osteotomy technique for severe HV deformity, outcomes have been encouraging, and none of the patients were dissatisfied. We deemed that this technique is easier compared with the time, effort, and steeping learning curve that are usually needed to perform traditional osteotomies for severe HV, yet can obtain comparable results.

Conclusion

Minimally invasive percutaneous double first metatarsal osteotomy technique with selective distal soft-tissue dissection provides a simple, adequate reproducible procedure, and effective alternative for treatment of severe HV deformity.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Radwan YA, Mansour AMR. Percutaneous distal metatarsal osteotomy versus distal chevron osteotomy for correction of mild to-moderate hallux valgus deformity. *Arch Orthop Trauma Surg* 2012; **132**:1539–1546.

2 Magnan B, Pezzè L, Rossi N, Bartolozzi P. Percutaneous distal metatarsal osteotomy for correction of hallux valgus. *J Bone Joint Surg Am* 2005; **87**:1191–1199.

3 Trnka H-J., Krenn S, Schuh R. Minimally invasive hallux valgus surgery: a critical review of the evidence. *Int Orthop (SICOT)* 2013; **37**:1731–1735.

4 Giannini S, Faldini C, Nanni M, Di Martino A, Luciani D, Vannini F. A minimally invasive technique for surgical treatment of hallux valgus: simple, effective, rapid, inexpensive (SERI). *Int Orthop (SICOT)* 2013; **37**:1805–1813.

5 Trnka HJ, Hofstaetter SG. Chevron osteotomy with lateral soft tissue release. *J Foot Ankle Surg* 2006; **5**:250–256.

6 Schneider W, Knahr K. Keller procedure and chevron osteotomy in hallux valgus: five-year results of different surgical philosophies in comparable collectives. *Foot Ankle Int* 2002; **23**:321–329.

7 Iannò B, Familiari F, De Gori M, Galasso O, Ranuccio F, Gi G. Midterm results and complications after minimally invasive distal metatarsal osteotomy for treatment of hallux valgus. *Foot Ankle Int* 2013; **34**:969–977.

8 Jones K, Feiwell L, Freedman E, Cracchiolo A. The effect of chevron osteotomy with lateral capsular release on the blood supply to the first metatarsal head. *J Bone Joint Surg Am* 1995; **77**:197–204.

9 Meier PJ, Kenzora JE. The risks and benefits of distal metatarsal osteotomies. *Foot Ankle* 1985; **6**:7–17.

10 De Lavigne C, Rasmont Q, Hoang B. Percutaneous double metatarsal osteotomy for correction of severe hallux valgus deformity. *Acta Orthop Belg* 2011; **77**:516–521.

11 Robinson AHN, Limbers JP. Modern concepts in the treatment of hallux valgus. *J Bone Joint Surg (Br)* 2005; **87-B**:1038–1045.

12 Park HW, Lee KB, Chung JY, Kim MS. Comparison of outcomes between proximal and distal chevron osteotomy, both with supplementary lateral soft-tissue release, for severe hallux valgus deformity: a prospective randomised controlled trial. *J Bone Joint Surg* 2013; **95-B**:510–516.

13 Mann RA, Rudicel S, Graves SC. Repair of hallux valgus with a distal soft-tissue procedure and proximal metatarsal osteotomy. *J Bone Joint Surg Am* 1992; **74**:124–129.

14 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* 1999; **20**:762–770.

15 Sammarco GJ, Idusuyi OB. Complications after surgery of the hallux. *Clin Orthop Relat Res* 2001; **391**:59–71.

16 Thomas RL, Espinoza FJ, Richardson EG. Radiographic changes in the first metatarsal head after distal chevron osteotomy combined with a lateral release through a plantar approach. *Foot Ankle Int* 1994; **15**:285–292.

17 O'Donnell T, Hogan N, Solan M, Stephens MM. Correction of severe hallux valgus using a basal chevron osteotomy and distal soft tissue release. *Foot Ankle Surg* 2010; **16**:126–131.

18 Ahn JY, Lee HS, Chun H, Kim JS, Seo DK, Choi YR, Kim SW. Comparison of open lateral release and trans articular lateral release in distal chevron metatarsal osteotomy for hallux valgus correction. *Int Orthop (SICOT)* 2016; **37**:1781–1787.

19 Perugia D, Basile A, Gensini A, Stopponi M, Simeonibus AU. The scarf osteotomy for severe hallux valgus. *Int Orthop (SICOT)* 2003; **27**:103–106.

20 Tanaka Y, Takakura Y, Kumai T, Sugimoto K, Taniguchi A, Hattori K. Proximal spherical metatarsal osteotomy for the foot with severe hallux valgus. *Foot Ankle Int* 2008; **29**:1025–1030.