Percutaneous double osteotomy of the first metatarsus for correction of severe hallux valgus deformity

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Background
The goal of operative treatment of severe hallux valgus (HV) is to offer relief of pain, correction of forefoot deformity, and a biomechanically functional foot.
However, the authors are constantly exploring ways of moving from open surgery to minimally invasive techniques, replacing large incisions with small 'ports' through which the surgeon works. Percutaneous less-invasive techniques have been successfully used for mild to moderate HV deformities; however, controversy exists for their use in cases with more severe involvement.
Aim
The aim of this prospective study was to assess the clinical and radiological outcomes of a percutaneous minimally invasive technique for the management of severe HV deformity.
Patients and methods
Between July 2013 and June 2015, 36 feet in 24 active patients, comprising 18 female and six male patients, where 12 patients had bilateral involvement, met the selection criteria for symptomatic severe HV deformity and treated by a minimally invasive double metatarsal osteotomy technique. 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 patients' age was 39.8 years.
Clinically, the American Orthopedic Foot and Ankle Society score and the subjective patient satisfaction were evaluated.
Radiologically, HV angle, distal metatarsal articular angle, 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 21.3 months (range: 18–24 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 a negligible first-ray shortening ($P=0.547$) and a few complications. At the end of follow-up period, no patient was dissatisfied.
Conclusions
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 in a minimally invasive procedure.

Keywords:
double metatarsal osteotomy, percutaneous less-invasive metatarsal osteotomy, severe hallux valgus deformity

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Introduction

Hallux valgus (HV) is a common disorder of the forefoot that results from medial deviation of the first metatarsal (MT-1) and lateral deviation and/or rotation of the great toe (hallux) with or without medial soft-tissue enlargement of the MT-1 head (bunion) [1]. 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 increases when patients shift their weight laterally. Orthoses and night splints do not appear to improve outcome, but surgery is reported to be beneficial [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; temporary hardware fixation, which possibly results in lower incidence of complications; early weight bearing, which allows bilateral surgery; and higher patient satisfaction [1–3].

Recently, a percutaneous less-invasive double metatarsal osteotomy (DMO) of the 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 [5–8] and the routine use of Weil's osteotomy in lesser toes to overcome MT-1 shortening after resection of a closing wedge proximally.

In this study, we devised a modified minimally invasive DMO 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. The distal components of the deformity were corrected distally by a subcapital MIDMO-based procedure [1–5], 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 (Fig. 4).

Figure 1

Preoperative dorsoplanter radiograph of the left foot with severe hallux valgus deformity.

Figure 2

Paraosteally position of the K-wire along the medial border of the proximal phalanx.

Patients and methods

Between July 2013 and June 2015, 36 feet in 24 active patients, comprising 18 female and six male patients, where 12 patients had bilateral involvement, with HV angle (HVA) greater than 40° and intermetatarsal angle (IMA) greater than 18°, met our selection criteria for symptomatic severe HV deformity and were treated by a modified minimally invasive DMO technique. The study was approved by Ethical Committee of Tanta University. All patients were operated in Tanta University Hospital after they had signed an informed consent form. Patients' selection criteria are shown. The procedure implied simple transverse-osteotomy, with lateral translation, of the MT-1 both proximally and distally combined with selective distal soft-tissue dissection. Average patients' age was 39.8 years. Clinically, the American Orthopedic Foot and Ankle Society scale and the subjective patient satisfaction were evaluated.

Radiologically, HV angle, distal metatarsal articular angle, intermetatarsal angle, tibial sesamoid position (TSP), and joint congruity were measured preoperatively and at the final follow-up.

Figure 3

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

Figure 4

At the final follow-up with complete union and normal alignment.

Inclusion criteria

The following were the inclusion criteria:

(1) Clinically irreducible deformity, with HVA greater than 40° and IMA greater than 18°.
(2) Painful juvenile HV deformity with an increased distal metatarsal articular angle (DMA) (refractory to conservative treatment for at least 3 months).
(3) Transfer metatarsalgia (functional disability with shoe-fitting problems).

Exclusion criteria

The following were the inclusion criteria:

(1) Severe degenerative changes of the first MTP-J-1 (HV et rigidus).
(2) Severe ankle and foot deformities.
(3) Failed previous HV surgeries.
(4) Generalized joint hyperlaxity and hypermobility of MT-C-J-1.
(5) Uncertain compliance.

Surgical technique

Under distal ankle-block 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 positioned to the patient's side, and a thigh tourniquet was applied. A small 15–20-mm dorsal first webspace 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 3-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 capital 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 re-displacement at the second osteotomy. Finally, the medial capsule was closed, without overtightening, after excising the redundant edges, whereas its tension was checked under fluoroscopy to confirm congruency of the MTP-J-1.

Postoperative Management

(1) Full weight bearing is encouraged on the day after surgery using a postoperative flat-soled shoe.
(2) Prophylaxis of thrombosis is recommended for 1 month.
(3) The great toe is 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 Kirschner wire and preventing recurrence of the deformity. A plantar kidney-shaped pad with its concavity surrounding the plantar aspect of the head of the MT-1 is used to reduce weight-bearing pressure beneath the capital fragment and to prevent dorsiflexion of the capital fragment.
(4) The Kirschner wires are removed after 4 weeks.
(5) The tape is removed at 6 weeks following surgery, and the patients are instructed to the rehabilitation protocol, taking particular care to obtain full dorsiflexion of great toe within 4–6 weeks.

Radiological evaluation

Posteroanterior weight-bearing foot radiographs were done preoperatively and postoperatively to evaluate the HVA, DMAA, IMA, and TSP [9,10].

HVA is the angle between the longitudinal axis of the MT-1 and that of the proximal phalanx. DMAA is angle between a line perpendicular to another line connecting the distal articular margins of MTP-J-1 and the longitudinal axis of the MT-1. IMA is the angle between the longitudinal axis of the first and second metatarsals.

TSP is the position of tibial sesamoid relative to the longitudinal axis of the MT-1 in grades (0–3) [11]. 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 done for evaluation of any sagittal subluxation or malalignment.

Results

Clinical evaluation

According to the American Orthopaedic Foot and Ankle Society hallux metatarsophalangeal-interphalangeal scale for the clinical assessment, a mean score of 86.9±12.6 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 final follow-up, all patients restored hallux function and near-normal gait pattern. Complete pain relief was achieved in 20 patients (30 ft), whereas the other four patients (6 ft) 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 ROM at the final follow-up was 54.36±18.48°of dorsiflexion and 32.18±7.38° of plantar-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, AVN, or MTP-J-1 arthrosis.

Superficial pin-tract infection was detected in 8 ft (six 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 intermetatarsal angle decreased from 14.3±3° (range: 10–20°) preoperatively to 6.7±2.3° (range: 4–16°) at the time of final follow-up. The mean HV angle improved to 13.6±6.4° (range: 8–25°) at the time of final follow-up compared with 31.7 ±10.3° (range: 19–42°) preoperatively. Mild MT-1 shortening was recorded with a mean shortening of 1.67±0.4 mm. There were statistically significant improvements (P<0.001) in HVA, IMA, and DMAA, after surgery. All incongruent MTP-J-1 became congruent postoperatively and till the last radiographs.

Discussion

In severe HV, orientation of the first MTP-J-1 axis (different from the MT-1 axis) is altered.

The collapse of MT-1 arch segment underweight bearing orients the MT-1 axis toward vertical and predisposes to adduction of the MT-1, 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 the current series, 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. The direction of osteotomy allows medial tilting of the capital fragment to correct increased DMAA, whereas DLSTR corrects the subluxation component.

The residual IMA deviation was then corrected proximally by another linear osteotomy to achieve smooth correction of all components of the deformity. Increasing tilting of the capital fragment will, theoretically, allow correction of a wide range of pre-existing deformities. However, it may be extremely difficult to obtain full correction of all components of the deformity in severe HV presentations by this type of osteotomy alone [5].

Concomitant DLSTR is mandatory, particularly in passively uncorrectable deformity [6–8]. 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 MT-1 head. These structures on the lateral side are important for the blood supply of the distal fragment [9,10,12].

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 [13].

In this study, proximal osteotomy is proposed to be easier and a less-invasive procedure as compared with the traditionally used alternative techniques [12–19]. 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 MT-1 varus deviation, can worsen pre-existing increased DMAA, as they depend on lateral rotation of MT-1, hence the importance of adding a distal osteotomy to re-orient metatarsal head medially [12,20].

In this study, complete union occurred in all cases in a mean of 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 [5,13,15–20] 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 [6–8,21]. 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-1incongruity (not severely subluxated according to inclusion criteria).

In the studies of severe HV that used proximal osteotomies with a more extensive DLSTR, the recurrence rate ranged from 0 to 22.9% [13,15–19].

Using MIDMO alone, Iannò *et al.* [5] noted 16 (18.8%) deformity recurrence rate, nine of which were in patients with preoperative HVA greater than 40°. In this series, 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 suspected for under-correction or recurrence of the deformity [22]. 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 [6–8,10,23,24].

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 [24].

This was in agreement with several reports using different reconstruction techniques [11,13,16–19].

MT-1 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-mm and 5-mm shortening was previously recorded after double osteotomy techniques [11,20]. 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 a 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 [12,18].

Incidence up to 28 and 61% of sagittal malalignment were reported after proximal osteotomies [14] and some MIDMO series [2], respectively. Tanaka *et al.* [18] 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 this 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, whereas their bending acts as a buttress for the displaced segment, preventing re-displacement, and adds stability by three-point fixation. However, in the current series, 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-1 of lesser toes, and two patients (3 ft) 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 [2,11,13,16]. On the contrary, significant MTP-J-1 stiffness has been previously documented after osteotomies combined with open DLSTR as compared with TDLSTR [24].

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.

Conclusions

Percutaneous double MT-1 osteotomy technique with selective distal soft-tissue dissection provides a simple, adequate reproducible procedure and an effective alternative for treatment of severe HV deformity in minimally invasive procedure.

It is cost-effective and provides technical (simple, and reproducible uniplanar osteotomies that correct all components of deformity), biomechanical (smooth correction at 2 affected-levels, stable, corrects DMAA, and not causing marked MT-1 shortening), and biological (small wounds, less severe displacements, and minimal release) advantages.

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Conflicts of interest

There are no conflicts of interest.

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