MINIMALLY INVASIVE DISTAL METATARSAL OSTEOTOMY FOR MILD-TO-MODERATE HALLUX VALGUS DEFORMITY

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Minimally invasive surgery has recently been introduced for foot and ankle surgery, and hallux valgus surgery is no exception. The purpose of our study was to analyze the early results and to present our experience of minimally invasive distal metatarsal osteotomy in correcting mild-to-moderate hallux valgus deformities. Between September 2005 and December 2006, 31 consecutive patients (47 feet) with mild-to-moderate hallux valgus deformities underwent minimally invasive distal metatarsal osteotomies. The clinical and radiographic outcomes were assessed. The satisfaction rate was 90.32%. The mean total American Orthopedic Foot and Ankle Society hallux-metatarsophalangeal-interphalangeal scale was 92.7 points. Complications included two (4.26%) episodes of stiffness, six (12.77%) episodes of pin tract infection, and one (2.13%) deep infection. There were no cases with nonunion, malunion, overcorrection, transfer metatarsalgia or osteonecrosis. On weight-bearing anteroposterior foot radiographs, the mean hallux valgus angle and first intermetatarsal angle corrections were 11.8° and 6.3°, respectively, which is a statistically significant difference (p < 0.001) between the preoperative and postoperative status. Here, minimally invasive distal metatarsal osteotomy was associated with good satisfaction, functional improvement and low complication rates. This technique offers an effective, safe and simple way to treat hallux valgus with a first intermetatarsal angle less than 15°.

Key Words: hallux valgus, minimally invasive
complications related to surgical exposure. The purpose of our study was to analyze the early results and to present our experience with MI DMO to correct mild-to-moderate hallux valgus deformities.

**Materials and Methods**

**Patient selection and perioperative data**
Between September 2005 and December 2006, 31 consecutive patients (47 feet) with hallux valgus deformities underwent MI DMO by senior surgeons at our institute (PJH and YMC). The inclusion criterion was painful primary mild-to-moderate hallux valgus deformity with a first intermetatarsal angle $\leq 15^\circ$ [2]. Exclusion criteria were hallux rigidus or a history of previous surgery on the affected hallux. All patients received conservative treatment for at least 2 months before surgery.

The demographic and baseline characteristics of the study population are summarized in Table 1, including sex, age, preoperative symptoms, operative procedures and operation time. There were four (12.9%) males and 27 (87.1%) females. The mean age was 40.8 years (range, 13–63 years). All patients complained of bunion pain due to footwear. Bilateral MI DMO was performed at the same time in 16 (51.6%) patients. The mean operation time for unilateral MI DMO was 14.4 minutes, and the mean operation time for bilateral MI DMO was 27.2 minutes.

**Surgical technique**
The MI DMO approach used here was modified from the method described by Magnan et al [9] but without fluoroscopy. First, a 1.5-cm skin incision was done and centered over the medial aspect of the first metatarsal neck. The incision was carried directly to the bone. The periosteum was elevated, and the osteotomy site was brought into vision. The osteotomy was performed at the subcapital level with an oscillating saw in a single plane, perpendicular to the metatarsal shaft axis.

Then, a 2.0-mm Kirschner wire was inserted percutaneously from the level at the middle of the proximal phalanx and advanced manually in a distal-to-proximal direction along the medial aspect of the metatarsal head in a parosteal position until the tip was observed in the incision wound. The wire can be inserted more dorsally or plantarly for metatarsal head plantar or dorsal translation later in accordance with the operating plan. Usually, however, the wire is placed in the midline for optimum metatarsal head engagement and control. Lateral translation of the metatarsal head was done and the wire was introduced under direct vision into the medullary canal of the metatarsal shaft. The correction of the big toe was determined grossly. Then, the wire was driven through the first tarso-metatarsal joint for greater stabilization (Figure 1).

A plantar pad was placed under the operated foot to reduce weight-bearing pressure under the first metatarsal head area. An elastic bandage was used as a postoperative dressing to hold the big toe in alignment. It was taped in a supination manner to counteract pronation of the big toe [10]. Postoperatively, the patients were allowed to bear weight with specially designed shoes on the day after surgery. The Kirschner wire was removed 6 weeks postoperatively. Patients were allowed to bear weight with normal shoes, and range of motion exercises of the first metatarsophalangeal joint was carried out from then on.

**Clinical assessment**
Clinical assessments were recorded postoperatively, including the visual analog scale, satisfaction, complications and the hallux-metatarsophalangeal-interphalangeal (Hallux-MTP-IP) scale proposed by the American Orthopedic Foot and Ankle Society (AOFAS) [11]. Satisfaction was evaluated as the patient’s willingness to undergo surgery again or not. Complications included any infection, nonunion, malunion, transfer

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**Table 1. Demographic and baseline characteristics for 31 patients who underwent minimally invasive distal metatarsal osteotomies**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
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<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>4 (12.9)</td>
</tr>
<tr>
<td>Female</td>
<td>27 (87.1)</td>
</tr>
<tr>
<td><strong>Age (yr)</strong></td>
<td>40.8 $\pm$ 13.8 (13–63)</td>
</tr>
<tr>
<td><strong>Preoperative symptoms</strong></td>
<td></td>
</tr>
<tr>
<td>Bunion pain due to footwear</td>
<td>31 (100)</td>
</tr>
<tr>
<td><strong>Operation procedure</strong></td>
<td></td>
</tr>
<tr>
<td>Unilateral</td>
<td>15 (48.4)</td>
</tr>
<tr>
<td>Bilateral</td>
<td>16 (51.6)</td>
</tr>
<tr>
<td><strong>Operation time (min)</strong></td>
<td></td>
</tr>
<tr>
<td>Unilateral</td>
<td>14.4 $\pm$ 4.9 (6–21)</td>
</tr>
<tr>
<td>Bilateral</td>
<td>27.2 $\pm$ 9.1 (16–51)</td>
</tr>
</tbody>
</table>

*Data presented as n (%) or mean $\pm$ standard deviation (range).
metatarsalgia, osteonecrosis and overcorrection (secondary hallux varus), for example. All analyses of clinical data were performed by a single observer to decrease potential bias.

Radiographic assessment
Weight-bearing anteroposterior and lateral radiographs were taken preoperatively, postoperatively and at the time of final follow-up. Radiographic parameters included the hallux valgus angle (HVA) and the first intermetatarsal angle (FIMA), which were measured as described by Mitchell et al [12] using the center of the articular surface of the metatarsal head and the proximal articulation as reference points to draw the first metatarsal axis. All analyses of radiographic data were performed by a single observer to decrease potential bias.

Statistical analysis
Standard paired Student’s t test was used to compare the preoperative hallux valgus angle and first intermetatarsal angle with the values at the final follow-up. The level of significance was set at \( p < 0.05 \).

RESULTS

Clinical results
The mean follow-up period was 23.7 weeks, ranging from 16 to 68 weeks. The average visual analog scale score was 9.02 points. Twenty-eight (90.32%) patients were willing to undergo the same surgery again. Complications included two (4.26%) episodes of stiffness, six (12.77%) episodes of pin tract infection, and one (2.13%) deep infection. There were no episodes of nonunion, malunion, overcorrection, transfer metatarsalgia or osteonecrosis.

The overall follow-up AOFAS scores of the 47 consecutive MI DMOs are presented in Table 2. The mean total AOFAS score was 92.7 points. The overall pain score averaged 35.7 points. There was no pain in 27 feet (57.45%), and mild pain in 20 feet (42.55%). The mean overall functional score and alignment score were 43.6 points and 13.4 points, respectively.

Radiographic results
The radiographic results of the 47 consecutive MI DMOs are presented in Table 3. The mean HVA decreased from 26° preoperatively to 14.2° at the final follow-up (\( p < 0.001 \)). The FIMA decreased from an average of 11.6° preoperatively to 5.3° at the final follow-up (\( p < 0.001 \)).
DISCUSSION

In recent years, MI techniques have been developed for foot and ankle surgery [13], and hallux valgus surgery is no exception [8,9,14–17]. MI distal first metatarsal osteotomy with a percutaneous technique was first described by Bösch et al in 1990 [14], and a satisfactory result was reported in a 7–10-year follow-up study [15]. Portaluri achieved an 89% satisfaction rate with the Bösch method [16] and stated that the advantages of this technique included short operation time and low incidence of complications. Sanna and Ruiu reported excellent results in a long-term follow-up study of percutaneous distal first metatarsal osteotomies [17]. Magnan et al reported that the patients were satisfied following 107 (91%) of 118 percutaneous distal first metatarsal osteotomies [8]. Numerous studies have revealed that MI hallux valgus surgery can achieve a good satisfaction rate similar to other open techniques [6,10,12,18–23].

The DMO in our study was a MI simple bony procedure without other advanced soft tissue procedures. We did not perform bunion resection, formal capsulorraphy, lateral release or capsulotomy. We did not use a fluoroscopic image intensifier and to prevent exposure to irradiation. The procedure was simplified and soft tissue damage was reduced as much as possible. The advantages of MI surgical techniques, including shorter operation time, better cosmetic appearance and smaller wound size, were gained, and the satisfaction rate was 90.32% in this study.

The AOFAS Hallux-MTP-IP scale is a popular instrument that assesses the clinical outcomes of hallux valgus surgery. In previous studies that used open techniques, the mean total AOFAS scores range from 83 to 93 points [19,22,23]. Magnan et al reported a mean total AOFAS score of 88.2 points using percutaneous distal first metatarsal osteotomy [8]. In our study, the mean total AOFAS score was 92.7 points. This indicated that good functional improvement can be achieved with MI hallux valgus surgery.

In Magnan et al’s and our studies, the Kirschner wire was uniquely transfixed to the first metatarsophalangeal joint medial capsule instead of being used to fix the bony capital fragment. Because the Kirschner wire was stabilized proximally, the stiffness of the wire contributed to the lateral translation of the capital fragment. Thus, there bunion resection was not necessary in our procedures because more medial eminence was preserved and resulted in greater lateral translation of the capital fragment. In our study, the mean HVA and FIMA corrections were 11.8° and 6.3° (Table 3) compared with 17.8° and 5.1° in Magnan et al’s study [8]. It has been demonstrated that the mean HVA correction ranged from 8.8° to 26°, and the mean FIMA correction ranged from 3.8° to 11° in studies that used open techniques [1,10,18–23]. Our results indicate that this MI technique can achieve angular correction that is as good as that achieved using traditional techniques.

A limitation of this approach is that we were unable to control the magnitude of lateral translation. This method simply relied on the stiffness of the Kirschner wire and the size of the capital fragment to achieve lateral translation. We believe that the magnitude of angular correction might limit the use of our approach to treat more severe hallux valgus deformities. This explains why the inclusive criterion in our study was set at first intermetatarsal angle $\leq 15°$.

The absence of lateral release or formal capsulorraphy might explain the absence of hallux varus after surgery [8]. In Magnan et al’s and our studies, there were no episodes of hallux varus (overcorrection). However, the HVA might increase after removal of the Kirschner wire without such soft tissue procedures. The valgus deformity recurrence rate reported by Magnan et al was 2.5%. In our study, we also found a tendency towards an increase in HVA after removing the Kirschner wire. In other studies that used open techniques in association with soft tissue procedures, the recurrence rate ranged from 0% to 10% [10,12,20–22,24]. Although some of our cases had an
increase in HVA after Kirschner wire removal, the HVA and FIMA were significantly decreased at final follow-up (Table 3).

We considered approaches to avoid under correction. First, a slight overcorrection was needed to prevent recurrence of the deformity. We found that most of the cases with under correction were early cases in our series who did not undergo slight overcorrection during surgery. Second, the Kirschner wire insertion level in our study was at the middle of the proximal phalanx. We thought that a more distal percutaneous insertion level of the Kirschner wire, as in Magnan et al’s study, might achieve a greater correction of the hallux valgus angle because of a longer level arm to abduct the big toe.

Postoperative stiffness of the first metatarsophalangeal joint is a significant concern in hallux valgus surgery. Soft tissue dissection around the first metatarsophalangeal joint causes stiffness in proportion to the extent of dissection [25]. Stiffness of first metatarsophalangeal joint was reported to range from 0% to 37.8% using open techniques with capsulotomy [10,20,21,24]. In MI DMO, because capsulotomy was not performed, the effect on the postoperative range of motion of the hallux was thought to be limited. Eight (6.8%) first metatarsophalangeal joints were stiff in Magnan et al’s study [8]. In our study, the stiffness rate was 4.26%. The reason for the postoperative stiffness might be due to unsuccessful rehabilitation after removing the Kirschner wire.

Transfer metatarsalgia, which might affect clinical outcomes, is a serious complication after first metatarsal osteotomy [10]. Transfer metatarsalgia occurred with a range from 0% to 40% in studies that used other open techniques [10,21,23,24]. Transfer metatarsalgia was not reported in our series, and it was not mentioned by Magnan et al [8]. The absence of transfer metatarsalgia might be due to two factors. First, the osteotomy performed in MI DMO was in a single perpendicular plane, which was unable to cause over-shortening of the first metatarsal. Second, there was no dorsiflexion of the capital fragment in the lateral radiographic image after surgery (Figure 2).

In our study, there were no episodes of nonunion, malunion or osteonecrosis of the first metatarsal head. The overall infection rate was 14.9% (7 feet). One (2.13%) of these was a deep infection, which healed after removal of the Kirschner wire 3 weeks postoperatively. However, the deformity recurred in this case. Other cases (12.77%) were pin tract infection, which was treated with oral antibiotics and pin tract care, without further complications, and did not influence the final results.

In conclusion, we have reported preliminary results for MI DMO. Good satisfaction, functional improvement, and low complication rates were achieved with this technique. Thus, MI DMO offers an effective, safe and simple way of treating mild-to-moderate hallux valgus deformities. We now routinely use this technique to treat hallux valgus with a first intermetatarsal angle less than 15°. For cases with a larger first intermetatarsal angle, we believe that a formal distal soft tissue procedure in combination with other distal or proximal metatarsal osteotomy is more appropriate. A well-designed prospective randomized controlled study with long-term results of a large study population is needed to support general use of this MI technique.

REFERENCES


使用微創遠端踝骨切骨手術治療輕至中度大腳趾外翻

林育全 鄭裕民 張瑞根 陳崇桓 黃鵬如
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近年來，微創手術在足踝手術領域漸趨發展，其中當然包括應用於大腳趾外翻。我們研究的目的，乃針對輕至中度大腳趾外翻施行微創遠端踝骨切骨手術，並對其治療結果及預後進行分析。從 2005 年 9 月至 2006 年 12 月，共有 31 位輕度至中度大腳趾外翻的病人（共 47 隻腳）接受微創切骨手術。我們根據其臨床及影像結果來評估。在臨床上，病人滿意度達 90.32%，而美國足踝學會功能量表平均分數有 92.7 分。併發症包括 2 例術後關節僵硬，6 例鋼釘傷口感染，僅 1 例深部感染，並沒有發現切骨處未癒合、癒合不良、過度矯正、轉移性踝骨疼痛及骨缺血性壞死等問題。在 X 光影像上，大腳趾外翻角度及第一踝骨間角度分別可被矯正 11.8 度及 6.3 度，和手術前比較具統計上顯著性差異。因此，我們的微創切骨手術不僅能達到良好的滿意度及功能，並且有低併發症發生率，對於輕至中度大腳趾外翻而言，確實是個有效、安全且簡單的治療方法。

關鍵詞：大腳趾外翻，微創
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