Ludloff's diaphyseal osteotomy in the treatment of hallux valgus

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Received 18 October 2017
Accepted 20 December 2017

The Egyptian Orthopaedic Journal
2017, 52:221–225

Background
Proximal first metatarsal osteotomy combined with distal soft tissue procedure is recommended for the surgical treatment of moderate to severe hallux valgus (HV) deformity with increased intermetatarsal (IM) angle.
Materials and methods
This is a retrospective study evaluating the results of the Ludloff's osteotomy, stabilized with two lag screws, for the management of HV cases with HV angle greater than 40° and IM angle greater than 13°. The procedures were undertaken from January 2011 and August 2015 and were done by the authors. The study included 16 female patients. All patients were assessed using the American Orthopedic Foot and Ankle Society Score preoperatively and postoperatively.
Results
There was a mean correction of HV angle of 30.6° and of IM angle of 7.9°. The average American Orthopedic Foot and Ankle Society Score improved from 48 preoperatively to 92 postoperatively. The average first metatarsal shortening noted was 1.4 mm. One case experienced transfer metatarsalgia. One case had nonunion, which was managed with revision fixation and bone graft.
Conclusion
Ludloff's osteotomy is a valuable operative management technique for moderate and severe HV, with low rate of complications.

Keywords:
hallux valgus, Ludloff's osteotomy, metatarsal osteotomy, proximal metatarsal osteotomy

Egypt Orthop J 52:221–225

1110-1148

Introduction

Hallux valgus (HV) is varus angulation of the first metatarsal with lateral displacement of the sesamoids and extensor tendons resulting in lateral deviation and/or rotation of the hallux. More than 130 surgical procedures have been described, particularly soft tissue release and bony correction using proximal and distal first metatarsal osteotomy [1].

Moderate to severe HV deformity with a first intermetatarsal (IM) angle of 15° is typically corrected with a first metatarsal osteotomy combined with a distal soft tissue procedure. In 1918, Ludloff's described an oblique osteotomy of the first metatarsal oriented from dorsal-proximal to distal-plantar when viewed in the sagittal plane. The original osteotomy did not include fixation, resulting in shorting of metatarsal. Later, a modified technique included fixation with two screws to increase stability and prevent shortening.

Recent clinical and biomechanical studies have suggested that this technique is reliable for the treatment of moderate to severe HV deformities [2–9].

The aim of our study was to evaluate the outcome of Ludloff's diaphyseal osteotomy as a treatment modality for HV.

Materials and methods

Patients

A total of 16 cases of HV operated upon between January 2011 and August 2015 were enrolled in this retrospective study. All the cases were females. The mean patient age was 38 years (range: 19–56 years). All procedures performed in this study were in accordance with the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards.

Diagnosis

The patients were examined clinically for range of motion of first metatarsophalangeal joint, first tarsometatarsal (TMT) joint stability, and the presence of lesser metatarsal head plantar callosities as an indication of transfer metatarsalgia. American Orthopedic Foot and Ankle Society Score (AOFAS) hallux-interphalangeal (IP) joint score for each case was recorded for assessment of its improvement after surgery.

 DOI: 10.4103/eoj.eoj_62_17

The patients were evaluated with standard weight-bearing anteroposterior and lateral radiographies to evaluate the IM and hallux valgus angles (HVAs). According to these measurements, 10 (62%) patients had moderate deformity with IM angle more than 13° and HVA more than 40°. The remaining six (38%) patients had severe deformity, with IM angle from 16 to 20° and HVA from 41 to 50°.

Operative technique

With the use of tourniquet, a dorsal incision is made over the first web space for the lateral soft tissue release, through the incision. The lateral capsule (the metatarsosesamoid ligament) is incised longitudinally, dorsal to the lateral sesamoid dorsomedial. The great toe was forced manually into a 20° varus position, and then release of the adductor tendon was performed. One suture was placed through the lateral aspect of the first metatarsal and the medial periosteum of the second metatarsal to be tied after the osteotomy is completed.

A second skin incision is made extending proximally from the first metatarsal phalangeal joint to the base of the first metatarsal. The capsulotomy is extended proximally through the periosteum of the first metatarsal. After finishing bunionectomy, the osteotomy is performed. The osteotomy extends from 1.5 cm distal to the base of the first metatarsal (proximal dorsal to distal planter), ending proximal to the sesamoid bones. Sloping of the osteotomy plane 10° plantar-laterally minimizes effective shortening [6,10]. Temporary fixation in the proximal part of osteotomy is accomplished with a Kirschner wire, or a screw, and then the distal part of osteotomy is completed. The distal fragment is rotated around the wire or screw to correct the IM angle and fixed with a second screw. The protruding medial edge of proximal fragment was removed. Closure is performed in a typical fashion.

Follow-up

Postoperative short-leg nonwalking cast was used for 3 weeks. Full weight bearing starts 3 weeks after surgery.

The mean follow-up period was 36 months (range: 11–60 months). The patients were examined in the outpatient clinic at 1, 3, and 6 weeks for wounds healing, pain improvement, radiological correction of IM, HVAs, and osteotomy union. The patients were followed up yearly and assessed according to AOFAS hallux-IP joint score and patient satisfaction.

Results

The average operative duration was 90 min (range: 60–110 min). Fifteen cases had union by 6 weeks, and only one case had nonunion managed with bone grafting and revision of fixation with screws. Postoperative intermetatarsal angle (IMA) average was 9.4° (range: 8.8–10.5°) and HVA average was 13.4° (range: 12–14°). These reductions were statistically significant ($P<0.05$).

The average first metatarsal shortening noted was 1.4 mm (range: 1.7–1.2 mm). One case experienced transfer metatarsalgia.

Follow-up of patients showed significant improvement of AOFAS hallux-IP joint score [preoperative score 48 (range: 42–55) compared with postoperative score range 92 (range: 77–98)], favorable patient satisfaction, and correction of radiographic hallux alignment [preoperative IMA 17.5° (range: 13–20) and HVA 44° (range: 40–50) compared with postoperative IMA 9.4° and HVA 13.4°] (Figs 1 and 2).

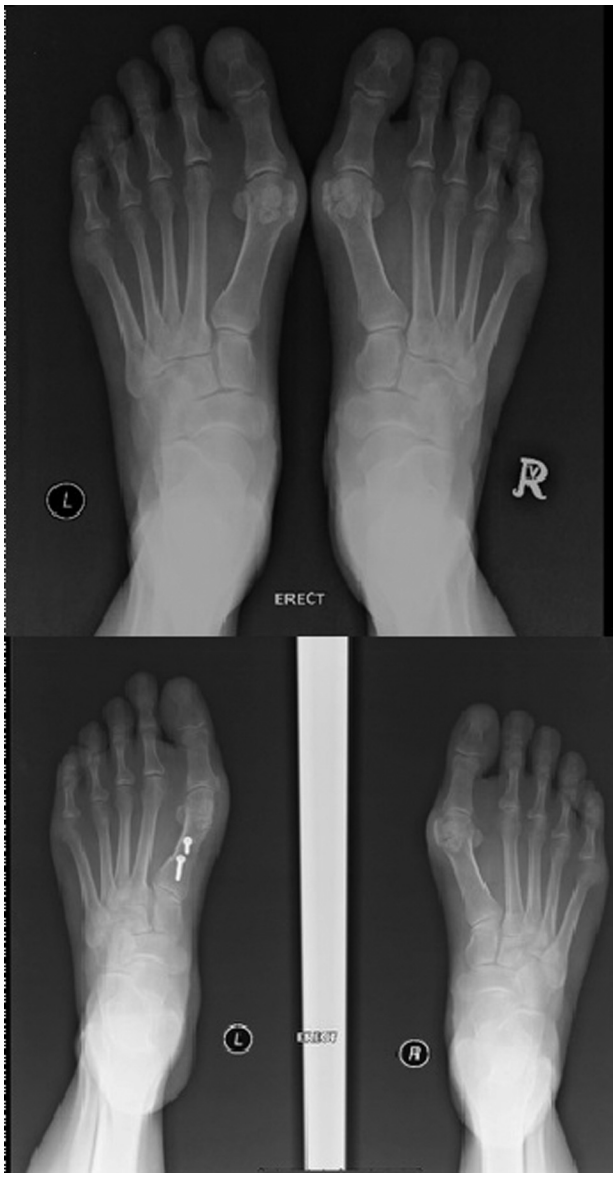
Discussion

Operative management of HV usually involves a combination of soft tissue and bony procedures. In moderate to severe deformity, distal osteotomies are associated with a high recurrence rate, and several first metatarsal shaft and proximal osteotomies have been used such as scarf, proximal chevron, proximal open wedge, Mau, proximal closing wedge, and Ludloff's osteotomies [11]. Researchers continue to study the advantages and disadvantages, both biomechanically and clinically, of the different options [3,4,6,8–10,12–20].

Ludloff's osteotomy is an oblique osteotomy and is particularly useful for correcting large IMAs. As originally described in 1918, the osteotomy was performed without any fixation. In the mid-1990s, Castaneda *et al.* [21] modified the procedure focusing on fixation of osteotomy to prevent any loss of correction during fixation and metatarsal shortening.

Lian *et al.* [22] have demonstrated that the bending strength of the Ludloff's osteotomy fixed with two screws is 82% greater than that of a crescentic osteotomy fixed with a single screw. Moreover, Trnka *et al.* [23] demonstrated that the Ludloff's osteotomy is significantly more rigid than both the proximal crescentic and chevron osteotomies. Nyska *et al.* [6] found greater stability with the Ludloff's osteotomy compared with the proximal crescentic and chevron osteotomies and reported that the

Figure 1



Preoperative and postoperative radiography of patient with left hallux valgus.

Figure 2

Clinical appearance of foot preoperative and postoperative of Ludloff's osteotomy.

Ludloff's osteotomy was associated with minimal metatarsal shortening. Scott *et al.* [15] compared the mechanical properties of a proximal chevron osteotomy fixed with a medial locking plate and a Ludloff's osteotomy fixed with two screws in a cadaveric model. They found that the bending stiffness of the Ludloff's osteotomy exceeded that of the proximal chevron [15]. The long osteotomy plane and additional fixation make the Ludloff's very stable to both bending and cyclic loading [13,14].

Additional fixation was described in the literature to improve stability and allow for earlier mobilization. Stamatis *et al.* [24] described the addition of a mini-locking plate as a buttress in addition to the screws, although they did not mention the incidence of prominent hardware, which could be higher with this technique. Schon *et al.* [8] used 1 or 2 Kirschner wires where the second screw fixation is not adequate. Stamatis *et al.* [18] demonstrated adequate fixation using threaded Kirschner wires in a biomechanical cadaver study. Saxena *et al.* [25] concluded that he use of a medial locking plate is superior to stabilization using two lag screws when performing the Ludloff's osteotomy particularly regarding maintaining correction [25,26].

In addition to mechanical stability, Ludloff's osteotomy has other advantages. Beischer *et al.* [16] studied the spatial geometry using three-dimensional computer modeling software and determined that the optimal Ludloff's osteotomy starts at the dorsum of the first metatarsal base at the first TMT joint and extends distally and plantarwards to a point just proximal to the sesamoid articulation to limit first metatarsal shortening, elevation, and sagittal plane rotational malalignment. In addition, a tilt of 10° in the coronal plane of the osteotomy is necessary to limit first metatarsal head elevation [16].

Nyska *et al.* [26] reported that it is a simple osteotomy, and it allows angular correction through bony rotation which allows greater correction than that obtained by displacement osteotomies [25].

There are possible complications of Ludloff's osteotomy including loss of fixation, malunion, and nonunion.

Loss of fixation and fracture of the dorsal fragment is possible in osteopenic bone or if the proximal screw is

inserted too close to the proximal end of the dorsal fragment. In addition, failing to countersink the screw head may also increase fracture risk.

Dorsal malunion may result if the saw blade is angled upward relative to the sagittal plane of the metatarsal forcing the metatarsal head into an elevated and pronated position. Persistent pronation of the hallux increases the risk of transfer metatarsalgia and deformity recurrence.

Hallux varus may develop with overcorrection of IM angle, excessive plication of the medial capsule, or excessive resection of the medial eminence.

In addition, infection and/or symptomatic hardware may require subsequent surgery. The complications listed may be the result of technical error or postoperative noncompliance with weight-bearing restrictions [16].

Clinically, our results demonstrate that the Ludloff's osteotomy minimizes the incidence of dorsiflexion malunion with only one case of transfer metatarsalgia.

We had a case of nonunion, which was managed with revision of fixation and bone graft. These results are comparable to favorable results of other publications. Saxena and McCammon [7] reported the results of 14 cases. The mean HVA was corrected from 30.1 to 13.4°, and the mean IMA was corrected from 15.9 to 9.4°. Metatarsal shortening was 1.4 mm, with no dorsal malunion. One patient had transfer metatarsalgia postoperatively [7].

Chiodo *et al.* [3] reviewed 70 cases that had a Ludloff's osteotomy for correction of HV. The average HVA and IMA were corrected from 31° and 16° preoperatively to 11° and 7° postoperatively. The mean AOFAS improved from 54 to 91 points and 98% of patients were satisfied with the results of surgery. The first metatarsal was shortened by an average of 2.3 mm. Complications consisted of prominent hardware in five, hallux varus in four, delayed unions in three healed with an extended period of protected weight bearing, superficial infections in four patients, neuralgia in three, and immediate recurrence requiring revision of the distal capsular repair in one. There were no patients with transfer metatarsalgia or nonunion [3].

Trnka *et al.* [20] reported on 111 Ludloff's procedures having 80% good to excellent results. There was significant improvement in AOFAS from 53 to 88 points. Patients younger than 60 years were happier with the procedure than patients older than 60 years. The IMA was corrected from 17° to 8°, and HVA was corrected from 35° to 9°. The mean shortening of the first metatarsal was 2 mm. Complications included four recurrences (two of which showed radiologic features of TMT instability) and nine hallux varus (only two were symptomatic); five patients had prominent hardware and a 2% incidence of delayed union. There was no incidence of dorsal malunion [20].

The greatest limitation of the present study is its retrospective design, small sample number, relatively short duration of follow-up, and not analyzing certain clinical variables such as concomitant surgery, osteoporosis, and BMI, which could have influenced our findings.

Conclusion

The Ludloff's osteotomy is an effective osteotomy for moderate to severe HV deformities. The first metatarsal shortening is less than other metatarsal osteotomy, and it allows for plantar flexion of distal fragment preventing transfer metatarsalgia. It has a broad area of bony contact with the advantages of predictable bone union and fixation supplementation with additional screws or wires.

Reduction of first IMA and HVA is at least as comparable to other procedures. In addition, the nonweight-bearing phase postoperatively is only 3 weeks, compared with other procedures, which require 6 weeks or more.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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