

TECHNIQUE

A New Modified Distal First Metatarsal Osteotomy for the Treatment of Hallux Valgus Deformity: The Reversed L-shaped Osteotomy

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■ ABSTRACT

Many different surgical procedures exist to correct hallux valgus deformity which may confuse foot and ankle surgeons in finding the appropriate solution. The optimal surgical strategy of hallux valgus treatment has remained an issue of debate. Maximal pain alleviation and stable restoration of a physiological metatarsophalangeal and intermetatarsal angle should be the main goals of the operative treatment.

Among all described procedures the distal chevron osteotomy is a very popular one allowing correction of mild and moderate hallux valgus deformities, using a simple technique and providing inherent stability. The reversed L-shaped distal first metatarsal osteotomy has been designed to obtain durable correction of moderate and severe hallux valgus deformities using a simple standardized surgical technique through a minimal medial approach to respect cosmetic appearance. Preliminary short-term results are encouraging with no avascular necrosis observed and stable anatomical correction of even larger hallux valgus deformities (ie, hallux valgus angle $\geq 35^\circ$) achieved. Despite the easy technique of the reversed L-shape, further investigations and longer follow-up periods are still necessary to confirm its overall effectiveness.

Keywords: hallux, valgus, distal, metatarsal, osteotomy

■ HISTORICAL PERSPECTIVE

Austin and Leventen¹ reported on a “V”-shaped distal first metatarsal osteotomy that has remained one of the most popular surgical interventions to correct symptomatic mild and moderate hallux valgus

deformities in adults. Since its introduction, different investigators have modified the inherent stable technique by either changing the osteotomy-angulations (eg, Kenneth-Johnson), adding screw fixation to avoid displacement and malrotation (tilting) of the head fragment or performance of distal soft-tissue releases to improve sesamoid positioning.^{2,3} The short-term outcomes of the so-called modified chevron osteotomy in combination with and without distal soft-tissue release were good to excellent.^{4,5} Despite its simple surgical technique there are major concerns like recurrence, under correction of the deformity and transfer metatarsalgias in case of excessive shortening.^{5–9} A serious complication after this procedure is osteonecrosis of the first metatarsal head. The rates of osteonecrosis throughout the literature have been reported to be as high as 40% particularly when osteotomy was combined with an adductor tenotomy.^{5,6,8,9} Another fundamental disadvantage is the impossibility to address severe hallux valgus deformities. This led to the development of more diaphyseal osteotomies as for example the scarf osteotomy.^{10–12} This inherent stable osteotomy-type, which is very popularly used in Europe,¹³ allows correction of mild to severe deformities.^{14–16} It is a surgically demanding technique with complications of fracture in the osteotomy site and of troughing of the osteotomy fragments,^{17,18} especially the presence of poor bone quality have been described. Another problem is the cosmetic issue of the extended medial incision needed to perform the osteotomy. To combine the advantages of the modified chevron and the scarf osteotomy we developed a new distal first metatarsal osteotomy called reversed L-shaped (ReveL) osteotomy. This technically simple and standardized surgical technique combines the minimal approach and strong fixation of the modified chevron osteotomy, the preservation of the vascularization of the head fragment and the corrective

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potential of the scarf osteotomy and shares the inherent stability of both osteotomies. Whereas in the literature a lateralization of the head fragment at maximally 5 mm is recommended, the present osteotomy allows a correction of up to 12 mm and still avoids either fracturing or troughing of the first metatarsal bone.

■ INDICATIONS

Patients who have chronically painful hallux valgus deformity and are refractory to conservative treatments (as for example shoe modifications) are candidates for the ReveL osteotomy. The indication requests a congruent first metatarsophalangeal (MP-I) joint and no local infectious disease. The ReveL osteotomy can be performed in the presence of mild asymptomatic arthritis of the MP-I joint. In the absence of severe hypermobility of the first ray, major deformities with an intermetatarsal angle of more than 25 degrees and a metatarsophalangeal angle of more than 35 degrees can also be treated by this technique. An increased distal metatarsal articular angle (DMAA) can be corrected by means of a biplanar ReveL osteotomy as already known in combination with chevron osteotomy.^{19–22}

■ CONTRAINDICATIONS

Contraindications for ReveL osteotomy include hypermobility of the first ray and moderate to severe symptomatic degenerative changes of the MP-I joint. Hypermobility of the first ray should rather be addressed by performance of a modified Lapidus procedure^{23–25} and MP-I-arthritis may be handled either by arthroplasty²⁶ or arthrodesis.²⁷

■ PREPARATION FOR SURGERY

Patient Evaluation

The patient is examined barefoot during walking and in a standing position. The axis of first metatarsal and first toe are evaluated. The pronation tendency of the hallux and contact to the lesser toes has to be checked. Flatfoot component must be assessed and seen as a sign of potential hypermobility of the first ray. The examination is continued in a sitting position. The foot of the patient is examined passively. The passive and active range of motion of the MP-I joint are assessed and signs of osteoarthritis like painful mobilization of the joint or painful palpation of dorsal osteophytes are looked for. The medial eminence of the first metatarsal head is often painful during palpation and may reveal local inflammatory signs. Dorsal hypermobility of the first ray should be evaluated and severe hypermobility should not be treated by ReveL osteotomy. Finally the muscular and neurovascular status must be carefully checked.

Radiology

Standing weight-bearing dorsoplantar and lateral radiographs of the entire foot are done preoperatively. The angle of the first metatarsophalangeal joint (MP-I–angle or hallux valgus angle) is measured by drawing a line bisecting the metatarsal shaft and the proximal phalanx of the greater toe. The normal value for the metatarsophalangeal angle should not exceed 15 degrees. The intermetatarsal angle is determined by measuring the angle performed by 2 lines bisecting the shafts of the first and second metatarsals and the normal value is considered to be less than 9 degrees. The presence of an abnormal DMAA can be evaluated by measuring the angle formed by a line running through the articular edges of the surface of the head and another line bisecting the metatarsal shaft.^{28,29} The sesamoids' position can be reliably evaluated by the method of Hardy and Clapham^{30,31} (Fig. 1).

Surgical Technique

The patient is placed under loco-regional anesthesia (popliteal block)³² in a supine position and the operated leg is disinfected and draped above the knee level. A single-shot dose of a second generation cephalosporin (Cefuroxim) is administered intravenously 30 minutes prior to surgery. A sterile tourniquet is applied on the proximal third of the calf with a pressure of 280 mm Hg (Fig. 2).



FIGURE 1. The image depicts a dorsoplantar standing weightbearing radiograph. The first metatarso-phalangeal angle measures 36 degrees, and the I-II intermetatarsal angle at 16 degrees. Note the normal DMAA and the congruent nonarthritic MP-I joint.



FIGURE 2. Patient's position on the operating table. The leg is disinfected and draped above the knee. A sterile tourniquet is installed at the calf.

The surgical intervention starts with a 3-cm long dorsomedial skin incision, located at the level of the first metatarsal head (Fig. 3). During superficial dissection the medial cutaneous branch of the superficial peroneal nerve has to be protected as it lies dorsally to the incision and bears the potential risk to be injured.



FIGURE 3. Depicted is the 3 cm long dorsomedial skin incision at the level of the first metatarsal head. Please note that the course of the medial cutaneous branch of the superficial peroneal nerve lies close to the incision.

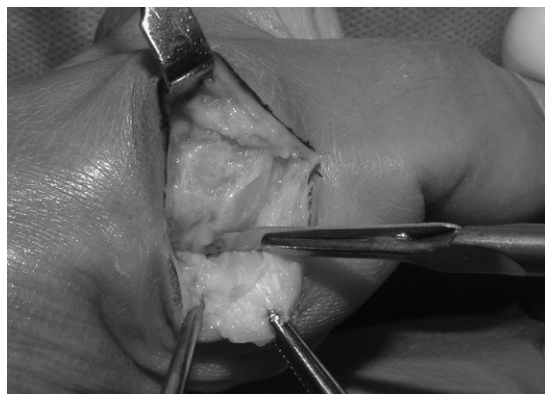


FIGURE 4. The longitudinal capsulotomy is done and the plantar capsular attachments are carefully released.

Then the joint capsule is incised longitudinally and the first metatarsal head is exposed dorsally and plantarly. The plantar capsular attachments are released while protecting the plantar artery during this approach (Fig. 4). As a next step, the capsular release must be completed dorsally and laterally. The scalpel is moved gently over the dorsal aspect of the distal first metatarsal and points toward the second metatarsal head by inclining the blade at approximately 20 degrees. A longitudinal incision in a proximal-distal direction is performed while avoiding injury to the insertion site of the adductor hallucis muscle (Fig. 5). The surgeon should be sure that the lateral capsular incision is more dorsal than the adductor hallucis insertion site. To facilitate the approach to the lateral capsule the great toe can be dorsiflexed to enable more working space.

After the capsular release the metatarsal head is exposed and the osteotomy in shape of an inverted L is performed (Fig. 6A). The apex of the osteotomy lies midway of the dorsoplantar distance of the first

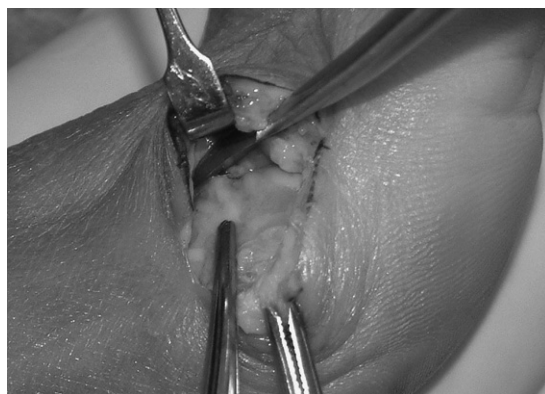


FIGURE 5. The lateral capsular release is performed through the same medial approach. Please note, the inclined (20 degrees) blade of scalpel, pointing toward the second metatarsal shaft. Avoid injury of the insertion site of the adductor hallucis muscle.

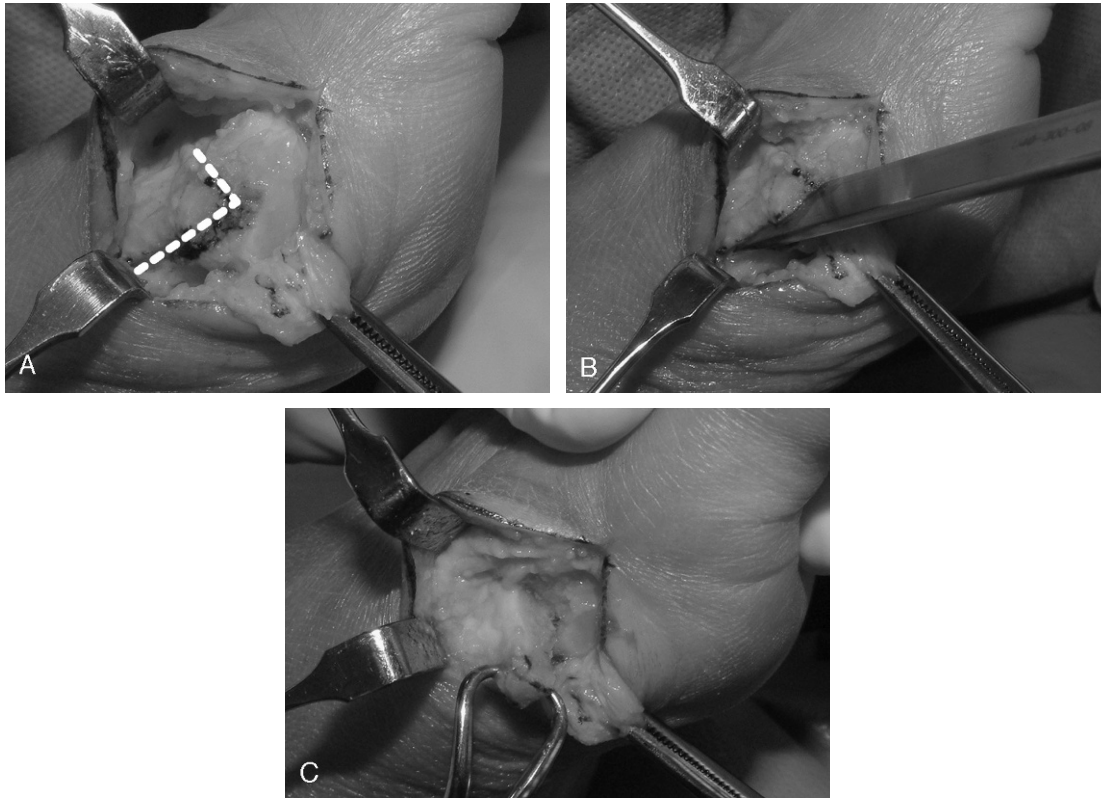


FIGURE 6. A, After exposure of the metatarsal head the inverted L-shape of the osteotomy is marked. The apex lays midway of the dorsoplantar distance of the first metatarsal head and 1 cm proximally to the joint line. The short dorsal arm is now cut vertically to the plantar plane and perpendicular to the long axis of the second metatarsal. B, After creation of the short dorsal arm the long plantar arm is cut perpendicularly to the initial dorsal arm and parallel to the long axis of the foot. The cut is extended proximally and exits the plantar cortex of the first metatarsal. The length of the plantar arm normally averages between 3 and 4 cm. This provides adequate and large bone contact areas between the fragment surfaces. C, After that the osteotomy is completed by means of an 8-mm chisel and the head fragment is displaced laterally. Make sure that the lateralization is enough and verify it by the recentered sesamoids.

metatarsal head and 1 cm proximally to the joint line. The short dorsal arm of the osteotomy is cut, directed vertically and perpendicularly to the long axis of the second metatarsal bone. Respecting this direction avoids potential shortening of the first metatarsal. The long plantar arm is cut perpendicular to the short dorsal arm and parallel to the long axis of the foot (Fig. 6B). It is extended proximally until exiting the plantar cortex at the midthird of the first metatarsal shaft. The length of the plantar arm averages between 3 and 4 cm providing an optimal bone contact between the surfaces of the osteotomy. The osteotomy is completed with an 8 mm chisel and the head fragment is displaced laterally according to the correction needed. It is possible to lateralize the fragment up to 75% of the metatarsal width (Fig. 6C). The adequate lateralization can be confirmed by verifying if the sesamoids are recentered. The osteotomy is stabilized by using two 2.4 mm cortical lag screws inserted in a proximal dorsal to distal plantar direction (Fig. 7). After fixation of the osteo-

tomy, the medial prominence is resected. The oscillating saw is oriented parallel to the medial sided long axis of the first metatarsal so that the eminence and some part of the metatarsal head can be resected (Fig. 8). The resection of the medial prominence of the metatarsal head should not go over the top of the medial condyle because this may lead to instability of the tibial sesamoid with subsequent pronation of the first metatarsal. After resection of the medial prominence, bone wax is applied to prevent bleeding and later capsular sided adhesions (Fig. 9). The dorsal limb of the medial capsular flap is then smoothly prepared and 3 to 4 mm are resected in a longitudinal manner. The medial sensory branch of the superficial peroneal nerve has to be protected while doing this maneuver (Fig. 10). An oblique capsulorrhaphy is performed using single monofilament stitches oriented in an oblique direction from dorsal proximal to plantar distal (Figs. 11A, B). By this step, the foot and the big toe has to be held in a neutral position. The subcutis is closed with single monofilament



FIGURE 7. The osteotomy is stabilized using two 2.4 mm cortical lag screws inserted in a proximal dorsal to distal plantar direction. Two screws provide optimal stability.

stiches and skin with a continuous nonabsorbable suture (Fig. 12). A sterile dressing and a stabilizing hallux valgus bandage are applied.

■ COMPLICATIONS

Nerve Lesions

The medial sensory cutaneous branch of the superficial peroneal nerve is at risk when performing the medial approach. This nerve supplies the great toe with sensory function and may form a painful neuroma in case of lesion. The skin incision should be strictly medially and the nerve should be exposed and protected by developing the dorsal capsular flap before performing the capsulorraphy.

Avascular Necrosis

Avascular necrosis (AVN) of the first metatarsal head has been reported in the literature and the ranges vary



FIGURE 9. To prevent further bleeding and later capsular adhesions which in turn may impair postoperative range of motion bone wax is applied on the surface area.

up to 40%.^{6,8,33,34} Kuhn et al³⁵ showed that the greatest insult to the vascular supply occurs with the medial capsulotomy (45%), which is somewhat unavoidable when performing the osteotomy. They found that lateral release and a chevron osteotomy each caused a decrease in blood flow to the metatarsal head of 13% for each step. Preliminary results of the ReveL osteotomy showed no clinical evidence of AVN. Due to the long plantar arm of the osteotomy, the blood supply to the metatarsal head from the plantar vessels is less likely compromised. The placement of the screws from proximal dorsal to distal plantar should not increase the risk of AVN.

Malunions and Nonunions

Nonunions and malunions are rare complications if fixation of the osteotomy is done properly. Even in unstable fixations of distal first metatarsals the osteotomy site often fuses without any residuals.^{2,33,34}

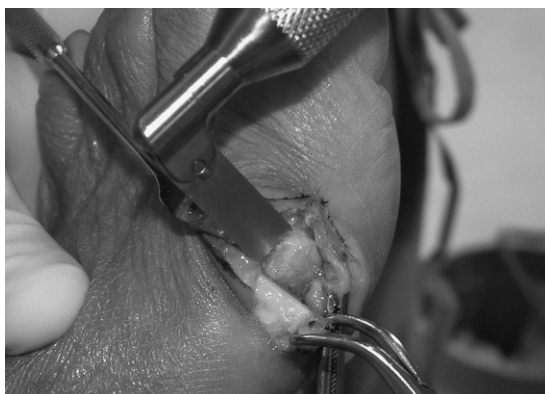


FIGURE 8. The medial prominence is then resected. The oscillating saw is oriented parallel to the long axis of the first metatarsal shaft. The resection of the medial prominence of the metatarsal head should not exceed 50% of the medial condyle to avoid destabilization of the tibial sesamoid.



FIGURE 10. The dorsal flap of the medial capsule is trimmed by resecting 3 to 4 mm tissue. This provides optimal tightening considering subsequent capsulorraphy. The medial sensory branch of the superficial peroneal nerve has to be explored and protected during this maneuver.

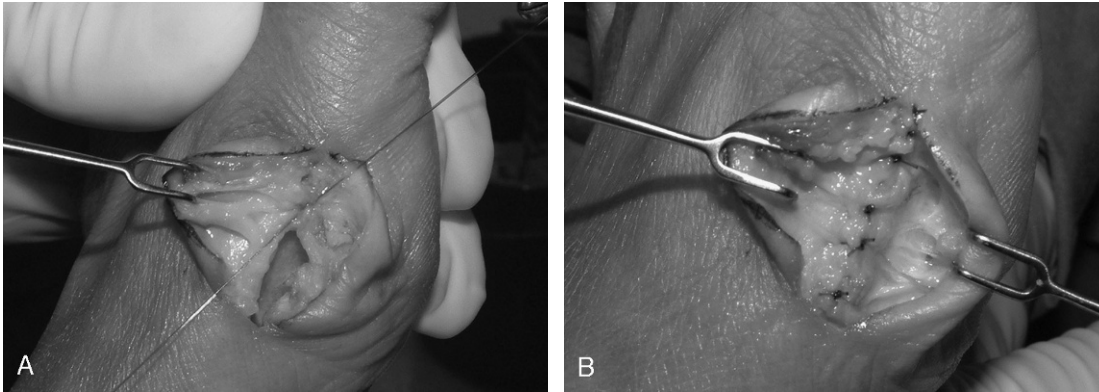


FIGURE 11. A and B, An oblique capsulorrhaphy is performed using single stitches oriented in an oblique direction from dorsal proximal to plantar distal. The foot and the big toe have to be hold in a neutral position.

A fixation with 2 lag screws as in our technique should give better stabilization of the head fragment.

Metatarsalgia

Transfer metatarsalgia may be found as a sequel of dorsalization of the first metatarsal head or significant shortening of the first metatarsal. Elevation of the metatarsal head can occur when the plantar arm of the osteotomy is not cut parallel to the long axis of the foot, but instead dorsally directed. Inversely a plantarization of the head fragment can be due to a plantarly oriented osteotomy. Shortening can happen if the dorsal arm of the osteotomy is not cut perpendicularly to the long axis of the second metatarsal.^{4,7,20,36,37}



FIGURE 12. Subcutis closure with single stitches and skin with continuous suture. A sterile dressing and a stabilizing hallux valgus bandage are applied.

Impaired Range of Motion at the MP-I Joint

Lengthening of the first metatarsal through an oblique distally oriented osteotomy (dorsal arm) and excessive medial capsular tightening may lead to impaired range of motion of the MP-I joint. However, this problem can be treated by early passive mobilization of the MP-I joint.

■ POSTOPERATIVE MANAGEMENT

Full weight bearing in a stiff-soled shoe is allowed immediately for 6 weeks after the operation. The stitches are removed after 2 weeks. A stabilizing elastic bandage is applied during the first 6 weeks. A clinical and radiographic control is performed for 6 weeks to check ambulatory status, range of motion of MP-I joint, and consolidation of the osteotomy (Fig. 13).



FIGURE 13. Postoperative radiograph, depicting the correction.

■ POSSIBLE CONCERNS, FUTURE OF THE TECHNIQUE

The ReveL osteotomy is a distal first metatarsal osteotomy that allows a stable correction of moderate and even severe hallux valgus deformities using a simple, standardized and less invasive surgical technique. The convenient post-operative management leads to high patient satisfaction. In our experience, this osteotomy is indicated to resolve symptomatic hallux valgus in the absence of hypermobility of the first ray. It allows a significant lateral displacement of the distal fragment (up to 12 mm) and provides a large osseous contact area as compared with the original chevron osteotomy. Our preliminary results reveal no loss of correction in the 2 years follow-up. The short and single skin incision is of great benefit considering the cosmetic result. Therefore, the ReveL osteotomy is considered to be a good alternative in the treatment of moderate to severe hallux valgus deformity yielding durable functional and cosmetic results.

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