A Rotational Scarf Osteotomy Decreases Troughing When Treating Hallux Valgus

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Abstract

Background The traditional scarf osteotomy has been associated with complication rates between 1.1% and 45%. We have modified the traditional technique with a rotational osteotomy to reduce these complications.

Questions/purposes We determined whether a modified rotational scarf osteotomy improves functional outcome scores, allows correction of a wide degree of an intermetatarsal (IM) angle deformity, has a low incidence of troughing, and maintains normal ROM postoperatively in the treatment of symptomatic hallux valgus (HV).

Patients and Methods We retrospectively reviewed 140 patients: 38 men and 102 women with a mean age of 54 years (range, 35–66 years) who underwent surgery for HV and had a minimum followup of 24 months (mean, 41 months; range, 24–68 months). All patients had preoperative and postoperative American Orthopaedic Foot and Ankle Society (AOFAS) forefoot and Short Form (SF)-36 V2 outcome scores recorded.

Results The mean AOFAS score improved from 52 points preoperatively to 92 points (range, 71–96 points) at followup. The mean SF-36 V2 score improved from

69 points preoperatively to 94 points (range, 67–98 points) at followup. The IM angle improved from a preoperative mean of 18° (range, 9°–23°) to a mean of 8° (range, 6°–12°). Eleven patients experienced a complication.

Conclusions The modified rotational scarf osteotomy has a low complication rate (9%) and apparently reduces the risk of troughing. This procedure can reduce a high degree of IM angle deformity while restoring function to the forefoot.

Level of Evidence Level IV, case series. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Throughout the past century, approximately 130 surgical procedures have been described for treatment of HV [14]. One such method, the scarf osteotomy, has been described for use with mild to moderate cases of HV. The increasing popularity of the scarf procedure is attributable to its innate ability to distribute load strength over the osteotomy site [2]. Meyer first described the inherent stability of the Z-cut osteotomy in treating HV [20]. Weil and Borelli [26] popularized the procedure in the United States, and Barouk [1] is largely credited with the increasing development of the scarf procedure in France and throughout Europe.

The functional outcome scores, degree of correction, and complications after the traditional scarf osteotomy have been described [4, 5, 8, 10, 13, 18]. Although functional outcome scores ranging from 62 to 96 points [4, 5, 8, 10, 13, 18] have been reported for correction of mild to moderate cases of HV, potential complications exist, including troughing of the first metatarsal (1%–35%) [6, 7] and postprocedure residual stiffness of the first metatarsophalangeal (MTP) joint (11%–41.7%) [11, 13]. A

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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translational scarf osteotomy is limited by the degree of IM angle to which it can correct safely without increasing the risk of troughing of the first metatarsal. Troughing occurs as the cortex of the dorsal half of the first metatarsal shaft collapses and wedges into the softer cancellous bone, thus leading to functional elevation of the first ray and, in due course, a pronated foot position with overload of the lesser metatarsals. Troughing was reported by Coetzee and Rippstein [7] to occur with and without rotation of the plantar half of the osteotomy (Fig. 1). Although rotational displacement of the osteotomy site was described by Duke [9] to facilitate correction of higher grades of IM angle, it is unclear regarding whether it reduces the aforementioned complications while allowing higher-grade correction.

The Akin osteotomy of the proximal phalanx has been described for treatment of hallux interphalangeus and also has been reported in conjunction with the scarf osteotomy [4, 15, 16]. Similarly, we used the Akin osteotomy to address an interphalangeus deformity in association with an HV deformity and to address any changes in distal metatarsal articular angle (DMAA) alignment caused by the rotational osteotomy.

To address troughing and postprocedure stiffness, we have modified the traditional scarf procedure in several ways. First, to reduce troughing and allow correction of a wide range of IM angles, we use a rotational displacement of the osteotomy site rather than the translational displacement. Second, to reduce postoperative scarring and

stiffness in the first MTP joint and maintain normal ROM postoperatively, one incision is used when performing the lateral soft tissue release.

Therefore, we asked whether these modifications of the traditional scarf procedure would (1) allow correction of a wide range of IM angle deformity, (2) provide a low incidence of troughing, and (3) maintain a normal ROM postoperatively in the first MTP joint.

Patients and Methods

We retrospectively evaluated all 152 patients who had undergone a modified rotational scarf osteotomy with lateral soft tissue release and Akin osteotomy for correction of mild to severe HV and interphalangeus at our institution between January 2004 and August 2007. The patients had a mean age at the time of surgery of 54 years (range, 35–66 years). Twelve patients were excluded from the study, eight patients owing to incomplete medical records and four because they did not have the appropriate 24-month followup. These exclusions left 140 patients (38 men and 102 women). Minimum followup was 24 months (mean, 41 months; range, 24–68 months). IRB approval was obtained.

All grades of IM angle variation (mild to severe) were treated in a similar fashion. The decision to use the Akin osteotomy was based on the presence of an interphalangeus deformity and changes in DMAA after the rotational osteotomy. Patients who did not require an Akin osteotomy were excluded from the study.

We obtained weightbearing AP, lateral, and oblique foot radiographs preoperatively for all patients. The first to second IM angle was measured as per the established methods of Venning and Hardy [24]. A normal IM angle range is between 7° and 9°. The HV angle was measured as the bisection of the first metatarsal and proximal phalanx. A normal HV angle range is between 10° and 15°. The DMAA was measured preoperatively by taking the lateral slope of the distal articular surface of the first metatarsal in relation to the long axis of the first metatarsal. A normal DMAA value is as much as 8°. The DMAA could not be measured postoperatively, as the rotational osteotomy disrupts the long axis of the first metatarsal.

The preoperative mean IM angle deformity was 18° (range, 9°–23°). The preoperative mean HV angle deformity was 37° (range, 22°–51°). The preoperative mean DMAA deformity was 16° (range, 5°–38°). Despite a normal IM angle range being 7° to 9°, two patients underwent correction for a 9°-IM angle deformity and interphalangeus attributable to progressive IM angle increase during a 3-month time period with a symptomatic bunion refractory to nonoperative treatment.

Fig. 1 A diagram illustrates troughing of the first metatarsal, which occurs as the cortex of the dorsal half of the first metatarsal shaft collapses and wedges into the softer cancellous bone, leading to pronation and lesser metatarsal overload.

Fig. 2 The abductor hallucis tendon is visualized and released from the lateral sesamoid bone through one incision for the lateral soft tissue release procedure. D = distal; P = proximal.

The senior surgeon (JGK) performed all surgeries in this study. A standard medial incision over the first MTP joint was made in all patients. The capsule then was resected from the dorsal aspect of the MTP joint and elevated from the bone to expose the lateral aspect of the joint. The lateral sesamoid was exposed and observed by distracting the first metatarsal medially, thereby eliminating the need for a second incision. A lateral soft tissue release then was performed, which resected the adductor tendon from the lateral sesamoid bone (Fig. 2). The lateral capsule also was resected from the bony attachment to allow full motion of the joint. Eliminating the second incision has the potential to lessen scarring postoperatively and also maintain a soft tissue envelope at the time of surgery. The medial eminence was resected using a size 39-saw blade. Care was taken to preserve the sesamoid metatarsal articulation at the most plantar aspect of the osteotomy. Standard scarf osteotomy cuts were made in the first metatarsal (Fig. 3). Once the two halves of the bone were mobilized, the plantar half of the bone was rotated medially to reduce the IM angle until the metatarsal head assumed a clinically parallel appearance to the second ray. The nutrient artery at the plantar aspect of the metadiaphysis was preserved throughout to reduce the risk of avascularity (Fig. 4). The rotation of the Z-cut on a central axis prevented any troughing by removing the need to translate one bone over the other and thereby eliminating parallel contact between the cortices of the metatarsal and the softer cancellous bone (Fig. 5). The position was checked with intraoperative fluoroscopy until the exact alignment was achieved. Once this was established, a bone clamp was used to secure the construct and provisional Kirschner wires were drilled proximally and distally. The final position was secured with two 3.0-mm TriMed® screws (TriMed, Inc, Valencia,

Fig. 3A–B (A) Using the marking pen, the Z-cut osteotomy is outlined on the first metatarsal. (B) The Z-cut osteotomy then is performed once the proper outline is made. D = distal; P = proximal.

Fig. 4 The nutrient artery is observed at the plantar aspect of the metadiaphysis and provides vascularity to the metatarsal head. (Supplied by and published with permission from TriMed Inc.)

CA, USA) (Figs. 6 and 7). The inferior proximal and distal dorsal residual prominences were resected to allow a flush medial border.

Fig. 5 The modified rotational scarf procedure rotates the two halves of the osteotomy, assuring adequate cortical crossover and thereby eliminates linear overlap between the cortices of the first metatarsal and softer cancellous bone. (Supplied by and published with permission from TriMed Inc.)

Fig. 6 The final position of the osteotomy was secured with two 3.0-mm TriMed® screws. (Supplied by and published with permission from TriMed Inc.)

Congruency of the joint and the position of the sesamoid sling relative to the metatarsal head were critical at all points during the operation. Having been mobilized, the sesamoid sling then was observed to ensure correct alignment and tracking of the sesamoid bones in the sesamoid groove (Fig. 8). This was a critical step and any mal-tracking of the sesamoids was addressed with additional

Fig. 7 A standard postoperative lateral radiograph shows satisfactory fixation of the osteotomy site.

Fig. 8 The sesamoid sling is observed to ensure correct alignment and tracking of the sesamoid bones at the sesamoid-metatarsal articulation. (Supplied by and published with permission from TriMed Inc.)

soft tissue resection or plication of the sling either medially or laterally with 0 Vicryl® suture (Ethicon, Inc, Somerville, NJ, USA). Once this was achieved, the capsule was sutured back together with 0 Vicryl® under sufficient tension to maintain congruency of the sesamoid joint.

The decision to perform the Akin osteotomy of the proximal phalanx was based on the presence of interphalangeus. The amount of bone resected was based on this and on the change in DMAA after the rotational osteotomy. This could be determined only after the rotational osteotomy was made. The Akin osteotomy was performed using a 38-saw blade to cut from medial to lateral at the meta-diaphysis of the proximal phalanx. The soft tissues were protected with a baby Bennett retractor. The saw blade was advanced $\frac{7}{8}$ of the way across the bone and an osteotome was used to complete the osteotomy. The two opposing surfaces then were pinned using a K-wire, and clinical and

Fig. 9 A standard postoperative AP radiograph shows satisfactory fixation of an Akin osteotomy of the distal phalanx.

fluoroscopic evaluations were used to determine whether proper alignment had been achieved. Larger DMAA angles required further angular correction. An optimal position was considered as having the metatarsal relative to the articulating surface of the proximal phalanx such that the residual valgus no longer was observed clinically or radiographically. Once this position was achieved, the osteotomy was held with one 2.3-mm TriMed[®] screw (Fig. 9).

Patients wore a standard postoperative shoe, were encouraged to be nonweightbearing for 48 to 72 hours after surgery to reduce swelling, and thereafter allowed to increase weightbearing by 10% of their body weight per day. At 2 weeks, sutures were removed and the patient then was allowed to ambulate as tolerated. A soft toe spacer was used for 1 month after surgery.

Preoperative and postoperative data were assessed and analyzed by the research fellow (CDM). All patients completed questionnaires using the AOFAS forefoot score and the SF-36 V2 score [12, 25]. These were completed preoperatively at the last office visit before surgery, and postoperatively at 2 months, 6 months, 1 year, and then yearly after surgery. Postoperative scores were completed at the time of the postoperative visits. Identical questionnaires were used in all instances. ROM was measured at the time of followup visits using a standard goniometer (Howmedica, Rutherford, NJ, USA) and compared with the nonoperative side. In the case of bilateral deformities, ROM was compared with standard norms.

Standard anterolateral, lateral, and oblique foot radiographs were taken at 2 weeks, 2 months, 6 months, and 1 year after surgery. Only patients who were symptomatic had radiographs after 1 year postoperative. The first and second IM and HV angles were measured as per the previously indicated methods used for preoperative radiograph measurements. All preoperative and postoperative foot radiographs were interpreted independently by the senior author (JGK) and the research fellow (CDM) to determine interobserver and intraobserver variability. Of the 560 radiographs measured (preoperative and postoperative radiographs of 140 patients with two observers), there was agreement between the two observers with less than 2° difference in 97% of cases. The interclass correlation coefficient of variability was determined to be 0.93.

Results

The IM angle improved from a preoperative mean of 18° (range, 9°–23°) to a mean of 8° (range, 6°–12°) at followup. The postoperative IM angle was normal in 116 patients (83%), less than 7° in six patients (4%), and greater than 9° in the remaining 18 patients (13%). The HV angle improved from a preoperative mean of 37° (range, 22°–51°) to a mean of 12° (range, 4°–22°) at followup. No patient had troughing of the first metatarsal identified at last followup.

ROM measurements showed dorsiflexion and plantar flexion were within 2° of normal in 89% of patients. Six patients (4%) reported having postoperative stiffness.

The mean AOFAS score improved from 52 points preoperatively to 92 points (range, 71–96 points) at followup. The mean SF-36 V2 score improved from 69 points preoperatively to 94 points (range, 67–98 points) at followup.

We identified 12 complications in 11 patients. Six patients reported postoperative stiffness, three of whom had an additional manipulation under anesthesia in the postanesthesia care unit. One of these three patients had postmanipulation stiffness and declined additional treatment. Another patient had stiffness and a postsurgical hallux varus deformity developed. This was identified early, and despite postoperative taping, the varus incongruity was not correctable. This patient had a simple capsular release at the time of a manipulation to reduce scarring; the patient subsequently did well and had a good outcome. Three patients had superficial wound infections from a subcuticular Vicryl[®] suture abscess. The procedure has since been modified to exclude the subcuticular suture layer, with no additional complications seen. One patient had an intraoperative fracture owing to malplacement of proximal hardware during screw fixation. Another patient had postoperative shift in fixation with resultant malunion.

This was caused by early ambulation in a man with a high body mass index in the immediate postoperative period. However, this was a clinically acceptable outcome and a satisfied patient. Two patients have requested screw removal, but these requests were not attributable to clinical symptoms and therefore not considered complications. We identified no patient with necrosis of the first metatarsal head.

Discussion

The scarf osteotomy has been described for treatment of mild to moderate HV deformities but has been associated with the complications of troughing of the first metatarsal and postprocedure stiffness of the first MTP joint. These complications have reported occurrence rates of 1% to 35% and 11% to 41.7%, respectively [6, 7, 11, 13]. In addition to these complications, a wide degree of IM angle correction is seen as a limitation of the traditional procedure. We therefore determined whether our modifications of the traditional scarf procedure would (1) allow correction of a wide range of IM angle deformity, (2) provide a low incidence of troughing, and (3) maintain a normal ROM postoperatively in the first MTP joint.

We acknowledge the following limitations to this study. First, the 24-month minimum followup is long enough to study only preliminary functional outcome scores, complications, and degree of IM angle correction; longer-term clinical followup is required. Second, the retrospective nature of the study resulted in data collected at varying times after the intervention. Whenever possible we analyzed data that were collected at standard yearly times after the intervention. Third, the nonrandomized nature of the study prevented us from discerning the actual rate of reduction in complications of troughing and postoperative stiffness by comparison to the traditional procedure.

The preoperative IM angle deformity improved in all patients whether the initial IM angulation was mild, moderate, or severe. Duke [9] reported a 50% greater transposition can be realized when rotation of the osteotomy site is used. This higher degree of IM angle reduction is not possible with a translational osteotomy. Previous studies of the translational scarf osteotomy therefore have limited the deformity correction to mild or moderate IM angles. Our method allowed correction of IM angle deformities as much as 23° using rotational displacement.

No case of troughing was identified at followup. We attribute this to the use of the modified rotational osteotomy. By using a central axis of rotation about the first metatarsal while reducing the IM angle deformity, the translating osteotomy seen in the traditional procedure is thereby eliminated. Previous studies have reported an

incidence of troughing between 1% and 35% [6, 7]. Troughing occurs as the cortices of the metatarsal collapse into the softer cancellous bone. This leads to functional elevation of the first ray and a pronated foot and also can lead to rotational malunion of the metatarsal. Although our study has addressed this complication, we acknowledge the distal metatarsal articular angle will be increased as a result of the rotational osteotomy. Consequently, incongruence may occur at the sesamoid articulation owing to an oblique orientation of the sesamoid crista. By adequately liberating the soft tissues on the lateral aspect of the metatarsal head, the sesamoid sling can be articulated in a precise fashion relative to the metatarsal head. At the time of medial capsular closure, this relationship should be preserved. We have not seen sesamoid-metatarsal arthrosis as a clinical problem to date, but we acknowledge the future importance of looking at the sesamoid view radiograph before and after surgery to assess this.

Eighty-nine percent of our patients had a normal postoperative ROM in the first MTP joint. Furthermore, only six patients (4%) reported increased postoperative stiffness of the first MTP joint, three of whom had an additional manipulation under anesthesia in the postanesthesia care unit for recurrent symptoms after a period of deep tissue massage and Class IV laser therapy. The deep tissue massages were performed by the physical therapist twice a week for 6 weeks. Previous studies report the rate of stiffness after a scarf osteotomy to be between 11% and 41.7% [11, 13]. The low rate of stiffness in our patients may have been an advantage of the single-incision technique, but without a comparative study, this is not clearly demonstrable. Biomechanical studies suggest the scarf procedure provides twice the mechanical solidity of a distal chevron osteotomy or a proximal crescentic osteotomy [22, 23]. Rigid compression and a large surface area for bone healing may provide for this solidity. Given the stability of the construct, we therefore emphasize early passive ROM followed by active mobilization to minimize postoperative scarring in and around the first MTP joint.

Our data suggest similar functional scores compared with other studies while maintaining a complication rate within the range of other studies but increasing the degree of IM angle to which the traditional procedure can correct (Table 1). Our data also are similar to those associated with other osteotomies currently used for surgical correction of an HV deformity [3, 17, 19, 21].

The modified rotational scarf osteotomy with accompanying lateral soft tissue release and Akin osteotomy has a low complication rate (9%) and specifically addresses the risk of troughing, with zero cases reported. In addition, this procedure can reduce a high degree of IM angle deformity (as much as 23° in our patients) while restoring function to the forefoot.

Table 1. Comparison of results with the modified rotational scarf osteotomy and traditional scarf osteotomy

Study	Cohort size	Mean followup (months)	AOFAS score	Preoperative IM angle (range)	Complication rate
Crevoisier et al. [8]	84	22	43–82		19%
Jones et al. [13]	35	20	52–89	10°–19°	8%
Lipscombe et al. [18]	31	12	47–96		6%
Gupta et al. [10]	23	18	53–91	10°–20°	6%
Berg et al. [4]	72	90			14%
Current study	140	41	52–92	9°–23°	9%

AOFAS = American Orthopaedic Foot and Ankle Society; IM = intermetatarsal.

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