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Original Article

# Scarf Osteotomy in Treating Hallux Valgus: Clinical and Radiographical Outcome and Technical Notes
# Scarf截骨術在治療拇外翻之臨床和X光片的結果及技術要點

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A R T I C L E I N F O

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A B S T R A C T

*Introduction:* Scarf osteotomy can be a technically demanding procedure and early reports have shown high complication rates. Proponents, however, suggest that this type of osteotomy is versatile and allows for both translation and angulation correction of the hallux valgus (HV) deformity. The purpose of this study was to evaluate the clinical and radiological results of the scarf osteotomy procedure performed in our hospital.
*Materials and methods:* We retrospectively reviewed 31 feet in 25 patients with an average follow-up duration of 16 months (range: 6–30 months).
*Results:* On the latest follow up, 77% of the patients were satisfied with the result, with an average postoperative American Orthopaedic Foot and Ankle Society score of 88. The average improvement of HV angle was from 37.9° to 10.0°. The intermetatarsal angle improved from 16.0° to 8.0°. The average first metatarsal shortening was 0.3 mm. Neither delayed union nor osteonecrosis was observed.
*Conclusion:* Scarf osteotomy is a reliable procedure to achieve correction of HV deformity with good patient satisfaction.

中 文 摘 要

Scarf 截骨術是一個技術要求很高的程序，早期報告顯示，有較高的並發症。 但是，這截骨術可允許橫向平移和角度矯正拇外翻畸形。本研究的目的是評估在我院進行的 scarf 截骨術的臨床和影像學結果。我們回顧了25例患者31足，平均隨訪16個月（範圍6–30個月）。在最新的隨訪，77%的患者滿意的結果，平均手術後的美國骨科足與踝關節協會得分(AOFAS)為88。拇外翻角平均由37.9° 改善為10.0°。蹠骨間角從16.0°改善到8.0°。第一蹠骨改善平均縮短了0.3毫米。無延遲癒合或骨壞死。我們的結論是，Scarf 截骨術是一種可靠的方法，使拇外翻畸形矯正，而且病者滿意

## Introduction

A distal soft-tissue procedure with first metatarsal (MT) osteotomy is the most common surgical option in dealing with hallux valgus (HV) deformity. Many different methods of osteotomy have been described previously. One such method, the scarf osteotomy, was first proposed by Meyer[1] and later popularized by Weil and Borelli[2] in the United States and Barouk[3] in Europe. The theoretical advantage of scarf osteotomy is based on its versatility in either or both rotational and translation corrections, while providing a mechanically stable construct to allow early weight bearing.

The complication rate associated with scarf osteotomy can be as high as 47%.[4] This includes troughing, rotational malunion, recurrence, fracture, osteonecrosis, and delayed union. Many modifications by different authors to the traditional scarf osteotomy have been proposed.[5] One modification is to shorten the depth of the short arm of the Z cut. This avoids cutting into the cancellous portion of the MT, thereby reducing the risk of troughing and the risk of fracture. The plane of the longitudinal cut can also be modified to give plantar or dorsal translation as indicated.[5]

The purpose of this study was to evaluate the results using the modified scarf osteotomy combined with distal soft-tissue procedure for patients with HV deformity. We evaluated the postoperative American Orthopaedic Foot and Ankle Society (AOFAS) score, radiographic parameters, patient satisfaction, and complications.

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## Patients and methods

We retrospectively reviewed all scarf osteotomies performed or supervised by the senior authors from October 2009 to March 2012. Distal soft-tissue procedure combined with modified scarf osteotomy was performed in 31 feet in 25 patients. The average age was 55 (range: 14–75). The average follow-up duration was 17 months (range: 6–38 months).

Exclusion criteria were severe first tarsometatarsal joint (TMTJ) instability and moderate to severe degenerative changes to the first metatarsophalangeal joint (MTPJ). One case with large intermetatarsal angle (IMA) and relatively narrow first MT was excluded after preoperative planning revealed less than one-third of bone contact after the scarf osteotomy (Figure 1).

The surgical procedure involved a standard medial incision over the first MTPJ and along the shaft of the first MT. After an L-shaped medial capsulotomy, the medial eminence was resected. A separate longitudinal incision was made over the first web space. Both heads of the adductor tendon and the transverse MT ligament were released. Adequate lateral capsulotomy was performed and the sesamoids were released and reduced.

In preparation for the scarf osteotomy, two 1.2-mm K wires were inserted at the corner points of the proposed osteotomy as guides to orientation of osteotomy. According to Coetzee and Rippstein,[5] the proximal corner point was at the diaphyseal–metaphyseal junction around 1.5 cm distal to the TMTJ and 5 mm from the planter cortex. The distal corner point was located 1 cm proximal to the MTPJ and 5 mm from the dorsal cortex. The K wires were placed parallel to the plantar surface and perpendicular to the first MT shaft as confirmed by intraoperative fluoroscopy (Figures 2 and 3). To complete the Z osteotomy, the longitudinal limb was adjusted parallel to the K wires. The short oblique limbs were made at 60° to the longitudinal limb. Care was taken to preserve the nutrient artery at the plantar aspect at the metaphyseal diaphyseal junction to reduce the risk of osteonecrosis.

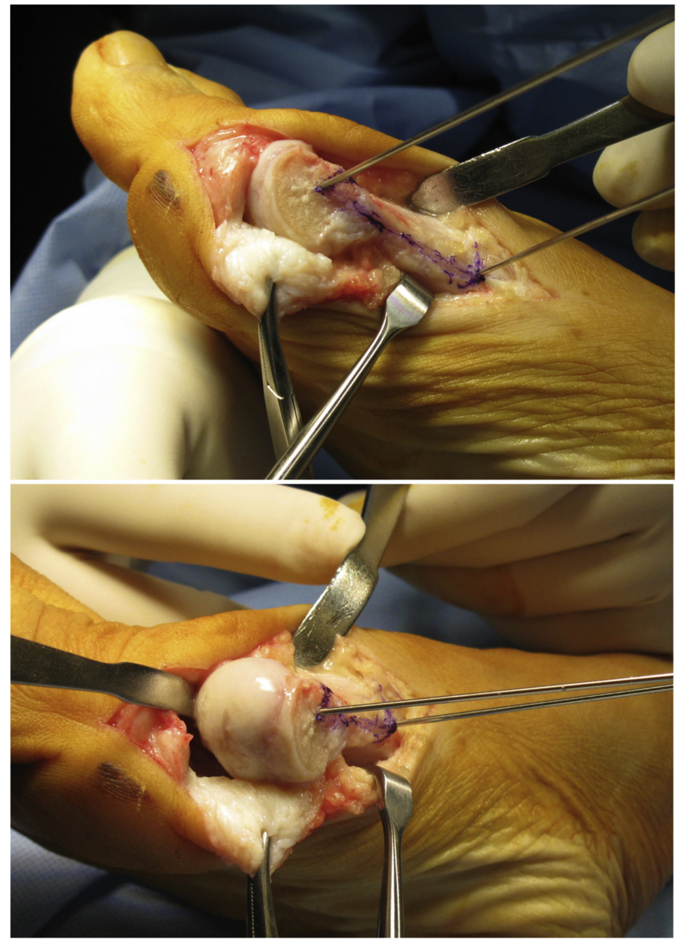

**Figure 2.** K wires were inserted at corner points. They were at 5 mm from the dorsal cortex distally and 5 mm from the plantar cortex proximally. K wires were parallel to the plantar surface of the first metatarsal shaft. The plantar nutrient artery was preserved to prevent osteonecrosis.

The direction of displacement of the osteotomy was decided intraoperatively. For cases with normal distal metaphyseal articular angle (DMAA), lateral translation with or without lateral rotation of plantar fragment was performed based on the severity. Bone contact of at least one-third the MT width was set as the limit of correction. For cases with enlarged DMAA, lateral translation and medial rotation were carried out to correct both IMA and DMAA. Lengthening by distal sliding of the capital fragment was performed for patients with transfer metatarsalgia and significant shortening of the first MT, with the aim of levelling the first and second MTPJ. Two cortical screws were used for fixation. The size of these screws ranged from 1.5 to 2.7 mm depending on the width of the MT. The medial bone excess was resected and wedged inside the distal osteotomy site as bone graft (Figure 4).

**Figure 1.** Severe hallux valgus deformity with an intermetatarsal angle of 32°. Adequate correction of the deformity using scarf osteotomy would entail less than one-third of bone contact. A basal crescentic osteotomy was performed; an early postoperative radiograph is shown.

Eight patients had symptoms of lesser toes. Concomitant excision arthroplasty of the proximal interphalangeal joint with or without metacarpophalangeal joint with Z lengthening of the extensor tendon was performed. Axial K-wire fixation was kept for 6–8 weeks.

Postoperatively, strapping was kept for 2 weeks. Patients were allowed to walk on a rocker bottom boot as tolerated for 8 weeks. Toe spacer was worn for 12 weeks.

Patients were assessed preoperatively and postoperatively for symptoms and radiological parameters. The preoperative AOFAS score was not calculated due to incomplete data. The postoperative AOFAS score was charted on the latest follow up along with patients' satisfaction regarding the result of operation.

Radiological assessment included IMA, HV angle (HVA), DMAA, and length of the first MT with respect to the second. Complications, such as troughing between osteotomy fragments, nonunion,

**Figure 3.** Intraoperative X-ray confirmed that the K wires were placed perpendicular to the first metatarsal (MT) shaft. The subsequent translation moved the plantar segment distally. This prevented shortening of the first MT due to bone loss.

or osteonecrosis, were noted. Measurements were taken with radiographs at weight-bearing dorsoplantar and lateral views. The IMA was measured as the angle formed by the intersection of the first and second MT. Normal values of IMA range from 7° to 9°. HVA was measured as the intersection of the bisector of the first MT and the proximal phalanx. The normal range is 10°–15°. DMAA was measured preoperatively, as the line along the articular surface and a perpendicular line to the bisector of the first MT. Normal values are less than 10°. Postoperative DMAA was not measured as the rotational osteotomy disrupts the long axis of the first MT. The length of the first ray and the second ray was measured as the perpendicular distance between the first and second MT head with reference to the second MT shaft as described by Davitt et al.[6] The paired Student *t* test was used to analyze the radiological parameters.

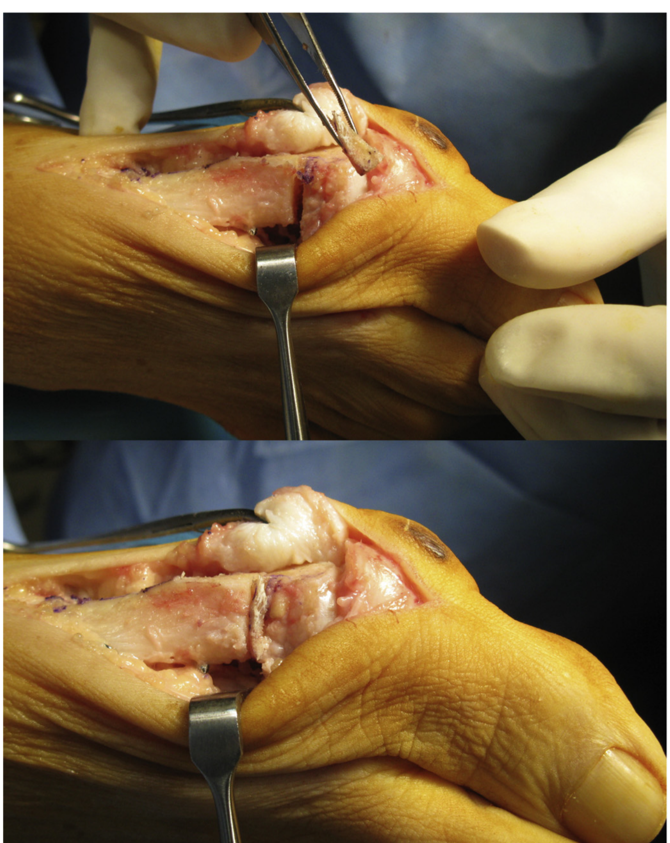

**Figure 4.** Excess bone on the medial side was resected and used as bone graft.

## Results

At the time of the latest follow up (mean: 17 months; range: 6–38 months), 77.4% of the cases were satisfied with the result, 9.7% were satisfied with reservation, and 12.9% were not satisfied. The average postoperative AOFAS score was 88 (range: 65–100). We identified 15 cases with preoperative transfer metatarsalgia and 11 cases (73%) had resolution or decreased symptoms on follow up. One patient (6.3%) developed new onset postoperative transfer metatarsalgia due to recurrence of HV. We illustrated a case of lengthening of the first MT by 4 mm and correction of HV deformity (Figure 5). Postoperatively, there was resolution of metatarsalgia.

The average preoperative HVA of 37.9° (range: 20°–55°) improved to 10.0° (range: −9° to 33°) postoperatively ($p < 0.0001$). The average preoperative IMA of 16.1° (range: 13°–22°) improved to 8.4° postoperatively (range: 2°–16°; $p < 0.0001$; Table 1). There was an average shortening of 0.3 mm of the first MT postoperatively, which was not statistically significant ($p = 0.36$). Two cases of troughing were noted, and both were mild with less than 2 mm subsidence on standing lateral films. On the latest follow up, both cases showed union of the osteotomy and the patients did not complain of any stiffness over the MTPJ.

We found that five feet in four patients had increased DMAA (>10°) preoperatively. One case was illustrated to demonstrate the

**Figure 5.** Patient with hallux valgus, overriding second toe, and symptoms of transfer metatarsalgia. Preoperative X-ray showed no sign of first metatarsophalangeal joint arthrosis. Scarf osteotomy was performed to lengthen the first metatarsal by 4 mm. Concomitant excisional arthroplasty of the second proximal interphalangeal joint was carried out.

**Table 1**
Average radiological measurements and AOFAS score. Because of insufficient data, the preoperative AOFAS score was not calculated

| | HVA | IMA | AOFAS |
|---|---|---|---|
| Preoperation | 37.9° | 16.1° | — |
| Postoperation | 10.0° | 8.4° | 88 |

AOFAS = American Orthopaedic Foot and Ankle Society; HVA = hallux valgus angle; IMA = intermetatarsal angle.

combined rotation and translation to correct IMA and DMAA simultaneously (Figure 6).

Iatrogenic fracture did not occur. None of the cases had a problem with bone union, and osteonecrosis was not observed in any of the cases. We had two cases (6.5%) of recurrent HV deformity, defined as HVA of more than 20°. One of the patients had ligamentous laxity with severe flat foot and spray foot deformity. The other patient had severe HV with IMA of 21° and HVA of 47° preoperatively. The recurrences were noted at 3 and 6 months after the operation, respectively. Two cases (6.5%) of hallux varus were noted (HVA of −3° and −9°). None of these patients required revision surgery. We report four cases (12.9%) of superficial infection or wound gapping. All the cases resolved with antibiotics and dressing.

## Discussion

A cookbook approach to HV reconstruction surgery is not appropriate. The specific corrective procedures for each case will be different depending on patient's symptoms and individual bone anatomy. While variations are limited for distal soft-tissue procedures, a vast amount of techniques had been described for osteotomy of the first MT.

Scarf osteotomy is designed to be versatile, allowing restoration of multiplanar HV abnormality. It permits horizontal displacement, lengthening, rotation, elevation, and lowering of the MT head. Multiple modifications were made to the traditional scarf osteotomy to improve the biomechanics and to decrease complication. Different surgeons' interpretation of the osteotomy cut also varies significantly.[7]

Because of bone loss after osteotomy, it is usual to have shortening of the first MT, which may result in transfer metatarsalgia.

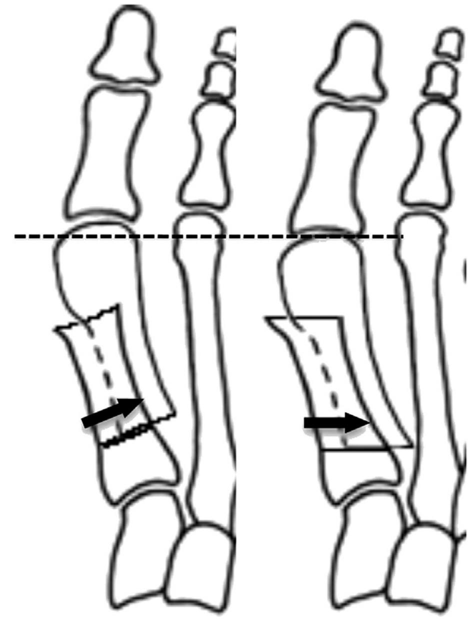

**Figure 7.** With the transverse limb of the osteotomy made perpendicular to the long axis of the first metatarsal, the resultant translation provided a lengthening effect, thus minimizing postoperative transfer metatarsalgia.

Our measures to prevent postoperative transfer metatarsalgia are twofold. First, the placement K wires were directed perpendicular to the shaft of the first MT, rather than to that of the second MT. The longitudinal osteotomy thus made was in the same plane as the original first MT, and the resultant translation will naturally result in a slight lengthening of the first MT (Figure 7).

Second, the dorsoplantar angle of the longitudinal cut will dictate the direction of displacement of the capital fragment. We found that the plantar surface of the MT shaft was at a 20° angle from the horizontal plane. We placed the K wires parallel to the plantar surface of the MT shaft, with the resultant cut in the same direction. The subsequent translation of the capital fragment will be towards the plantar surface, increasing the weight bearing under the first MT (Figure 8). Using the two aforementioned measures, we

**Figure 6.** Hallux valgus with increased distal metaphyseal articular angle of 25°. Scarf osteotomy was used as a single osteotomy to provide lateral translation and medial rotation to correct both deformities.

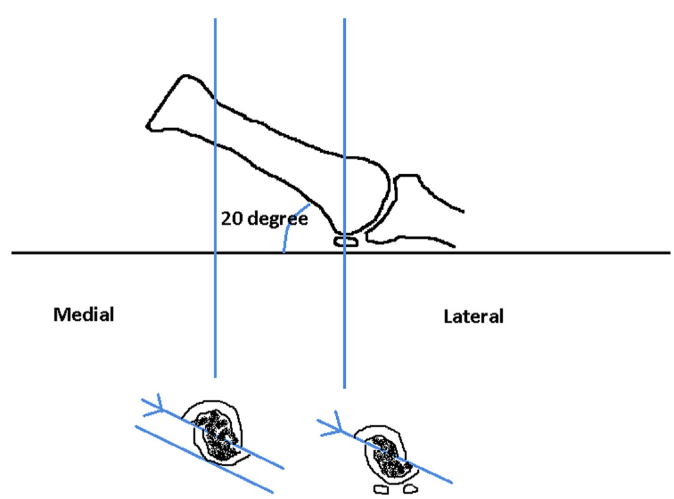


**Figure 8.** The plantar surface of the first metatarsal (MT) shaft was oriented at a 20° angle from the horizontal plane. Cuts were made parallel to the plantar cortical surface. This resulted in a plantar displacement of the cephalic segment, thus lowering the first MT head, allowing more weight bearing.

were successful in minimizing the first MT shortening due to bone loss and in preventing postoperative transfer metatarsalgia.

Additional lengthening of the first MT may be desired to alleviate transfer metatarsalgia symptoms.[8] Scarf osteotomy allows for distal translation of the osteotomy segments. Excessive bone on the medial side was resected and wedged inside the gap at the distal osteotomy site as described by Murawski et al.[9] This bone graft enhanced the stability of the osteotomy and we achieved 100% union rate with this method. In our study, 73% of the patients had improved symptoms of transfer metatarsalgia.

Following the modification by Coetzee and Rippstein,[5] we limited the distal and proximal short arms of the osteotomy to 5 mm of the respective cortices. This prevented unintentional overcut of the oblique limbs of the “Z” osteotomy from reaching the opposite cortex and thus completing the fracture. With this modification, no iatrogenic fracture was encountered. Two cases of troughing were noted, but both were asymptomatic. With care taken to preserve the plantar nutrient artery, none of the cases developed osteonecrosis despite lateral soft-tissue release.

DMAA can be abnormal in HV. Maintaining MTPJ congruency while correcting the IMA and HVA is crucial to the success of HV surgery. Smith and Coughlin[10] suggested that double and triple osteotomies must be used to achieve good outcome for patients with DMAA abnormality. We have demonstrated that scarf osteotomy is an alternative method to dispense the combined procedures. It offers a choice to correct all the deformities by a single and stable osteotomy with guaranteed union.

The scarf osteotomy is not without limitations. To maintain enough stability, the minimal contact area between the two osteotomy fragments should be no less than one-third of the MT width.[5] With this principle, scarf osteotomy would not be advisable for patients with an excessively large IMA combined with narrow MT width. However, the exact relationship between MT width and the degree of rotation and translation possible has not been investigated before. O’Briain et al[11] used a geometric formula to plan specific scarf osteotomy cuts. Using the formula, he concluded that a large IMA combined with DMAA deformity could not be adequately corrected by scarf osteotomy. Future studies should focus on incorporating different anatomical parameters into geometric formula and to predict feasibility of scarf osteotomy preoperatively.

The drawback of this study was its retrospective nature. The short- to medium-term follow-up period could not have picked up all the cases of recurrence. There was neither a control group nor blinding of the outcome measures.

## Conclusion

In this short- to mid-term study, we concluded that scarf osteotomy along with a distal soft-tissue procedure provided good patient satisfaction. We have demonstrated that scarf osteotomy was versatile enough to allow multiplanar correction of HV deformity, such as DMAA correction. The orientation of the osteotomy minimizes first MT shortening and increases weight bearing, thereby preventing postoperative transfer metatarsalgia. Lengthening can also be achieved as indicated. There are inherent limitations to scarf osteotomy, which required further studies to clarify.

## Conflicts of interest

The authors declare that they have no financial or non-financial conflicts of interest related to the subject matter or materials discussed in the manuscript.

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