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# The SCARF Osteotomy for the Correction of Hallux Valgus Deformities

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## ABSTRACT

**The authors report their experience with a modified SCARF osteotomy with three years follow-up. Correction of moderate to severe hallux valgus deformities was achieved using a Z step osteotomy cut to realign the first metatarsal bone. A retrospective analysis was undertaken in 89 consecutive patients (111 feet). Results were analyzed by clinical examination, a questionnaire including the AOFAS forefoot score, and plain roentgenograms. Hallux valgus and intermetatarsal angle improved at mean 19.1° and 6.6°, respectively. Mean forefoot score improved from 50.1 to 91 points out of 100 possible points. Satisfactory healing time was expressed by an average return back to work of 5.8 weeks and back to sport of 8.3 weeks. Persistence or recurrence of hallux valgus was seen in seven patients (6%). The complication rate was 5.4% including superficial wound infection, traumatic dislocation of the distal fragment, and hallux limitus. The presented technique provides predictable correction of moderate to severe hallux valgus deformities.**

## INTRODUCTION

The corrective osteotomy of the first metatarsal bone to reduce a increased inter metatarsal angle is performed using a Z step cut. SCARF is the carpentry term of this Z step osteotomy and osteosyntheses technique. Since the first description of SCARF osteotomy,[15] this procedure has been used with great success for correction of moderate to severe hallux valgus deformities.[2] Meyer[15] first described the principle of this osteotomy technique in search for greater stability of the corrective first metatarsal osteotomies. At this time, the use of this operative technique was limited, probably because of the lack of sophisticated osteotomy tools. Approximately 70 years later, micro oscillating saws allowed angulated osteotomy cuts in bone. Early weight bearing due to great inherent stability and rare postoperative complications have contributed to its frequent application.[27,4,29] For correction of up to 5° of intermetatarsal angles in mild hallux valgus deformities, distal metatarsal osteotomies have obtained a high degree of success.[10] The proximal osteotomy along with a soft tissue procedure[13] or the proximal chevron osteotomy with their high corrective potential[14] are excellent procedures in the treatment of moderate to severe hallux valgus deformities. However, sagittal-plane instability frequently leads to prolonged osseous healing and first metatarsal dorsiflexion malposition.[25] Therefore, midshaft osteotomies may fill the gap between the limitation of distal osteotomies and the instability of proximal osteotomies. An increased intermetatarsal (IM) angle, a normal or increased distal metatarsal articulation angle (DMAA), adequate bone stock, and symptomatic hallux valgus (HV) deformity have been established as major indications for the SCARF osteotomy.[4] To date only a few reports exist in the literature describing midterm results of SCARF osteotomy in larger populations. The literature concerning the SCARF osteotomy includes technical notes,[2,4,27] but indications and contraindications have not been well defined. The current authors report their experience with a modified SCARF procedure in a three-year follow-up and indicate the use of this procedure with respect to other corrective procedures.

## PATIENTS AND METHODS

### Patient Population

Between January 1995 and December 1996 SCARF osteotomy was performed in 117 feet (95 patients). At

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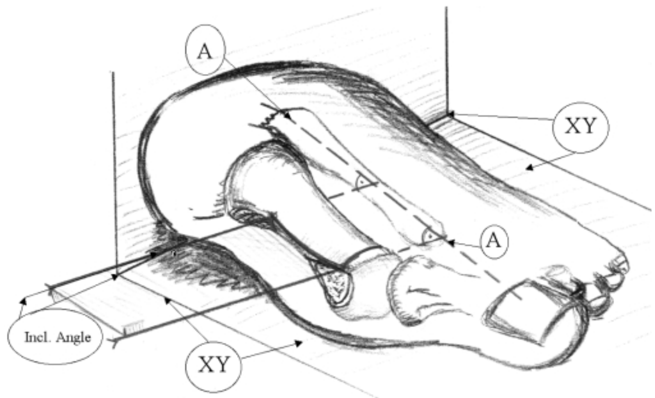


**Fig 1a:** Placement of the guiding K wires at the corner points of the planned SCARF cut. The standard orientation for the lateral translation is 90° to the longitudinal axis to the second metatarsal (A) and in approximately 20° horizontal inclination (Incl. Angle) to the plantar surface (XY).

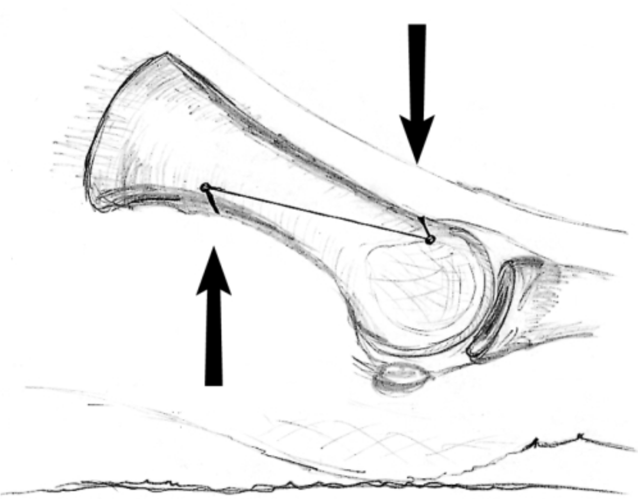

**Fig 1b:** Medial view of the first metatarsal. Entry points of the proximal and distal guiding K wire at the corner points of the Z shaped SCARF cut.

the time of follow-up six patients were lost—three patients died of unrelated causes and three patients could not be traced—leaving a study cohort of 89 study patients (111 feet). Preoperative complaints were related to footwear difficulties, functional as well as cosmetic foot deformity, and chronic pain. Pain was rated on the 10-point visual analog scale (VAS). Surgery was proposed after failure of an adequate regimen of nonoperative treatment including active foot exercises, accommodating shoes, inserts, orthoses, and nonsteroidal anti-inflammatory medication. Exclusion criteria comprised severe hallux limitus (grades III-IV), absent pedal pulses, or open epiphyseal plates.

There were 81 female and eight male patients. The average age at the time of surgery was 55.3 years (range, 29 to 82 years). Thirty-three patients had systemic disorders which caused neuropathy and/or angiopathy of the lower extremity. There were 28 patients (32%) who smoked (more than 10 cigarettes a day), two patients with diabetes mellitus, five patients with Raynaud's phenomenon (two of them in the smoker group. All cases who were at risk for vascular problems, had diabetes mellitus, a Raynaud`s syndrome or who were smokers were sent for sonography of the lower extremity arteries. Patients with pathologic sonography and manifest peripheral angiopathy were refused surgery. If the results revealed no signs of peripheral vascular angiopathy but other comorbidities existed, patients were informed about a higher risk for possible wound healing complications. If they still wanted the operative treatment, surgery was planned. Patients were also informed to stop smoking, but none did. Three patients had had previous hallux valgus operations of different types. In 31% of all the operated feet a total of 36 associated procedures were performed. Akin osteotomy was performed in seven cases.[3,1] Akin osteotomy was added to SCARF osteotomy in those cases where hallux valgus interphalangeus (HVI) with a HVI angle greater than 15° was present or if, after completing the Scarf osteotomy and the soft-tissue reconstruction, the hallux was still in more than 10° of valgus position. In 23 cases with symptomatic hammertoe deformity, hammertoe corrections using the Hohmann resection arthroplasty was added. Weil osteotomy of the lesser metatarsals[5,17] was performed in six cases for treatment of metatarsalgia.

Twenty-two patients underwent surgery on both feet, 15 patient in a single session and seven patients in two sessions with an average interval of six months. At mean of 34 months (range, 24 to 48 months) a retrospective analysis including clinical examination and radiographic evaluation was undertaken. Seventy-seven patients (94 feet) were seen in clinic, 12 patients (17 feet) were evaluated via telephone questionnaire.

**Clinical and Radiological Assessment**

Clinical preoperative and follow-up evaluation was obtained by using the 100-point AOFAS forefoot score.[9] All patients were examined preoperatively by the two operating surgeons. Follow-up examination and rating was done by two independent investigators not involved in the primary treatment. All patients seen in clinic were photographed and overall satisfaction and cosmesis were rated. Radiographic assessment was done on weight-bearing radiographs obtained pre- and postoperatively in standardized dorsoplantar and lateral views. Measurement of the forefoot align-

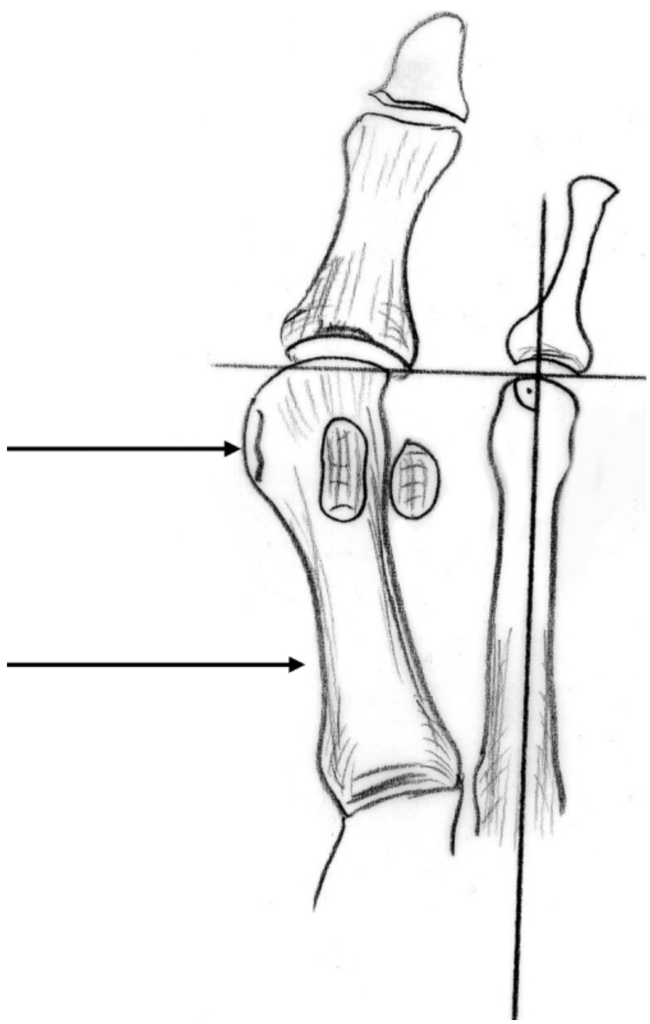

**Fig. 2a:** Options of displacement. Lateral displacement is achieved if the pins, and therefore the short osteotomy cuts, are oriented perpendicular to the longitudinal axis of the foot.

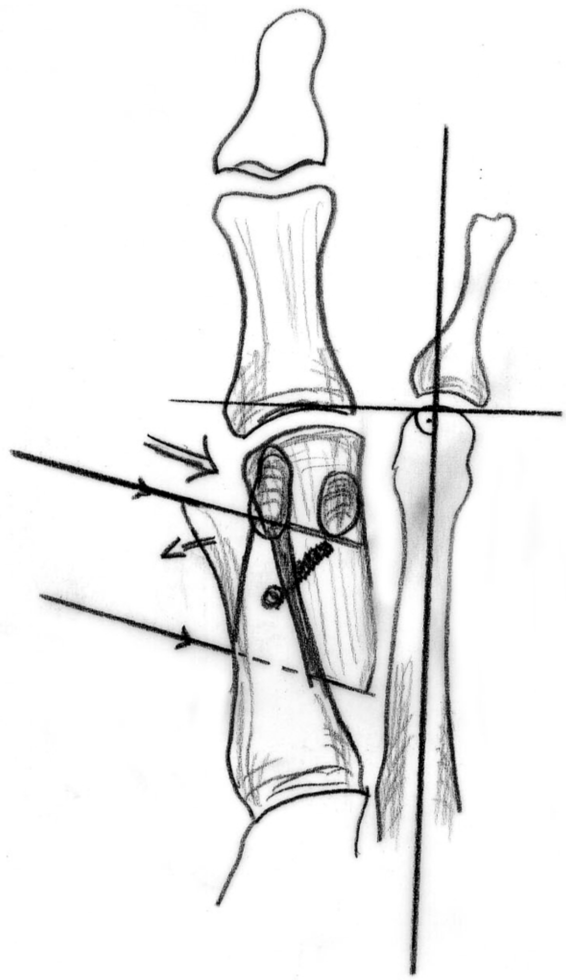

**Fig 2b:** Displacement plus shortening. Proximal oriented inclination of the pins / short osteotomy cuts causes shortening depending on the angle of inclination and the amount of translation.

ment was performed according to the guidelines accepted by the American Orthopædic Foot and Ankle Society.[21] The following radiological criteria were assessed: hallux valgus angle (HV), intermetatarsal angle (IM), distal metatarsal articulation angle (DMAA), lateral displacement of the sesamoids (sesamoid luxation), joint congruency, metatarsal index (metatarsal length I/II), and hallux valgus interphalangeus angle (HVI) (Fig. 2c).[16,21,22,23]

**Surgical Technique**

Operations were performed using a peripheral nerve block (ankle block) and a tourniquet just above the malleoli. The standard approach was via a medial incision, at the junction of the plantar and the dorsal skin, with its proximal part below the surface projection of the metatarsal to avoid hypertrophic scar formation. The joint capsule and the medial collateral ligament of the MPI joint were incised horizontally. The attachments of the collateral ligaments were retracted, but the plantar dissection of the medial ligament structures was limited to retain the vascularity of the metatarsal head. The medial aspect of the metatarsal head was exposed. The medial eminence of the metatarsal head was partially resected. A lateral release was indicated if the lateral ligaments were shortened and the MP I joint could not be manipulated in a 15° varus position. From an additional small dorsal interdigital approach, the lateral capsule was released longitudinally above the lateral sesamoid, leaving the plantar plate and the adductor tendon intact. The sesamoids were then mobilized. Some severely contracted joints required an additional vertical incision of the lateral capsule at the edge of the proximal phalanx. With the release completed, there

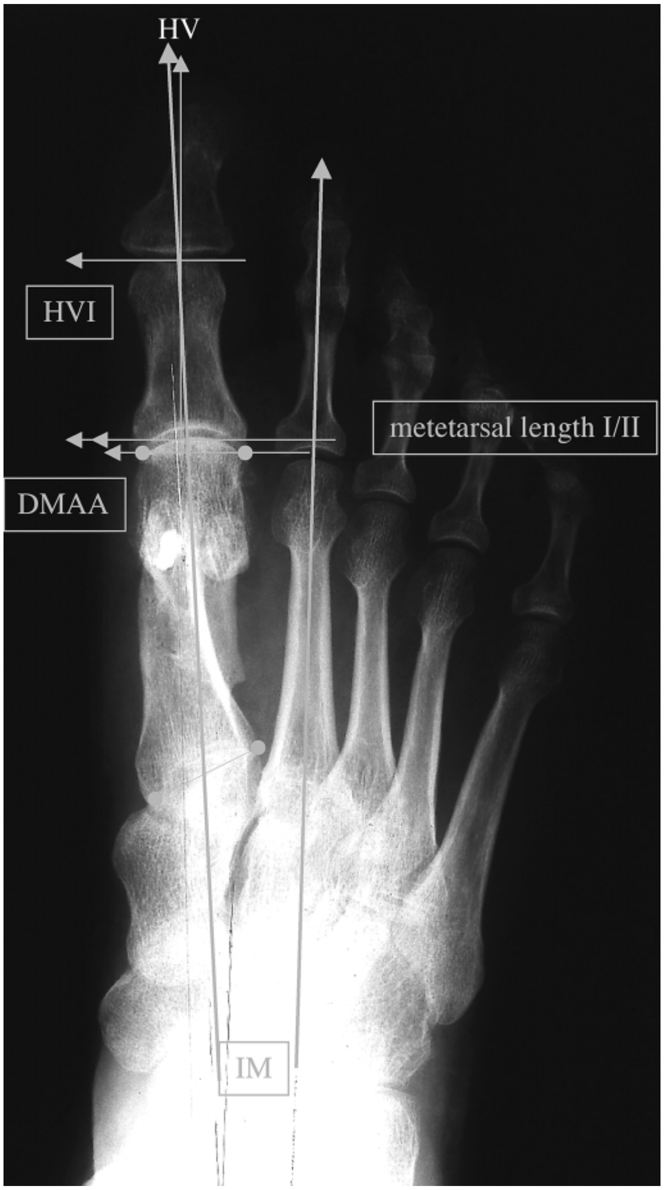


**Fig 2c:** Radiographic evaluation.

was a slight elastic resistance holding the toe in valgus. In preparation for the three osteotomy cuts, two guiding 1.2-mm K wires were inserted at the corner points of the planned SCARF cut. The entry point of the proximal pin averaged 2 cm distal to the first metatarsal medial cuneiform joint line, over the concavity of the inferior aspect of the metatarsal at the junction of the plantar-inferior to the medial aspect. The entrance point of the distal pin crossed the metatarsal head 5 mm proximal to the dorsal cartilage surface in the dorsal to the medial aspect. Both K wires were oriented strictly parallel to each other. (Fig. 1a) The horizontal osteotomies were performed using the micro-oscillating saw and the transversal osteotomies were performed using the micro-reciprocating saw (Hall Surgical, Zimmer, US). The angle of each cut was at 45° to 60° to the longitudinal metatarsal axis. (Fig. 1b) The authors' modification of the SCARF osteotomy described by Barouk[4] includes the angulation of the distal osteotomy cut and the placement of the distal pin on the dorsal-medial aspect of the first metatarsal. This modification alters the inclination of the longitudinal cut making it more oblique. After completing the osteotomy, the distal fragment was displaced laterally to reduce the intermetatarsal angle. Lateral displacement was achieved by pushing the distal fragment laterally while holding the proximal fragment of the first metatarsal in place. Different options of displacement are possible, depending on the translation and the orientation of the SCARF cut.

Pure translation is the most usual and is indicated for isolated hallux valgus with a large intermetatarsal angle. (Fig. 2a) The translation is greater for larger IM angles. For maximal stability of the osteotomy after translation, it is necessary to orient the proximal and distal osteotomy cut strictly parallel to each other. Translation and lowering was indicated for hallux valgus with intermittent metatarsalgia or a deficit of the first metatarsal head in weight-bearing. This is best diagnosed clinically rather than radiologically.[4] The osteotomy was modified by directing the orientation of the K wires and the horizontal cut more plantar. The preferred obliquity of the horizontal cut in the present study was approximately 20° to the plantar surface (Fig. 1a: Incl. Angle). The plantar surface (Fig. 1a: XY) represents the orientation of the foot in a barefoot standing position on an even floor. Translation and shortening of the first metatarsal could be performed. (Fig. 2b) Shortening was obtained by increasing the obliquity of the anterior and posterior cuts with respect to the longitudinal axis of the second metatarsal. If additional shortening was needed, small bony fragments at the level of the anterior and posterior cut were resected. Additional shortening was indicated in severe forefoot deformity with luxation of the lesser toes at the metatarso-phalangeal joints. In those few cases, first metatarsal shortening can be combined with Weil osteotomy. Translation and lengthening were indicated in cases with short first metatarsal combined with metatarsalgia. Lengthening was obtained by decreasing the obliquity of the anterior and posterior cuts with respect to the longitudinal axis of the second metatarsal. To prevent shortening, the obliquity of the pins and the proximal and distal cut must be oriented distally. Translation and rotation were used for congenital hallux valgus to attempt to correct oblique DMAA angle. Fixation of the osteotomy was achieved using a small cannulated bicortical compressive screw

(Barouk screw, Johnson & Johnson, DePuy, France), placed over a guidewire from dorsal to plantar in an angle of 20 to 45° to the longitudinal axis of the first metatarsal. (Fig. 3a, 3b) For soft tissue correction, the medial MP I joint capsule and ligaments were closed with two sutures. Tight circular capsulorathy was avoided in order to maintain MP I joint mobility in the sagittal plane. A 1.2-mm hole was drilled in the medial dorsal cortex of the proximal fragment. To suture the proximal medial ligaments a Dexon II thread (Braun-Dexon, Sherwood Med., St Louis, US) was used. The proximal suture of the medial collateral ligament was pulled through the osseous drill hole. (Fig. 4a) In order to provide a stronger fixation, the thread was stitched again through the proximal part of the medial ligament and through the osseous drill hole in the same direction. (Fig. 4b, 4c) This suture technique was named the transosseous trimming suture. The advantage the proximal part of the medial collateral ligament can be tightened via the transosseous block. By pulling on the thread, a controlled reposition of the great toe into a neutral to slightly overcorrected position was performed. (Fig. 4d) The postoperative protocol consisted of intravenous and oral pain medication. Patients operated on one foot stayed in the hospital for four days on average (range, one to six days). Those patients operated bilaterally stayed in the hospital for six days on average (range four to eight days). In the hospital, patients were encouraged to stand the next day, and they were instructed in active and passive mobilization exercises for the toe. Progressive weight bearing of the forefoot in an open-toed sandal with a firm sole was then performed.

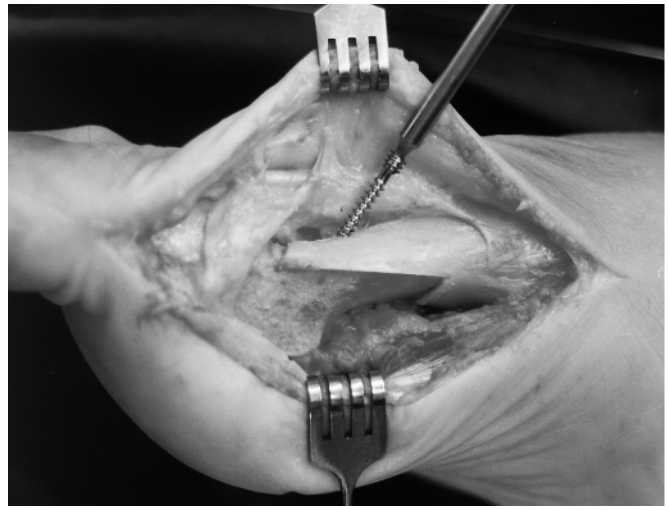

**Fig 3a:** Fixation of the osteotomy using a cannulated compressive screw.


**Fig 3b:** Radiologic six weeks postoperative standing side view. Visualization of the osteosynthesis technique and the lowering of the metatarsal head.

**RESULTS**

The average clinical and radiographic follow-up was 34 months (range 24 to 48 months) (Fig. 5). Preoperative pain level averaged 6.1 points VAS and was reduced to 1 point after surgery. With respect to postoperative pain, 78% of operated feet reported to be completely pain-free, and 12% of operated feet reported to have only occasional or slight discomfort. The remaining 10% had mild to moderate discomfort. The length of the first metatarsal was reduced by an average of 2.5 mm (+/- 2.7 mm). Healing was expressed by the ability of full weight bearing gait pattern and the time from surgery to return back to work and back to sports of 5.8 and 8.4 weeks, respectively. Bone healing was documented on plain radiographs six weeks after surgery. At the time of final follow-up, no loss of correction of the intermetatarsal angle was noted. However, seven patients (6%) showed a recurrent or persistent hallux valgus. Complications were rare and comprised superficial wound infections necessitating antibiotic medication (two feet) and traumatic dislocation of the osteosyntheses (one foot). Four cases developed a postoperative hallux limitus with a range of motion of less than 40° at the follow-up examination. All four cases were female, aged older than 70 years, with preoperative HV angle greater than 45°, and intraoperatively noticed cartilage lesions grade III on the metatarsal head.

A significant correlation was found for the AOFAS postoperative score, the postoperative IM angle and HV angle, respectively. The amount of postoperative correction of the sesamoids also correlated significantly with IM angle and HV angle ($p<0.001$ and $p<0.003$). Back to work and back to sport data showed a significant correlation ($p<0.002$). Comparison of bilateral procedures done at the same time or on different dates produced no statistical significance ($p<0.29$). When performing a linear regression the following trend was detectable: the higher age and HV angle before surgery, the lower was the postoperative score.

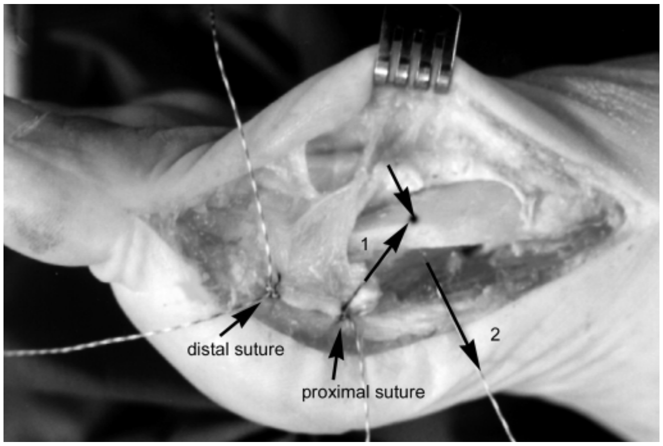


**Fig 4a:** Transosseous trimming suture of the medial collateral ligaments and the joint capsule. The thread of the proximal suture (1) is pulled through a osseous drill hole (2).

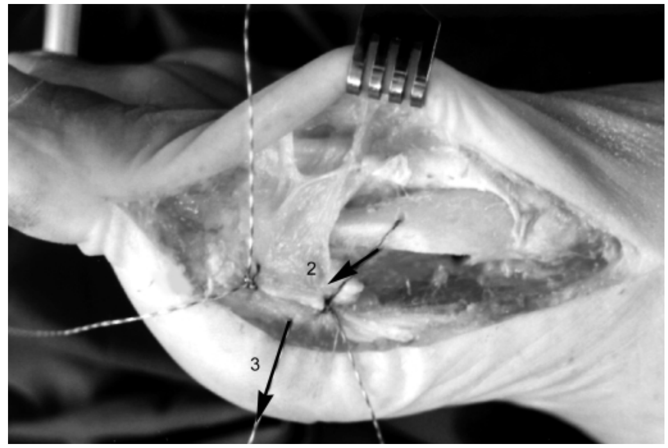


**Fig 4b:** The thread is passed inside out (2) through the medial collateral ligaments distal to the stitch (3).


**Fig 4c:** The thread (3) is pulled through the osseous drill hole again in the same direction (4).

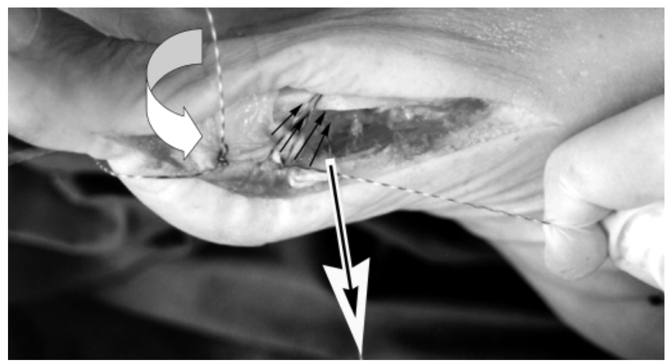

**Fig 4d:** The proximal end of the medial collateral ligaments is tightened via the transosseous block by pulling on the thread. This allows a controlled correction of the hallux and attaches the medial ligament to the desired insertion site.

Analyzing the AOFAS score, the radiological measurements and complication rates in the sub groups, the following outcome was detected:

There was no statistically significant difference between the vascular “high risk” group, composed of 28 patients (32%) who smoked, two patients with diabetes mellitus and five patients with Raynaud’s phenomenon, compared to the other patients. Superficial wound infection and delayed wound healing were seen in one case of a smoking patient with Raynault’s phenomenon. The other case of delayed wound healing was in the group without vascular risk. The patients within the smoker group were back to work after 4.6 weeks on average. This is earlier, but not statistically significant, than the other patients.

Adding Akin osteotomy to the SCARF procedure did not influence the healing time and postoperative mobilization followed the same regime. The proximal part of the distal fragment was translated in an attempt to correct an oblique DMAA but insufficient derotation correction occurred (Table 1).

**DISCUSSION**

The SCARF osteotomy has become a widely used procedure in middle Europe since the introduction and the development of specially designed osteosyntheses material.[2] This paper, introducing the SCARF osteotomy, describes the operative procedure and the possibilities of the SCARF in combination with other osteotomies in lesser metatarsals. A recently published short term follow-up study (mean 14 months) of 53 cases[29] showed an average improvement of the hallux valgus angle of 43° to 23° and the IM angle of 16° to 8°. Complications included two metatarsal fractures (3.8%) at the level of the distal screw.

Valentin[27] reported in a five-year follow-up of 56 cases with average improvement of the hallux valgus angle of 38.5° to 19°, the IM angle of 16.6° to 11.3°. Fifteen cases of hallux limitus were observed as post-operative complications. Rippstein[19] reported in a two year follow-up of 52 cases an average improvement of the hallux valgus angle from 32° to 10°, and the IM angle from 14° to 6°. One metatarsal head necrosis and one painful overcorrection were reported. Besse[6] reported in a one-year follow-up of 50 cases an average improvement of the hallux valgus angle from 32° to 13.4°, the IM angle from 13.8° to 7.8°. Two patients developed reflex sympathetic dystrophy and two fractures of the first metatarsal were seen.

The correction of DMAA malalignment by SCARF osteotomy was not significant. Therefore, DMAA malalignment should be treated using a modified, shorter SCARF[7,12] or using distal osteotomies.

Back-to-work data was influenced by many social factors, which are not always comparable in different countries. People with sedentary work were able to be back after 14 days. People carrying out heavy manual or standing work had to wait for six weeks to return to work. Patients were back at their usual level of recreational sports activity, which was mainly hiking, after 8.4 weeks. Comparative data on sports activities in the literature is rare, because back to sports and sports activities are not included in scoring systems.[23] A comparable result is reported following a group of competitive athletes treated with first metatarsal osteotomy being back at sports after 8.9 weeks.[20]

The authors are aware of the possible complications in patients with neuropathy and angiopathy. However, after careful neurovascular examination and patient selection in the "high-risk" groups, they did not find a significant higher rate of complications in this group.

It must be added in comparing these groups, that the vascular "high-risk" group included younger and more active patients. Patients with sonographic proven peripheral angiopathy were not accepted for surgery.

Cadaver studies analyzing different osteotomies and osteosyntheses of the first metatarsal under bending load conditions categorized the SCARF osteotomy to have double the stability of a distal Chevron osteotomy, or the proximal crescentic osteotomy.[18,26]

A finite element analysis showed areas of high stress within the first metatarsal at the following locations:

**Fig 5:** Dp standing radiograph of the same patient before surgery and at three years follow up after SCARF osteotomy plus an added Akin osteotomy.

**Table 1**

| | HV-angle | IM-angle | Sesamoid luxation | DMAA |
|---|---|---|---|---|
| Pre | 32.5° (18-51) | 14.5° (9-22) | 67.5 % (25-75) | 77.8° (61-93) |
| Post | 13.4° (5-42) | 7.9° (2-16) | 25% (0-75) | 81.2° (60-95) |

Values in mean (minimum – maximum)
Sesamoid luxation: Position of the medial sesamoid relative to the middle axis of the first metatarsal. 0 = no displacement, medial sesamoid medial of the middle axis; 100 = complete displacement, medial sesamoid lateral of the middle axis.

1. plantar proximal to the metatarsal head and
2. dorso-medial 2 cm distal to the base of the first metatarsal, which is the metatarso-cuneiform joint area.[11]

The area plantar proximal to the metatarsal head can be avoided using the SCARF osteotomy cut but the osteotomy cut reaches the area dorso-medial 2 cm distal to the base. This may explain postoperative fractures in the proximal part of the dorsal cortex as described in the literature.[4] Therefore, it is necessary to angle the osteotomy cut as mentioned above.

The soft-tissue technique with a lateral capsular release and medial capsular repositioning through a transosseous trimming suture is as important as the osseous correction of the first metatarsal deformity. The radiologic results were equal but not better than those for a modified Austin or chevron procedure including a soft-tissue procedure.[24]

The SCARF osteotomy is technically difficult, but the authors believe that the SCARF is indicated in hallux valgus cases with an IM angle of 14° to 18°. This procedure is then indicated to fill the gap between the limited corrective possibility of the distal chevron and the more unstable proximal osteotomies with the need for stronger immobilization. The experimentally proven greater stability of the SCARF osteotomy[11,26] favors its use.

We routinely used a one-screw fixation technique instead of the described two-screw fixation technique.[4,6,7,18,19,27,29] The experimental proven stability encouraged us to believe there was sufficient stability with one screw.

The correction of the IM angle was 7° to 8° with the SCARF technique and could be increased to 12° in severe cases needing a maximal displacement. There is no strict age limitation; however, patients older than 70 years with a large hallux valgus deformity and arthritis of the MP I joint are at risk of inferior results. The authors set the lower limit for the SCARF osteotomy at 14° of IM angle because lesser deformities can be treated using a distal chevron osteotomy.

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