Scarf osteotomy for hallux valgus
A PROSPECTIVE CLINICAL AND PEDOBAROGRAPHIC STUDY

S. Jones,
H. A. Al Hussainy,
F. Ali,
R. P. Betts,
M. J. Flowers

From the Northern General Hospital, Sheffield, England

We prospectively reviewed 24 patients (35 feet) who had been treated by a Scarf osteotomy and Akin closing-wedge osteotomy for hallux valgus between June 2000 and June 2002. There were three men and 21 women with a mean age of 46 years at the time of surgery. The mean follow-up time was 20 months.

Our results showed that 50% of the patients were very satisfied, 42% were satisfied, and 8% were not satisfied. The mean American Orthopaedic Foot and Ankle Society score improved significantly from 52 points pre-operatively to 89 at follow-up (p < 0.001).

The intermetatarsal and hallux valgus angles improved from the mean pre-operative values of 15˚ and 33˚ to 9˚ and 14˚, respectively. These improvements were significant (p < 0.0001). The change in the distal metatarsal articular angle was not significant (p = 0.18).

There was no significant change in the mean pedobarographic measurements of the first and second metatarsals after surgery (p = 0.2). The mean pedobarographic measurements of the first and second metatarsals at more than one year after surgery were within the normal range.

Two patients had wound infections which settled after the administration of antibiotics. One patient had an intra-operative fracture of the first metatarsal and one required further surgery to remove a long distal screw which was irritating the medial sesamoids.

We conclude that the Scarf osteotomy combined with the Akin closing-wedge osteotomy is safe and effective for the treatment of hallux valgus.

Hallux valgus is a common condition and surgical correction has remained a challenge over the last 100 years with at least 130 procedures being described. The choice of operation depends principally on the severity of the deformity. For mild and moderate deformities, distal osteotomies of the first metatarsal joint such as the Chevron, Austin, Wilson or Mitchell techniques are used.

A proximal metatarsal osteotomy is recommended for more severe deformities because it allows a greater degree of correction. This may be at the expense of stability and bony healing. The Scarf osteotomy has gained popularity because of its inherent stability, minimal shortening of the first metatarsal and ease of internal fixation.

Meyer first described the greater stability of this osteotomy (Z step cut) but initially its use was limited probably because of a lack of sophisticated instruments. Recently, Weil and Borelli in the USA and Barouk in France have contributed to its development. Nevertheless, most of the studies have been retrospective. We present the results of a prospective study of the Scarf osteotomy and Akin procedure for the treatment of hallux valgus.

Patients and Methods
Between June 2000 and June 2002, 26 patients (37 feet) underwent a Scarf osteotomy of the first metatarsal and an Akin closing-wedge osteotomy of the proximal phalanx of the great toe for the correction of hallux valgus.

Pre-operative complaints included a bunion, pain and difficulty with footwear. Surgery was proposed after failure of a trial of non-operative treatment which included using accommodating shoes, orthoses and non-steroidal anti-inflammatory drugs. Exclusion criteria included hallux rigidus, open epiphyseal plates, absent pedal pulses and local infection.

We performed a prospective evaluation including clinical, radiological and pedobarographic assessment.

Two patients (two feet) were excluded because one had previous surgery to the feet and the other was lost to follow-up. This left 24 patients (35 feet) in the study. There were
three men and 21 women with a mean age at the time of surgery of 46 years (18 to 73). Bilateral procedures were undertaken on 11 patients. The mean follow-up was 20 months (9 to 33). All patients were evaluated before and after operation by a single observer (HAA).

The clinical evaluation was both subjective and objective. As part of the subjective assessment the patients were asked if they were very satisfied, satisfied or not satisfied with the results of surgery. The hallux metatarsophalangeal interphalangeal scale developed by the American Orthopaedic Foot and Ankle Society (AOFAS score) was used for the objective assessment.19 The questionnaire was completed at the pre-operative assessment clinic and at the final follow-up. The pre-operative AOFAS score was not available to the patients or assessor at the final review thus eliminating bias.

Radiological evaluation. Dorsoplantar and lateral weight-bearing radiographs were obtained at the pre-operative assessment clinic and at the final follow-up. The pre-operative AOFAS score was not available to the patients or assessor at the final review thus eliminating bias.

Radiological evaluation. Dorsoplantar and lateral weight-bearing radiographs were obtained at the pre-operative assessment clinic and at follow-up visits. The parameters measured included the intermetatarsal angle (IMA), the hallux valgus angle (HVA), the distal metatarsal articular angle (DMAA) and the length of the first metatarsal as compared with the second.

The IMA is the angle formed by the intersection of the bisection of the first and second metatarsals. The bisection of the first metatarsal was determined using the technique recommended by Nestor et al20 which consists of a line drawn through the centre of the head and the proximal metaphyses. The reference point for the latter is equidistant from the outer border of the medial and lateral cortices. For the second metatarsal, the reference points recommended by Coughlin, Saltzman and Nunley21 were used. Normal values for the IMA range from 7˚ to 9˚.22

The HVA was assessed using the intersection of the bisection of the first metatarsal and proximal phalanx. The normal value for the first metatarsophalangeal (MTP) joint is 10˚ to 15˚.23

The DMAA is formed between the perpendicular to the effective articular cartilage of the first metatarsal head and its intersection with the bisection of the first metatarsal. The normal value is up to 8˚.23

The length of the first metatarsal was assessed using a modified version of the method described by Davies and Saxby.24 This was carried out on the dorsoplantar weight-bearing radiograph using the following equation:

\[
\left[ \left( \frac{B_{\text{post-operative}}}{A_{\text{post-operative}}} \right) \times \left( \frac{A_{\text{pre-operative}}}{A_{\text{pre-operative}}} \right) \right] - B_{\text{pre-operative}}
\]

in order to obtain accurately the length of the first metatarsal. For example, if line ‘A’ (second metatarsal or any other non-operated bone length) measures pre- and post-operatively 100, and 105mm, respectively, this makes the magnification factor 1.05, and if line ‘B’ (first metatarsal length) measures pre- and post-operatively 85, and 84mm, respectively, the first metatarsal, therefore is lengthened by 3.2mm (Fig. 1).

Pedobarography. This was carried out using the method described by Betts, Franks and Duckworth.25 The method is well-documented and involves a calibrated optical-pressure measuring plate which is at a defined point along a walk path 10 m long and this is connected to a computer which records the data.

The patients repeatedly walk barefooted along the path at their normal pace from a predetermined point. Five readings are recorded for each foot from which the mean for each foot is calculated. The measurements for both feet were recorded in all patients who had pedobarography.

The pre-operative assessment was carried out usually within one month of surgery and the post-operative evaluation one year after operation. Previous experience has shown that within a year of surgery pedobarography is usually not entirely accurate since most patients do not fully load the first metatarsal.

Operative technique. All the operative procedures were carried out by the senior author (MJF) under general anaesthesia. A mid-thigh pneumatic tourniquet (300 mmHg) was used.

A lateral soft-tissue release as described by Barouk8 was undertaken through a dorsal skin incision between the first
and second metatarsal heads. A separate dorsomedial longitudinal skin incision was made over the first MTP joint. The length of the skin incision varied depending on the length of the first metatarsal Z (Scarf) osteotomy. The medial aspect of the first MTP was exposed after a longitudinal capsulotomy. Using a pneumatic oscillating saw the medial eminence of the first metatarsal head was resected. The Scarf (Z) osteotomy was then cut with the oscillating saw. The plantar fragment was translated laterally while holding the dorsal fragment (Fig. 2). Lateral translation is required, and in addition, lowering, shortening or lengthening of the first metatarsal may be achieved.

Translation and lowering of the first metatarsal were indicated for hallux valgus with metatarsalgia and a callosity related to the second metatarsal head. This was achieved by directing the long transverse limb of the osteotomy more plantarward.

Shortening of the first metatarsal was obtained by increasing the obliquity of the transverse limbs of the osteotomy with respect to the longitudinal axes of the second metatarsal. Additional shortening was achieved by resecting small bony fragments at the level of the transverse limbs, ‘the Maestro cut’.

Lengthening was indicated in patients with a short first metatarsal combined with metatarsalgia. This was obtained by decreasing the obliquity of the transverse limbs of the osteotomy with respect to the longitudinal axes of the second metatarsal. The osteotomy was stabilised by two cannulated Barouk screws and the overhanging edge of the bone was then resected.

An Akin closing-wedge osteotomy of the proximal phalanx of the great toe was undertaken if at this stage there was any contact between the distal ends of the great and second toes. The Akin osteotomy was stabilised using an 8 mm staple (Depuy France S.A., Lyon, France). With the great toe plantar flexed the medial capsule was repaired (double-breasted) using absorbable vicryl sutures. The skin edges were apposed using absorbable monocryl subcuticular sutures.

Second-generation cephalosporin (cefuroxime 750 mg) was given intravenously at the induction of anaesthesia and at eight and 16 hours after operation. Thromboembolic prophylaxis was not routinely administered.

Post-operatively, all patients wore a forefoot plaster-cast for three weeks and were allowed to bear weight on the heel immediately. They were then encouraged to return to normal activities and to wearing normal footwear.

**Table I.** Details (mean, range) of the clinical and radiological evaluation

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative</th>
<th>At follow-up</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AOFAS score (points)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global (max 100)</td>
<td>52 (15 to 78)</td>
<td>89 (50 to 100)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pain (max 40)</td>
<td>20 (0 to 30)</td>
<td>34 (20 to 40)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Function (max 45)</td>
<td>29 (15 to 35)</td>
<td>38 (27 to 45)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Alignment (max 15)</td>
<td>1 (0 to 8)</td>
<td>14 (0 to 15)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Radiographic angles (˚)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMA</td>
<td>15 (10 to 19)</td>
<td>9 (2 to 15)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HVA</td>
<td>33 (24 to 46)</td>
<td>14 (2 to 32)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>DMAA</td>
<td>14 (6 to 35)</td>
<td>11 (3 to 25)</td>
<td>0.18</td>
</tr>
</tbody>
</table>

**Results**

All the patients required an Akin closing-wedge osteotomy of the proximal phalanx in addition to the Scarf osteotomy. The great toe was the sole site of surgery in all cases. At the
time of follow-up 50% of the patients were very satisfied, 42% were satisfied and 8% were not satisfied.

The mean global AOFAS score improved significantly from a pre-operative score of 52 points (15 to 78) to 89 (55 to 100) at follow-up (p < 0.001).

The mean pain subscore improved from 20 points (0 to 30) before operation to 34 (20 to 40) at follow-up (p < 0.001), the mean function subscore from 29 points (15 to 35) to 38 (27 to 45) (p < 0.001), and the mean alignment subscore from 1 point (0 to 8) to 14 (0 to 15) (p < 0.001) (Table I).

There was no statistically significant difference between the global AOFAS score in the very satisfied and not satisfied groups. There was no statistically significant difference (p > 0.3) in the mean AOFAS score at follow-up of patients aged <49 years from that of those >49 years.

The pre-operative range of movement of the first MTP joint was >75° in 20 feet (57%), between 30° and 74° in 12 (34%), and <30° in three (9%). Post-operatively, it was >75° in 25 feet (71%), between 30° and 74° in nine (26%), and <30° in one foot (3%).

The mobility of the first MTP joint improved in nine feet (26%), was unchanged in 22 (63%) and reduced in four (11%).

Three of the patients who lost movement of the first MTP joint had a pre-operative range of movement of less than 40°. All were women and intra-operatively, lesions of the articular cartilage (grade III) had been noted on the metatarsal head.

Comparison of the clinical outcome (AOFAS score) of bilateral procedures done at the same time or on different dates produced no statistical significant difference (p = 0.2).

The IMA significantly improved from a pre-operative mean of 15° (10 to 19) to 9° (2 to 15) at follow-up (Fig. 3; p < 0.001). The HVA improved significantly from a pre-operative mean of 33° (24 to 46) to 14° (2 to 32). The improvement was statistically significant (p < 0.001) (Table I).

The DMAA changed from a pre-operative mean of 14° (6 to 35) to 11° (3 to 25) at follow-up. The change was not statistically significant (p = 0.18; Table I).

The correlation coefficient between the global AOFAS score and the hallux valgus angle and the IMA was respectively low (<0.45).
The first metatarsal was shortened by a mean of 1 mm (SD ± 1.9) after surgery. At the latest review, there were no cases of transfer metatarsalgia.

Pre- and post-operative pedobarographic data were available for 30 feet (Fig. 4). In all of these patients the post-operative measurement was carried out at more than one year after surgery. Five patients did not have post-operative pedobarography. Four of these five patients did not have a post-operative assessment because their follow-up was less than one year and thus did not fulfil the criteria. One patient declined further pedobarography. The mean peak-pressure measurement of the first metatarsal heads decreased after surgery while that of the second metatarsal heads remained similar to the pre-operative readings. The change of the first metatarsal head peak pressure was not significant (p = 0.2). The mean readings after surgery were within the normal range. In those patients with unilateral deformities there was no statistical difference (p = 0.2) between the pre- and the post-operative pedobarographic measurements of the non-operated normal side.

Two patients had high post-operative peak pressures beneath the first metatarsal heads. One of these had had bilateral procedures (Fig. 4) and had a low AOFAS score and was not satisfied with the results of surgery. The other had a long distal screw which was removed.

Complications. Two patients had superficial wound infections which settled after administration of appropriate antibiotics.

A fracture of the first metatarsal occurred intra-operatively in one patient but this healed satisfactorily without compromising the outcome. In one patient, the distal screw was prominent and irritated the medial sesamoid causing pain. The pain resolved when the screw was removed after the osteotomy had healed.

Discussion

‘Scarf’ is the English translation of the phrase le trait de Jupiter des Charpentiers. It is a technique used by carpenters to increase the size of an entrance. Beams of timber are secured longitudinally together after notching or grooving the ends thereby allowing a degree of overlap. They are then fastened firmly as one piece.

Although it is accepted that no single operative procedure can address the wide range of deformity of hallux valgus the Scarf osteotomy has become widely used because of its great versatility. It allows lateral displacement of the plantar bone fragment thus reducing the IMA, medial displacement of the capital fragment in cases of hallux varus, plantar displacement to increase the load of the first ray and vice versa, elongation in cases of a short first metatarsal, and shortening in cases of a long first metatarsal.7-10

In addition, it avoids the complication of metatarsus elevatus associated with other proximal metatarsal osteotomies.27

Modifications of the Scarf osteotomy have been described,5,28,29 but they all have in common a Z-type first metatarsal osteotomy which is internally fixed, a lateral release, excision of the medial bony eminence and a medial capsulorraphy.10

Rigid compression of large areas of bone on bone provide a good environment for primary bone healing thus allowing early return to normal weight-bearing and exercises to prevent stiffness of the joint.28 Cadaver studies have confirmed that under loaded conditions the Scarf osteotomy has double the stability of a distal Chevron osteotomy or a proximal crescentic osteotomy.30,31 The patients in our series were allowed to bear weight on the heel and then immediately return to full weight-bearing when the plaster was removed at three weeks, without any significant complications.
There was a mean improvement of the IMA of 6° (from 15° to 9°) and of the HVA of 19° (from 33° to 14°). These results are comparable to published results.\(^2\,12\)-\(^{18}\)

The correlation of the DMAA was not significant; it increased in some patients and decreased in others. There did not appear to be any disadvantages associated with increasing the DMAA. It would seem logical to believe that restoration of bone and joint alignment were more important than realigning the cartilaginous surface of the metatarsal head (DMAA) which is difficult to assess on radiographs.\(^2\)

Sullivan, Robison and Palladino\(^32\) have shown that there is little correlation between the pre-operative radiograph and intra-operative measurement of DMAA.

The range of movement of the first MTP joint improved in 26% of cases and remained unchanged in 63%. These results are comparable to observations by Crevoisier et al.,\(^17\) who reported that 71% of cases had a range of movement >75° at follow-up.

We believe that this good range of movement is due to a combination of factors which include ‘pristine-looking’ articular cartilage overlying the first MTP joint, early passive, then active mobilisation of the first MTP joint and repair of the capsule with the great toe maximally plantar flexed.

The low correlation between the radiological results and the global AOFAS score in this study and other reports\(^17\),\(^18\) suggests that the AOFAS score may not be adequate for assessing outcome and other aspects of skeletal correction not currently included may be required.

Glasoe, Allen and Saltzman\(^33\) have suggested that the dorsal mobility of the first ray correlates positively with the IMA. However, the mobility of the first ray is difficult to assess accurately.\(^34\) The plantar-pressure patterns in the foot have also been suggested as a means of providing additional information.\(^31,\)\(^35\) We have found pedobarography to be useful in assessing forefoot plantar-pressure patterns and have used it both as a pre-operative tool and to assess outcome in addition to other measures such as the AOFAS score and radiography.

In conjunction with radiography it helps to determine those cases which require lowering, shortening or lengthening of the first metatarsal. Figures 4, 5a and 5b demonstrate the usefulness of pedobarography as a pre-operative tool. In this patient the first metatarsal was shortened and the plantar-pressure patterns in the dorsal mobility of the first ray correlates positively with the subjective outcomes.

In this series two patients with high post-operative peak-pressure readings had correspondingly poor objective and subjective outcomes.

 Reported complications include infection, transfer metatarsalgia, osteonecrosis of the first metatarsal head, fracture of the first metatarsal, prominent screw causing irritation, screw back-out, post-operative neuralgia and reflex sympathetic dystrophy,\(^11\),\(^18\),\(^36\) In our series the rate of complication was low and only one patient has required further surgery.

The limitations of our study are that some patients did not have pedobarography and with a mean follow-up of 20 months no conclusions could be made about the long-term outcome of the Scarf osteotomy. We conclude however, that in the short term, the Scarf osteotomy and Akin closing-wedge osteotomy of the proximal phalanx of the great toe appear to be safe and effective for the treatment of hallux valgus.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


