The Foot and Ankle Online Journal
Official Publication of the International Foot & Ankle Foundation
faoj.com / ISSN 1941-6806

The Scarf Osteotomy: A technique variant: The trotation scarf and Akin osteotomies for hallux valgus: Short term results of 73 cases

by Felix M. Lopez [1], Ian Reilly[1], Lee Murphy[1]

The Foot and Ankle Online Journal 8 (1): 3

Background: Hallux valgus is the most common foot deformity seen within specialty foot and ankle clinics. The diaphyseal scarf osteotomy has gained significant popularity due to its ability to achieve a greater degree of correction and stability. This particular technique of the scarf osteotomy was developed following the undertaking of both the traditional translation with a trotation variation of the scarf osteotomy with satisfactory results post-surgery. The current technique employed within this cohort of patients within this study entails both translation and abductory rotation aspects. Podiatric surgeons in the UK have coined this technique the trotation scarf osteotomy.
Methods: Between October 2009 and June 2011, 73 patients underwent trotation scarf and Akin osteotomies for the treatment of hallux valgus. A retrospective review of the case notes and x-rays both pre and post operatively was undertaken in order to review the degree of correction of the intermetatarsal angle and hallux valgus angle following this variation of the scarf technique, with the use of distal and proximal fixation achieved via a part threaded Kirschner wire and AO screw respectively.
Results: Seventy-three patients underwent surgery for hallux valgus. Sixty-three patients (86%) also had an Akin osteotomy. Preoperatively the mean hallux valgus angle measured was 32.8 degrees (SD 7.4). The mean first-second intermetatarsal angle was 15.6 degrees (SD 3.0). Postoperatively the mean hallux valgus angle was reduced to 8.4 degrees (SD 7.5). The mean first-second intermetatarsal angle was reduced to 4.1 degrees (SD 2.6). The mean reduction in hallux valgus angle and intermetatarsal angle was 24.4 degrees (SD 8.7) and 11.5 degrees (SD 2.8) respectively. There were no cases of recurrence with first MTP joint/hallux valgus angles in excess of 15 degrees in the 6 month follow up period. Hallux varus occurred in 3 feet (4%). There was one case of DVT (1.4%). Nine feet of the sample (12.3%) required removal of the internal fixation within 6 months due to irritation of the metalwork.
Conclusions: The trotation scarf osteotomy technique undertaken within this cohort in conjunction with the Akin osteotomy is an effective variant on the traditional translation and rotation scarf techniques for the treatment of hallux valgus with high intermetatarsal angles. The fixation technique employed has a relatively low complication rate.

Keywords: hallux valgus, Akin, osteotomy, trotation

Hallux valgus is the most common condition affecting the great toe [1] and is a significant cause of foot pathology [2].

Address correspondence to: Ian Reilly, Northampton General Hospital, Billing Road, Northampton E-mail: ian.reilly@nhft.nhs.uk
[1]Northamptonshire Healthcare NHS Foundation Trust, Department of Podiatry, Podiatric Surgery, Battle House, Northampton General Hospital, Billing Road, Northampton NN1 5BD.
Blackpool Victoria Hospital, Whinney Heys Road, Blackpool, Lancashire, FY3 8NR

ISSN 1941-6806 doi: 10.3827/faoj.2015.0801.0003

Due to the complexity of the deformity no two cases will ever be identical [3]. There are over 130 operations reported for the correction of hallux valgus [4], however, no single technique can address every case presented to the foot and ankle surgeon [1,5]. The scarf and Akin osteotomies have been well documented within the literature with regards to correction of hallux valgus with favorable results [6-34].

There are several variations on the surgical interpretation among surgeons for reduction of the intermetatarsal angle [6-13, 35]. Some authors feel a pure translation scarf osteotomy is restricted by the degree of intermetatarsal angle (IMA) correction available without risking troughing [20]. In view of this limitation, a rotational displacement has been described initially by Duke [12] in order to correct higher degrees of IMA's, however, it is unclear whether troughing is eliminated with this technique and if higher degree IMA's are addressed [33]. The technique employed in this study entails both translation and rotation and will evaluate the degree of IMA and hallux valgus angle (HVA) correction.

Methods

Seventy three patients who had undergone hallux valgus correctional surgery via combination translation / rotation (trotation) scarf and Akin osteotomies for a symptomatic bunion deformity between October 2009 and June 2011 were entered retrospectively into this clinical audit. The audit was approved by the audit committee. The clinical case notes along with pre and post-operative X-rays were reviewed with the following details obtained; the HVA, IMA, type of fixation, intra-operative troughing, post-operative troughing, non-union, delayed union, mal-union, avascular necrosis, metatarsal osteotomy fracture, fixation irritation and removal, hallux varus, hallux valgus reoccurrence and satisfaction at six months post-surgery were all noted.

In the 73 patients reviewed, 10 patients did not require an Akin osteotomy. However, 25 adjunctive procedures were performed: three Weil osteotomies for pre-existing metatarsalgia, 19 second toe proximal interphalangeal joint (PIPJ) arthrodeses, two third toe PIPJ arthrodeses, and one fifth metatarsal scarf osteotomy for the correction of a Tailors bunion.

Clinical and Radiographic Evaluation

The foot was examined clinically in both standing and non-weightbearing, as splaying of the foot is evident during weightbearing reflecting the exact functional position of the foot [5,36]. Pronation of the foot has been linked with both increased space between the IMA and first metatarsal dorsiflexion [37].

Standard pre-operative radiographic assessment of the hallux valgus includes dorsal-plantar and lateral weightbearing views of the foot. Specific measurements include the HVA and IMA of the first and second metatarsal. Severity of the deformity may be determined according to these specific measurements (Table 1) [5]. In addition, first MPJ congruency should be noted as well as position of the sesamoids [38]. It has also been suggested that first MPJ degeneration should also be considered [5, 36].

	HVA	IMA
Mild	<_19 degrees	<_13 degrees
Moderate	20-40 degrees	14-20 degrees
Severe	>40 degrees	>20 degrees

Table1 Classification of hallux valgus according to HVA and IMA.

The measurement of the HVA was carried out via the technique described by Miller [39] using a bisection of the first metatarsal and proximal phalanx with measurement of the deviated angle. The IMA was measured via bisections of both the first and second metatarsals with the degree of metatarsal splay measured. The first metatarsal joint congruency and sesamoid position was not recorded in this study, nor was the metatarsus adductus angle measured. The use of the scarf and Akin osteotomies for the correction of hallux valgus with associated metatarsus adductus is well documented [19, 40].

Although angular measurements vary with regards to intra and interobserver variability [41, 42], they are useful in demonstrating the severity of the deformity. All measurements were undertaken by the lead author to exclude interobserver error.

Operative Technique

All the procedures were carried out on a day case surgery basis via the use of a pneumatic ankle tourniquet under regional local anesthesia. An ankle block was administered with further popliteal blockade for the management of post-operative pain.

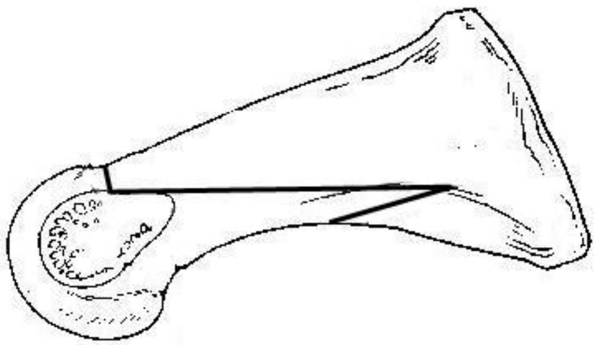

Figure 1 Demonstrates the sagittal view of the cut orientations.

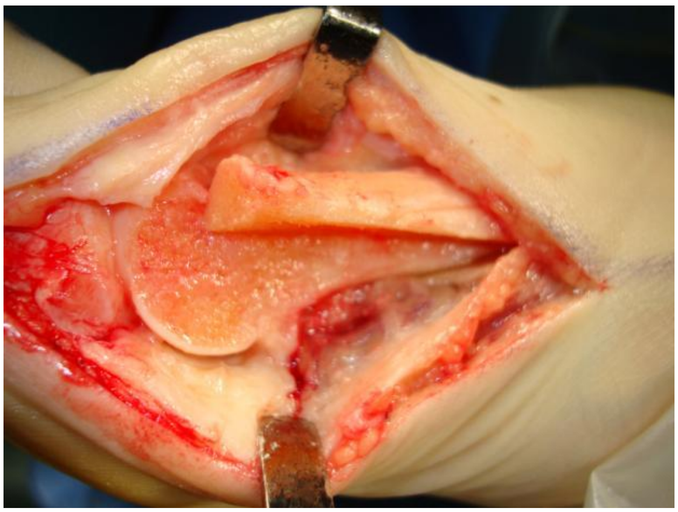

Figure 2 Demonstrates the sagittal view of the cut orientations plus the translation and rotation aspects of the osteotomy.

A semi elliptical longitudinal skin incision was placed along the medial aspect of the first metatarsal, which extended distal from the first metatarsocuneiform joint to proximal of the interphalangeal joint of the hallux. Vessels were cauterized via bi-polar diathermy. The incision was deepened to the periosteum and joint capsule via careful sharp dissection with protection of the medial branch of the superficial peroneal nerve. A further longitudinal semi elliptical capsular incision was used to expose the metatarsal and first MPJ via the periosteum and capsule. A McGlamry elevator was scooped around the metatarsal head to release the lateral sesamoid complex and capsule.

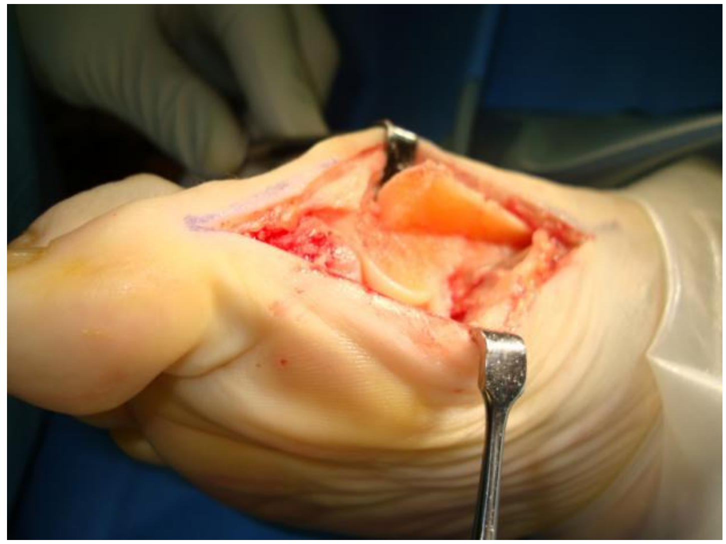

Figure 3 Demonstrates further the translation and rotation aspect of the osteotomy.

The medial eminence was resected; a dorsal distal cut was made at 90 degrees medial to lateral perpendicular to the second metatarsal to preserve the length of the metatarsal. The longitudinal cut was made along the length of the diaphysis medial to lateral, sloping dorsal-distal to plantar-proximal, in order to reduce the stress riser risk and fracture [43,44] i.e. 1/3 dorsal to 1/3 plantar. The saw blade was also aimed plantarward as it passed laterally, allowing plantar displacement and offloading of the lesser rays [5]. The proximal cut was made distal to the plantar metatarsal base flare medial to lateral perpendicular to the second metatarsal at an acute angle close to twenty to thirty degrees from the longitudinal cut in the sagittal plane; this creates a plantar shelf which aids transposition and rotation during correction of the IMA, Figure 1 & 2.

The dorsal and plantar fragments of the metatarsal were separated and any remaining soft tissue attachments were released. The dorsal fragment was then pulled medial and the plantar fragment pushed lateral as described by Barouk [45] in order to correct the IMA. The proximal fragment in this technique was transposed proximally 1/3 of the width of the base of the metatarsal and the head of the metatarsal was rotated until adequate correction was achieved, Figure 3.

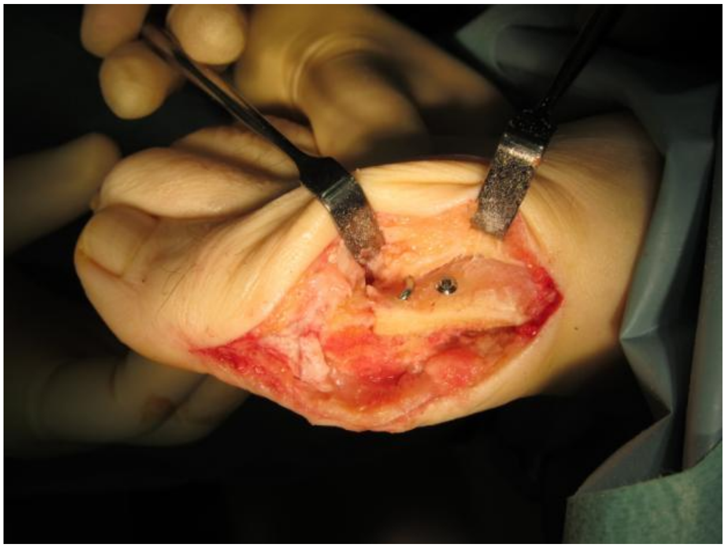

Figure 4 Demonstrates the position of the distal Kirschner wire and AO screw fixation.

Figure 5 Demonstrates the sagittal view and profile of the Kirschner wire and AO screw.

The tibial sesamoid was located and checked to be directly under the medial sesamoid groove of the first metatarsal head. The osteotomy was inspected for intra-operative troughing and then fixated distally via a 1.6mm part threaded Kirschner wire placed obliquely into the metatarsal head, it was inspected not to permanently breach the articular surface of the first metatarsal head. It was then bent, cut and rotated to sit flush within the first intermetatarsal space against the lateral cortex of the metatarsal, a variation on the technique known as the lock pin technique developed and popularized by Yu and Malay [46].

Figure 6 Demonstrates the dorsal view the Kirschner wire locked into the dorsal lateral aspect of the 1st metatarsal into the intermetatarsal space.

Proximal fixation was achieved via a 2.0mm AO cortical screw, Figure 4, 5 & 6. The medial overhang was then resected and an Akin osteotomy, should it be required, was carried out and fixated with either a 1.6mm fully threaded Kirschner wire or 2.0mm AO cortical screw. The foot was then further assessed to determine if an adductor hallucis release was required and should this have been the case this was then carried out intraarticularly as described by Kramer [11]. The area was flushed with saline and the capsule and periosteum closed without tension via a 2.0 Vicryl® locking suture technique. The skin was closed using 3.0 Prolene® horizontal mattress sutures.

Post-Operative Care

The wound was dressed with a paraffin gauze dressing, interdigital gauze bandage, Sofban™ and external Coban™ for compression, in order to reduce postoperative edema. The patient was advised regarding two days bed rest with hydration, elevation and calf exercises. The patient was then able to mobilize with crutches within a non-flexible postoperative shoe with heel weightbearing and instructed to remain on light duties for four weeks. The wound was inspected at two weeks, with sutures removed and a further dressing applied; patients were encouraged to dorsiflex and plantarflex the first metatarsal phalangeal joint to tolerance. Post-operative x-rays were undertaken at four weeks with a review and advised to return to footwear if deemed appropriate. Patients were then reviewed at six months post operation.

Results

Seventy three patients underwent surgery for hallux valgus. All had a trotation scarf osteotomy fixated distally with a single part threaded Kirschner wire and a proximal screw. There were no intra-operative troughing episodes, non-union, mal-union, delayed unions, avascular necrosis, metatarsal osteotomy fractures or transfer metatarsalgia within this study cohort, nor were there any hallux valgus reoccurrence at the six month review. No superficial or deep infections were seen.

Sixty three (86%) of patients had an Akin osteotomy fixated with a single screw or Kirschner wire. Twenty-two (30%) of patients underwent a secondary procedure at the same time (either lesser toe fusion, arthroplasty or lesser metatarsal osteotomy).

Pre-operatively the mean HVA was measured on weight bearing x-rays was 32.8 degrees with a range of 14.3 to 56.8 degrees (SD 7.4). The mean first-second IMA was 15.6 degrees with a range of 5.8 to 22.3 degrees (SD 3).

Postoperatively the mean HVA measured on weight bearing x-rays was 8.4 degrees with a range of -12 to 30.3 degrees (SD 7.5). The mean first-second IMA was reduced to 4.1 degrees with a range 0.2 to 10.5 degrees (SD 2.6). The mean reduction in hallux valgus angle and intermetatarsal angle was 24.4 degrees (SD 8.7) and 11.5 degrees (SD 2.8) respectively.

There were no cases of early recurrence with first MTP joint/hallux valgus angles in excess of 15 degrees in the 6 month period. Hallux varus occurred in 4.1% (3 feet). 2 participants required revision surgery for hallux varus. There was one case (1.4%) of deep vein thrombosis (DVT) treated successfully via the DVT clinic.

12.2% of the sample (9 feet) required removal of the internal fixation within 6 months due to irritation of the metalwork.

Seventy one of the 73 patients were happy with their results, the two patients that were dissatisfied developed hallux varus post operatively. These patients went on to further surgery and although initially disappointed, they were completely satisfied following correction. The nine patients that developed metalwork irritation and required removal were also completely satisfied, even before metalwork removal. This was conveyed in the 6 month post-operative review.

Discussion

The first Z-shaped osteotomy was originally developed by Meyer in 1926 [47]; however, the osteotomy was within the sagittal plane and was not intended for hallux valgus correction. Burutaran [48] some fifty years later described a Z-shaped osteotomy for the correction of hallux valgus. Weil went on to develop the technique achieving widespread use following the description of fixation using two AO screws [49, 50].

The scarf technique advantages include: compression of large surface areas of bone enabling primary bone healing with return to weightbearing [45, 51] due to the inherent stability [52, 53]. The early commencement of range of motion exercises with a view to preventing joint stiffness and edema may also be employed [9]. The osteotomy further allows considerably accurate intermetatarsal angle reduction and can be modified to enable the metatarsal to be shortened or lengthened, and plantarly or dorsally displaced should this be required [22] it has also been demonstrated to be an extremely effective technique following iatrogenic recurrent hallux valgus [54].

As a diaphyseal procedure, the scarf is very well suited to the reduction of moderate-to-high metatarsus primus varus deformities with IMA of 12-20 degree [14, 20, 55]. It may provide reduction in the metatarsus primus varus angle up to 10 degrees [56].

The scarf osteotomy has therefore become widely popular for the treatment of all grades of hallux valgus, the multiplanar correction cannot be matched by other techniques [53, 57]; the geometry of the osteotomy enables considerable versatility and is therefore open to considerable interpretation compared to other osteotomies [35].

Glickmann and Zahari in 1986 undertook a Z osteotomy with a horizontal cut of 2.5cm with a dorsal-distal and plantar-proximal cut angled at 30 degrees [6]. Kelikian in 1988 reviewed a Z osteotomy with a 3 cm horizontal cut with the dorsal-distal and plantar-proximal cuts angled at 45 degrees; he also angled the dorsal-distal cut 15 degree laterally [7]. Gill in 1988 modified the Z osteotomy to incorporate a 2.4 cm horizontal cut with proximal-dorsal and distal-plantar cuts angled at 60 degrees, in addition wedges could be removed both proximally and distally to achieve proximal articular set angle (PASA) correction [8]. Zygmunt, Gudas and Laros in 1989, undertook an osteotomy with a horizontal cut of the Z osteotomy being 2.5 to 3 cm long and angled 5 to 10 degrees plantarly. The proximal-plantar and the dorsal-distal cuts were angled at 70 to 80 degrees. The osteotomy was transposed laterally 1/3 to ½ the width of the metatarsal and could be rotated to gain PASA correction [9]. Pollack et al. also in 1989 undertook a Z osteotomy with a 2 cm horizontal cut angled at 15 degrees plantarly. The dorsal-distal cut was made perpendicular to the horizontal cut, and the proximal-plantar cut was made at a 45 degree angle. The proximal-plantar cut was also made from distal-medial to proximal-lateral to aid transposition [10]. Kramer et al. in 1992 introduced a 90 degree dorsal-distal cut with a Reverdin-type wedge resection and fibula sesamoid resection [11]. Duke in 1992 introduced the rotational scarf (Z) osteotomy in order to address large IMA's with a horizontal cut 3 to 4 cms in length. The dorsal-distal cut was made perpendicular to the shaft, and the proximal-plantar cut was made at a 45 degree angle. The capital fragment was then rotated laterally on an axis at the proximal-lateral aspect of the axial osteotomy [12]. Friend, Grace and Stone in 1994 compared fixation methods with the Z osteotomy. The osteotomy consisted of a dorsal-distal cut angled at 70 to 80 degrees and a plantar-proximal cut angled at 45 degrees. Each osteotomy was fixated with either a single screw or absorbable pins. Following fixation with the absorbable pin the authors suggested that the dorsal-distal cut be made at 45 degrees due to dorsiflexion and dislocation of the head [13].

In order to maintain adequate correction fixation is essential, in view of this there have been a variety of fixation techniques described for the scarf osteotomy, threaded Kirschner wires [58] one [17,18] or two screws [19, 24, 40, 45, 49, 59-61]. Barouk [45] has developed and patented his own screw for the fixation of the scarf osteotomy but again advocates the use of two screws. The general consensus and accepted method is two points of fixation directed from the dorsal cortex through to the plantar cortex [45, 51, 62]. Although a study by Wagner, Fuhrmann & Abramowski [14] placed the distal screw into the metatarsal head as this allowed better fixation in osteoporotic cases. Maestro [63] described a technique without screw fixation, due to the degree of translation there was no space left for a screw. Instead fixation was achieved via bone cerclage with an absorbable suture in order to obtain distal fixation, with proximal fixation via an impacted autologous bone graft.

The dorsal cut in this technique is at ninety degrees due to ease of distraction and displacement as opposed to other techniques which may make distraction and displacement difficult due to cut orientation [6,7,13,45] it is also parallel with the second metatarsal as shortening of the first metatarsal has been demonstrated to incur transfer metatarsalgia and post-operative pain [20,64]. The plantar cut at twenty to thirty degrees in the sagittal plane provides stability as the metatarsal is transposed laterally at the proximal aspect of the osteotomy before being rotated at the metatarsal head in order to reduce the intermetatarsal angle. It also enables the osteotomy to become locked in position before fixation negating the need for use of a bone clamp reducing surgical exposure time. The distal fixation with the use of a part threaded Kirschner wire enables engagement of the dorsal cortex of the first metatarsal and provides the operator with further ability to correct the IMA in a joystick-like fashion, should this be required before engagement of the plantar fragment of the osteotomy. To the authors' knowledge the trotation technique variation for the scarf osteotomy along with this particular fixation has not been published before.

There has been a similar technique described which entails translation and rotation, however, this was for the correction of PASA deformity [9, 15, 17, 32, 31]. The PASA in this study has not been measured as it has been found that the measurement technique is plagued with significant error, with both intra- and inter-observer reliability being poor, it has been suggested that PASA is of no particular value clinically [65-67].

The traditional transpositional osteotomy used for mild to moderate IMA's has commonly been reported to incur difficultly with troughing during fixation, which results in a lost in height of the metatarsal with dorsiflexion of the metatarsal head [20, 51] however, the development of the rotation of the capital fragment in order to address higher IMA's enables contact between both the dorsal and plantar cortices [12] although it is unclear whether this may reduce the incidence of troughing. Troughing has been reported with both of the aforementioned techniques [68]. This trotation technique uses both a transposition and rotation in order to correct potentially higher degrees of IMAs whilst providing theoretical stability during fixation due to the crossed cortices described in Duke's technique [12]. This may be why there was no incidence of troughing both intra-operatively and post-operatively within this study.

Table 2 Comparison of previous studies with regards to pre- and post-operative intermetatarsal correction via scarf osteotomy with mean intermetatarsal reduction. (Pre- and post- IMA measured in degrees).

Table 2 demonstrates the pre and post-operative 1st and 2nd IMAs with the mean IMA correction of twenty nine studies in comparison to this patient cohort. Six of the 29 studies had a greater degree of pre-operative IMA; however, only two studies had marginally greater post-operative improvement [7, 34]. None of the studies achieved a greater mean IMA reduction than the 11.5 degrees presented by the trotation scarf technique.

The authors' along with Maestro [63] and his particular technique have also found that with the trotation technique, due to the ability to aggressively correct the degree of IMA deformity, there is no space left for any screw fixation; hence, fixation with a part threaded Kirschner wire.

The authors' believe like O'Kane & Kilmartin [19, 61], that soft tissue capsular correction is generally temporary and that correction must be obtained via osteotomies. With adequate correction via osteotomy this allows for the return of weight from the second metatarsal back to the first ray [27], which may account for lack of metatarsalgia post-surgery within this study cohort.

During this study the authors' found that the most common adverse event was related to internal fixation irritation due to footwear as did O'Kane & Kilmartin in their studies [19, 61]. In view of this we currently now ensure that the Kirschner wire is well within the intermetatarsal space locked down on the lateral cortex of the first metatarsal under the extensor hallucis longus tendon.

The limitations of this study are certainly the short term duration of follow-up and lack of the use of a hallux valgus validated patient-reported outcome measures, such as the Manchester Oxford Foot Questionnaire [69]. This has subsequently been adopted by the department to determine more accurately patient satisfaction.

Although the duration of follow-up was only 6 months, despite this the authors' believe the surgical technique of the trotation scarf osteotomy and fixation method has provided adequate correction and fixation with a relatively low rate of complications with a good rate of patient satisfaction.

Acknowledgement

Mr. A.L. Murphy FCPodS for assistance with interpretation of the data and Mrs. N. Donovan, Staff Podiatrist, for help with the manuscript.

References

1. Lin JS, Bustillo J: Surgical treatment of hallux valgus: a review. Curr Opin Orthop 2007, 18:112-117.
2. Kilmartin TE: Critical Review: The Surgical Management of Hallux Valgus. Br J of Podiatry 2006, 9(1): 4-24.
3. Thomas S, Barrington R: Hallux Valgus. Current Orthopaedics 2003, 17,299-307.
4. Kelikian A: The Surgical treatment of hallux valgus using the modified Z-osteotomy. Clin Sports Med 1988, 7:61-74.

5. Robinson AHN, Limbers JP: Modern concepts in the treatment of hallux valgus. J Bone Joint Surg [Br] 2005, 87-B: 1038-45.
6. Glickman S, Zahari D: Short "Z" bunionectomy. J Foot Surg 1986, 25:304-306.
7. Kelikian A: The Surgical treatment of hallux valgus using the modified Z-osteotomy. Clin Sports Med 1988, 7:61-74.
8. Gill P: Modification of the scarf bunionectomy. J Am Podiatr Med Assoc 1988, 78:187-189.
9. Zygmunt K, Gudas C, Laros G: Z-bunionectomy with internal screw fixation. J Am Podiatr Med Assoc 1989; 79:322-329.
10. Pollack R, Bellacosa R, Higgins K, Sharp B, McCloskey T: Critical evaluation of the short "Z" bunionectomy. J Foot Surg 1989, 28:158-161.
11. Kramer J, Barry LD, Helfman DN: The modified scarf bunionectomy. J Foot Surg 1992, 31:360-367.
12. Duke H: Rotational scarf (Z) bunionectomy for correction of high intermetatarsal angles. J Am Podiatr Med Assoc 1992, 82:352-360.
13. Friend G, Grace K, Stone H: Cortical screws versus absorbable pins for fixation of the short Z-bunionectomy. J Foot Ankle Surgery 1994, 33:411-418.
14. Wagner A, Fuhrmann R, Abramowski I: Early results of scarf osteotomies using differentiated therapy of hallux valgus. Foot and Ankle Surgery 2000, 6:105-112.
15. Blair S, Ong M, Gregori A: The scarf osteotomy for hallux valgus: a clinical and radiological review. The Foot 2001, 11,140-143.
16. Rippstein P, Zund T: The "Scarf" osteotomy for the correction of hallux valgus. Operat Orthop Traumatol 2001, 9:101-112.
17. Kristen KH, Berger C, Stelzig S, Thalhammer E, Posch M, Engel A: The Scarf osteotomy for the correction of hallux deformities. Foot & Ankle International 2002, 23(3):221-229.
18. Perugia D, Basile A, Gensini A, Stopponi M, Minniti de Simeonibus AU: The scarf osteotomy for severe hallux valgus. International Orthopaedics (SICOT) 2003, 27:103-106.
19. O'Kane C, Kilmartin TE: The rotation Scarf and Akin osteotomy for the correction of severe hallux valgus. The Foot 2002, 12:203-212.
20. Coetzee JC: Scarf osteotomy for hallux valgus repair: The dark side. Foot & Ankle International 2003, 24:29-33.
21. Aslam N, Lavis G, Porter D, Cooke PH: A radiographic evaluation of the scarf osteotomy for the correction of hallux valgus. Foot and Ankle Surgery 2004, 10: 35-39.
22. Jones S, Al Hussainy HA, Ali F, Betts RP, Flowers MJ: Scarf osteotomy for hallux valgus: A prospective clinical pedobarographic study. J Bone Joint Surg [Br] 2004, 86-B: 830-6.
23. Aminian A, Kelikian A, Moen T: Scarf osteotomy for hallux valgus deformity: An intermediate followup of clinical and radiographic outcomes. Foot & Ankle International 2006, 27(11):883-886.
24. Berg RP, Olsthoorn PGM, Poll RG: Scarf osteotomy in hallux valgus: a review of 72 cases. Acta Orthop. Belg. 2007, 73:219-223.
25. Malviya A, Makwana N, Laing P: Scarf osteotomy for hallux valgus-is and Akin osteotomy necessary? Foot and Ankle Surgery 2007, 13:177-181.
26. Deenik A., de Visser E, Louwerens J-WK, Malefijt M de W, Draijer FF, de Bie RA: Hallux valgus angle as a main predictor for correction of hallux valgus. BMC Musculoskeletal Disorders 2008, 9:70.
27. Lipscombe S, Molloy A, Sirikonda S, Hennessy MS: Scarf osteotomy for the correction of hallux valgus: Midterm clinical outcome. J Foot Ankle Surg 2008, 47(4):273-277.
28. George HL, Casaletto J, Unnikrishnan PN, Shivratri D, James LA, Bass A, Bruce CE: Outcome of the scarf osteotomy in adolescent hallux valgus. J Child Orthop 2009, 3:185-190.
29. Jager M, Schmidt M, Wild A, Bittershol B, Courtois S, Schmidt TG, Krauspe R: Z-osteotomy in hallux valgus: clinical and radiological outcome after scarf osteotomy. Orthopeadic Reviews 2009, 1(4):11-16.
30. Kerr H-L, Jackson R, Kothari P: Scarf-Akin osteotomy correction for hallux valgus: Short-term results form a District General Hospital. The Journal of Foot & Ankle Surgery 2010, 49:16-19.
31. O'Malley M, Gu Y, Wagshul A: Scarf Bunionectomy. Oper Tech in Orthop 2010, 20:167-174.
32. Fuhrmann RA, Zollinger-Kies H, Kundert H-P: Mid-term results of Scarf osteotomy in hallux

valgus. International Orthopaedics (SICOT) 2010, 34:981-989.
33. Murawski CD, Egan CJ, Kennedy JG: A rotational scarf osteotomy decreases troughing when treating hallux valgus. Clin Orthop Relat Res 2011, 469:847-853.
34. Maher AJ, Kilmartin TE: Patient reported outcomes following the combined rotation scarf and akin's [Akin's] osteotomies in 71 consecutive cases. The Foot 2011, 21:37-44.
35. Davies MB, Blundell CM, Marquis CP, McCarthy AD: Interpretation of the scarf osteotomy by 10 surgeons. Foot and Ankle Surgery 2001, 17:108-112.
36. Coull R, Stephens MM: (ii) Operative decision making in hallux valgus. Current Orthopaedics 2002, 16:180-186.
37. Eustace S, O'Byrne J, Stack J, Stephens MM: Radiographic features that enable assessment of first metatarsal rotation: the role of pronation in hallux valgus. Skeletal Radiol 1993, 22: 153-156.
38. Smith RW, Reynolds JC, Stewart MJ: Hallux Valgus assessment: report of research committee of American Orthopaedic Foot and Ankle Society. Foot Ankle 1983, 5:92-102.
39. Miller JW: Distal first metatarsal displacement osteotomy: its place in the scheme of bunion surgery. J Bone Joint Surgery 1974, 56-A, 923-31.
40. Larholt J, Kilmartin TE: Rotational scarf and akin osteotomy for correction of hallux valgus associated with metatarsus adductus. Foot & Ankle International 2010, 31(3):220-228.
41. Spinner S, Lipsman S, Spector F, Radiographic criteria in the assessment of hallux abductus deformities. J Foot Surg 1984, 23:25-30.
42. Kilmartin TE, Barrington RL, Wallace WA: The X-ray measurement of hallux Valgus: an inter-and intra-observer error study. Foot 1992, 2:7-11.
43. Weil L. *Master Techniques in Podiatric Surgery: The Foot and Ankle*, Lippincott Williams & Wilkins: Philadelphia, PA; 2004.
44. Naismith AR, Pavier JCS: Fracture patterns following Scarf & Akin osteotomies. Podiatry Now 2008, 24-30.
45. Barouk LS: Scarf Osteotomy for hallux valgus correction local anatomy, surgical technique, and combination with other forefoot procedures. Foot and clinics 2000, 5(3):525-558.
46. Yu GV, Malay DS: Enhanced fixation of the traditional Austin bunionectomy. Foot Ankle Q 1999, 12:27-36.
47. Meyer M: Eine neue modification der hallux valgus operation. Abl. Chir. 1926, 53:3215-3268.
48. Burutaran J: Hallux valgus y cortedad anatomica del primer metatarsano (correction quirugica). Actual. Med. Chir. Pied. 1976, XIII: 261-266.
49. Borelli AH, Weil LS: Modified scarf bunionectomy: our experience in more than 1000 cases. J Foot Ankle Surg 1991, 30:609.
50. Weil L.S. Scarf Osteotomy for correction of hallux valgus: historical perspective, surgical technique and results. Foot Ankle Clin 2000, 5:559-80.
51. Gudas C: From Scarf Z-Osteotomy. In *McGlamry's Comprehensive Textbook of Foot and Ankle Surgery. Volume 1.* 3rd edition. Edited by Banks A., Downey M., Martin D., Miller S (Eds). Philadelphia: Lippincott Williams & Wilkins; 2001:563-571.
52. Prosche H, Fuhrmann R, Lin BW, Frober R: The postoperative stability of the first metatarsal. Eur J Anat 2004, 8:55-59.
53. Robinson A, Bhatia M, Eaton C, et al. Prospective Comparative Study of the Scarf and Ludloff osteotomies in the treatment of hallux valgus. Foot Ankle Int 2009, 30:955-963.
54. Bock P, Lanz U, Kroner A, Grabmeier G, Engel A: The Scarf Osteotomy: A salvage procedure for recurrent hallux valgus in selected cases. Clin Orthop Relat Res 2010, 468:2177-2187.
55. Schoen N, Zygmunt K, Gudas C: Z-bunionectomy: retrospective longterm study. JFAS 1996, 35:312-317.
56. Peterson W, Seide HW: Early outcome of correction of hallux valgus with scarf osteotomy, Z Orthop Ihre Grenzgeb 2000; 138(3): 258-264.
57. Sammarco V, Acevedo J: *Stability and Fixation Techniques in First Metatarsal Osteotomies: Foot and Ankle Clinics: Osteotomy of the Foot and Ankle.* Philadelphia, PA, W.B.Saunders; 2001.
58. Schwartz N, Groves E: Long term follow-up of internal threaded Kirschner-wire fixation of the scarf bunionectomy. J Foot Surg 1987, 26:313-316.
59. Boon G, Maher A: An unusual complication following rotational Scarf osteotomy. Br J of Podiatry 2006; 9(3):77-80.

60. Bevilacqua NJ, Rogers LC, Wrobel JS, Shechter DZ: Restoration and preservation of first metatarsal length using the distraction scarf osteotomy. The Journal of Foot & Ankle Surgery 2008, 47(2):96-102.
61. Kilmartin TE, O'Kane C: Combined rotation scarf and Akin osteotomies for hallux valgus: a patient focused 9 year follow up of 50 patients. Journal of Foot and Ankle Research 2010, 3(2):1-12.
62. Popoff I, Negrine JP, Zecovic M, Svehla M, Walsh WR: The effect of screw type on the Biomechanical properties of SCARF and cresentic osteotomies of the first metatarsal. J Foot Ankle Surg 2003, 42:161-164.
63. Maestro M: Scarf osteotomy without screw fixation. Interact Surg 2007, 2:12-16.
64. Fresion M, Gayet LE, Bouche G, Hamacha H, Nebout J, Pries P: Scarf Osteotomy for the treatment of hallux valgus: a review of 123 cases with 4.8 years of follow up. Rev Chir Orthop Reparatrice Appar Mot 2005, 91:257-266.
65. Vittetoe D, Saltzman C, Krieg J, Brown T: Reliability and validity of distal metatarsal articular angle. Foot Ankle 1994, 15:541-7.
66. Coughlin MJ, Freund E: The reliability of angular measurements in hallux valgus deformities. Foot Ankle 2001; 22:369-79.
67. Chi TD, Davit J, Younger A, Holt S, Sangeorzan BJ: Intra- and inter-observer reliability of the distal metatarsal articular set angle in hallux valgus. Foot Ankle 2002, 22:722-6.
68. Coetzee JC, Rippstein P: Surgical strategies: scarf osteotomy for hallux valgus. Foot Ankle Int 2007, 28:29-33.
69. Dawson J, Doll H, Coffey J: Responsiveness and minimally important change for the Manchester-Oxford foot questionnaire compared with AOFAS and SF-36 assessments following surgery for hallux valgus. Osteoarthritis Cartilage 2007, 15:918-931.