FOOT AND ANKLE

Treatment of moderate hallux valgus by percutaneous, extra-articular reverse-L Chevron (PERC) osteotomy

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Aims
The aim of this study was to report a single surgeon series of consecutive patients with moderate hallux valgus managed with a percutaneous extra-articular reverse-L chevron (PERC) osteotomy.

Patients and Methods
A total of 38 patients underwent 45 procedures. There were 35 women and three men. The mean age of the patients was 48 years (17 to 69). An additional percutaneous Akin osteotomy was performed in 37 feet and percutaneous lateral capsular release was performed in 22 feet. Clinical and radiological assessments included the type of forefoot, range of movement, the American Orthopedic Foot and Ankle (AOFAS) score, a subjective rating and radiological parameters.

The mean follow-up was 59.1 months (45.9 to 75.2). No patients were lost to follow-up.

Results
The mean AOFAS score increased from 62.5 (30 to 80) pre-operatively to 97.1 (75 to 100) post-operatively. A total of 37 patients (97%) were satisfied. At the last follow up there was a statistically significant decrease in the hallux valgus angle, the intermetatarsal angle and the proximal articular set angle. The range of movement of the first metatarsophalangeal joint improved significantly. There was more improvement in the range of movement in patients who had fixation of the osteotomy of the proximal phalanx.

Conclusion
Preliminary results of this percutaneous approach are promising. This technique is reliable and reproducible. Its main asset is that it maintains an excellent range of movement.

Take home message: The PERC osteotomy procedure is an effective approach for surgical management of moderate hallux valgus which combines the benefits of percutaneous surgery with the versatility of the chevron osteotomy whilst maintaining excellent first MTPJ range of motion.

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Hallux valgus is a common deformity that may lead to transfer metatarsalgia and claw-toe deformities.1-3 Surgical correction is indicated when the patient complains of pain and has difficulty with footwear. Some of the many distal first metatarsal osteotomy procedures have been adapted for minimally invasive or percutaneous surgery.4-8 Percutaneous procedures are quick to perform, reduce morbidity and shorten recovery.9 In 2002 an international research and study group Groupe de Recherche et d’Etude en Chirurgie Mini-Invasive du Pied (GRECMIP) was founded to evaluate and develop percutaneous techniques in forefoot surgery.

The Reverdin-Isham percutaneous osteotomy was described in 1991.10 An intra-articular medial closing wedge osteotomy of the distal metatarsal is combined with an Akin osteotomy,11 both performed without fixation. This was the first percutaneous technique that we adopted, in 2002.12 The patients in our initial prospective cohort study group described a high satisfaction rate but, paradoxically, we found a lack of post-operative joint congruency and significant post-operative stiffness.4,13,14 We therefore changed our approach to a percutaneous, extra-articular reverse-L chevron (PERC) osteotomy. This novel technique allowed for minimal post-operative MTPJ stiffness through the extra-articular location of the osteotomy, whilst combining the benefits of percutaneous surgery and versatility of the proven chevron osteotomy.
The open 90° chevron or “reverse-L” osteotomy has good outcomes when associated with other procedures such as a lateral release or Akin osteotomy; it is a good compromise between the competing objectives of satisfactory angular correction and mechanical stability.

The original open multiplanar 90° chevron osteotomy was derived from the open uniplanar 60° Austin osteotomy. Compared with the open technique, the percutaneous alternative is extra-articular, there is no bunionectomy, and the apex of the chevron is more proximal. If required, a lateral release and Akin osteotomy can also be performed percutaneously.

The goal of this study was to describe the prognostic factors and outcomes of PERC osteotomy in the treatment of moderate hallux valgus.

**Patients and Methods**

We analysed the prospectively collected data of a single-surgeon, two-centre series of 45 consecutive PERC procedures in 38 patients. The patients also underwent at total of 37 percutaneous Akin osteotomies and 22 percutaneous lateral release procedures. The mean age of the patients at surgery was 48 years (17 to 69); there were 35 women and three men. Surgery was performed on 23 right feet and 22 left feet.

The period of the study was between September 2008 and September 2010 and moderate hallux valgus was defined as a hallux valgus angle (HVA) of < 40° and an intermetatarsal angle (IMA) of < 20°. Exclusion criteria included signs osteoarthritis in the first metatarsophalangeal joint (MTPJ) or if the range of movement in this joint was < 80°. Patients with a follow-up of < 12 months and those who also had procedures performed on the lateral rays were excluded. An independent assessor (J.LyH) made the clinical and radiological measurements at the last follow-up. The mean follow-up was 59.1 months (45.9 to 75.2); no patients were lost to follow-up.

**Surgical technique.** The procedure is performed using regional anaesthesia without a tourniquet, as an outpatient. In order to allow access for the powered handheld tools and mini C-arm fluoroscopy unit to the foot, the contralateral leg is flexed to 90°.

A medial approach is used just proximal to the flare of the metatarsal head, at the junction of the upper (dorsal) and lower (plantar) two-thirds, using a beaver blade (Fig. 1). The osteotomy is performed using a burr, the thickness of which is selected according to the planned correction and shortening. We most commonly use a 3/20 mm burr (FH Orthopedics SAS, Heimsbrunn, France). The positioning of the first bicortical tunnel to create the ‘Chevron apex’ is critical as it determines both cuts of the osteotomy. This first tunnel is made in a proximal-to-distal direction to limit the metatarsal shortening; it is angled 45° plantarwards to lower the metatarsal head during lateral translation (Fig. 2). The burr is then used to make the dorsal cut. If rotational correction is also required to make the first MTPJ parallel to the tangential angle to the second axis (TASA = 0), the medial resection of the dorsal cut is increased.

In order to perform the plantar cut, a thinner burr is inserted into the initial tunnel (2/12 mm Shannon burr, FH Orthopedics). Its tip is initially angled in a plantar direction and then directed proximally to finish on the medial cortex (Fig. 3). The speed of the burr should not exceed 8000 rpm and it is irrigated with normal saline to avoid thermal necrosis of the skin or bone.

Upon completion of the osteotomy, a specifically designed “pry bar” is introduced into the proximal canal via the site of the osteotomy to translate the metatarsal head in a lateral and plantar direction (Fig. 4). The correction is verified fluoroscopically. In cases where a lateral release is required it is easier to control the final position of...
the metatarsal head if this manoeuvre is performed prior to the lateral release.

A second dorsolateral approach is then performed 1.5 cm proximal to the osteotomy on the lateral aspect of the extensor hallucis longus tendon and the osteotomy is fixed using a self-drilling, self-tapping 3 mm diameter cannulated and headless compression screw (FH Orthopedics) (Fig. 4). The screw is inserted in a proximal to distal, dorsal to plantar and slightly lateral to medial trajectory.

If fluoroscopy shows a congruent first MTPJ at this point, a lateral release is deemed unnecessary. Conversely, if the congruency is unsatisfactory, a lateral release is performed through a third dorsolateral approach. The beaver blade is inserted within the first MTPJ (confirmed by fluoroscopy) and a medial to lateral vertical movement is used to divide both the suspensory ligament and the phalangeal expansion of the transverse head of the adductor hallucis muscle (Fig. 5).

An Akin osteotomy of the proximal phalanx is performed if the forefoot is of an Egyptian shape and/or if there was residual hallux valgus. This is undertaken through a dorsomedial approach, medial to the extensor hallucis longus tendon, using a 2/12 mm Shannon burr (FH Orthopedics). The aim of this metaphyseal medial closing wedge osteotomy is to eliminate the need for internal fixation by the preservation of the lateral cortex and creation of a bony hinge (Fig. 6). If the lateral cortex is broken, either intentionally or inadvertently, the osteotomy is considered to be unstable and fixation is performed with a 3 mm cannulated self-tapping, non-compression screw through a medial approach. Intentional breach of the lateral cortex allows shortening of the phalanx and/or correction of any residual pronation deformity.

The incisions are not sutured, to allow haematoma to drain. Low dose regional anaesthesia (Ropivacaine) is continued for two days post-operatively to facilitate discharge but allow full weight bearing. A layered wet and dry gauze dressing is applied by the operating surgeon to help maintain the correction. This is replaced after two weeks (Fig. 7) by a
silicone spacer between the first and second toe to maintain the alignment of the first ray for a further 15 days. In cases where the Akin procedure was performed without fixation and the surgeon deemed it necessary to apply external reinforcement, the first web spacer is incorporated into the operating room dressing. Plain radiographs are taken after the initial change of dressing. Full weight bearing is allowed immediately with a rigid flat-bottomed orthopaedic shoe, for the first three weeks. Anticoagulants are only used in patients with a cardiovascular history or risk factors for the development of deep venous thrombosis.

The patients were reviewed clinically and radiographically at six weeks, four and 12 months post-operatively and then annually.

Clinical outcome. The clinical outcome was assessed using the American Orthopedic Foot and Ankle Society (AOFAS) forefoot score, which was recorded pre-operatively and at final follow-up. The arc of passive movement in the first MTPJ was measured with a goniometer, in a standardised manner, with the patient supine, the ankle in a neutral position and the knee extended. Pre-operatively, feet were classified according to the shape of the forefoot as Egyptian, Greek, or square. Patient satisfaction (very satisfied, satisfied, dissatisfied or disappointed) was determined at the end of the follow-up period and any complications were recorded.

Radiological assessment. Anteroposterior (AP), lateral and Muller–Gunztz weight-bearing views were obtained pre-operatively and at the final follow-up (Fig. 8). Several measurements were made on each view by a single independent observer (JLyH): Hallux Valgus Angle (HVA), Inter Metatarsal Angle (IMA), TASA, proximal articular set angle (PASA), interphalangeal angle (IPA) and metatarsal index.

Statistical analysis. Qualitative variables were expressed as numbers and percentages. Quantitative variables were expressed as means with ranges or medians. Statistical analysis was performed using a paired t-test to compare pre- and post-operative AOFAS scores, the range of movement of the first MTPJ and all radiological parameters. Prognostic factors were determined using ANOVA and Mann–Whitney–Wilcoxon tests. The level of statistical significance was set at a p-value of < 0.05. The statistical analysis was performed using the XLstat software (Addinsoft, Paris, France). The study had ethical approval and all patients gave informed consent.

Results

Clinical and radiological. The results are summarised in Table I. Extension (dorsiflexion) and the overall movement of the first MTPJ improved significantly, while dorsiflexion did not change significantly. The only variable predictive of improved range of movement was the use of fixation when an Akin osteotomy was performed. A total of 37 patients (97%) were satisfied or very satisfied. One patient was disappointed. A total of 37 feet (82.2%) underwent Akin osteotomy, 20 of these required screw fixation. Baseline angles for this group were: HVA 26.6° (20° to 40°); IPA 12.1° (8° to 22°); IMA 11.9° (6° to 17°). At the final follow-up the mean IPA was 7.4° (4° to 12°). Table II shows positive prognostic factors for predicting improvement in the range of movement of the first MTPJ as well as AOFAS score (IMA< 15°, PASA< 12°, arthrolysis performed, Akin Fixation performed) (Fig. 8). The mean AOFAS functional score improved significantly from 62.5/100 (30 to 80) pre-
operatively to 97.1/100 (75 to 100) at final follow-up \((p = 1.32 \times 10^{-27})\). We also identified that a lower initial AOFAS score was associated with a more significant improvement in the score post–operatively (Table III).37-42

### Complications

Complications occurred in seven feet (15.5%). There were five complications in the first 25 procedures (20%) and two in the subsequent 20 (10%). A screw was required to be removed from four feet during the first post-operative year (Fig. 9). There was one failure of fixation. Delayed wound healing occurred in one patient and one required further surgery for a painful residual exostosis. No patient developed hallux varus.

### Table I. Summary of pre-operative and last follow-up clinical and radiological findings; mean and standard deviation and range are given for each variable

<table>
<thead>
<tr>
<th>Range of movement of the first MTPJ (*)</th>
<th>Pre-operative</th>
<th>Last follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall movement (°)</td>
<td>101.6° (14.1°)</td>
<td>104.7° (SD 16.3°)</td>
</tr>
<tr>
<td>Dorsiflexion (°)</td>
<td>83.1° (SD 8.7°)</td>
<td>85.6° (SD 10.6°)</td>
</tr>
<tr>
<td>Plantar flexion (°)</td>
<td>18.4° (SD 8.5°)</td>
<td>19.1° (SD 9.0°)</td>
</tr>
</tbody>
</table>

### Table II. Association of study variables with outcomes

<table>
<thead>
<tr>
<th>Numbers</th>
<th>AOFAS score increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMA (*)</td>
<td></td>
</tr>
<tr>
<td>15°+</td>
<td>36.6</td>
</tr>
<tr>
<td>&lt; 15°</td>
<td>34.2</td>
</tr>
<tr>
<td>PASA (*)</td>
<td></td>
</tr>
<tr>
<td>&lt; 12°</td>
<td>33.2</td>
</tr>
<tr>
<td>12°+</td>
<td>35.5</td>
</tr>
<tr>
<td>Arthrolysis</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>37.4</td>
</tr>
<tr>
<td>No</td>
<td>32.0</td>
</tr>
<tr>
<td>MTP1 overall mobility increase (°)</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>31°</td>
</tr>
<tr>
<td>Akin fixation*</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>7.0°</td>
</tr>
<tr>
<td>No</td>
<td>-0.8°</td>
</tr>
</tbody>
</table>

MTP, metatarsophalangeal joint; HVA, Hallux Valgus Angle; IMA, Inter Metatarsal Angle; PASA, Proximal Articular Set Angle; TASA, Tangential Angle to the Second Axis; IPA, inter phalangeal angle

* Data with significant improvement
subjective results were probably due to the minimally invasive nature of the procedure. The functional results, as demonstrated by improvement in AOFAS scores were also good.

Stiffness of the first MTPJ is a common complication of surgery for hallux valgus. Moderate stiffness with a loss of about 10% of movement is usually reported with open techniques including scarf and chevron osteotomies.21,43-45 We believe that medial capsuloplasty is the main cause of post-operative stiffness. However, our previous series of patients who underwent percutaneous Reverdin-Isham osteotomy also had loss of movement.14 This is likely to be due to the intra-articular location of the osteotomy, the bunionectomy and the presence of bone debris in the joint space. In this series, dorsiflexion and overall movement of the joint improved significantly while plantar flexion did not change significantly. The improved movement may be explained by the use of the percutaneous approach, a more proximal and extra-articular ostetomy, resulting in no intra-articular bone debris, and the lack of a bunionectomy. The improvements in the HVA, IMA, PASA, TASA and IPA are also similar to those following other techniques, performed open or percutaneously (Table III).

Our percutaneous approach enables correction of both the IMA and PASA, in contrast to the Reverdin-Isham osteotomy, which corrects the PASA, through medial rotation of the metatarsal head, but allows only limited correction of the IMA.13 The percutaneous approach for the scarf osteotomy and other more distal osteotomy procedures such as Hohmann’s or Mitchell’s provide good correction of the IMA but a limited correction of the PASA.5,6,37 We found that a more severe initial presentation as measured by the AOFAS score was associated with greater
improvement in the score post-operatively. Although no predictive criteria were identified, these results validate our “à la carte” approach to the corrective surgery for hallux valgus. For each deformity, we chose the procedures sequentially based on our findings and avoided performing all of them routinely. For example, lateral release was initially described to extend the indications for the classic chevron osteotomy. However, we did not perform a lateral release after the PERC osteotomy if intra-operative imaging demonstrated a congruent joint, with a TASA close to zero (Fig. 10).

The only variable predictive of significant improvement in the range of movement of the first MTPJ was fixation of the Akin osteotomy. Although this was not a randomised, controlled trial we suggest that a fixed Akin osteotomy provides a faster post-operative recovery due to the increased stability of the proximal phalanx. We have initiated a randomised prospective study to validate this hypothesis.

The most common complications were related to the positioning of the screws. The reasons for screw-related pain included breach of the dorsal or plantar cortex. Distal migration of a screw led to loss of fixation and displacement of the metatarsal head. The accurate placement of screws of an appropriate length is an essential element of the procedure. These complications were more common early in the study, emphasising the importance of training and experience for this demanding procedure.

Other authors have reported recurrent deformity of the first MTPJ, necrosis of the first metatarsal head and hypoesthesia; we did not find any of these complications.

Evolution of percutaneous surgery and its advantages. Since it was founded, GRECMIP has observed the evolution of percutaneous surgery. The initial percutaneous procedures performed for the first ray combined the Reverdin-Isham osteotomy and the Akin osteotomy, both without fixation. This technique relied heavily on the post-operative dressing to maintain correction. The indications for this procedure have subsequently been limited due to the dependance on post-operative care and dressings. This study group have emphasised three aspects: the theoretical and practical training, the learning curve which varies according to the different percutaneous procedures (first ray, DMMO, claw toe, quintus varus) and the publication of all the techniques it assesses.

Gradually, the members of GRECMIP have developed and popularised other procedures, mixing open fixed metatarsal osteotomies (scarf or chevron-like) with a percutaneous, unfixed Akin osteotomy. Thus the minimally-invasive or hybrid surgery was developed, with the aim of addressing the limitations of the historical percutaneous surgery and its advantages.
osteotomies of the first ray (post-operative stiffness, demanding to perform, few indications) whilst maintaining the benefits of the percutaneous Akin procedure.

Our technique was developed between 2008 and 2010. Its advantages are a reliable and proven chevron osteotomy which is well known to correct HVA, IMA and DMDA combined with the smaller incision and faster recovery of a percutaneous procedure.

Vernois and Redfern28 have modified the percutaneous chevron technique by adding double-screw fixation (Minimally Invasive Chevron Akin, MICA, technique). This expands the indications by allowing greater translation of the first metatarsal head and limiting secondary displacement.17 Although we now secure the osteotomy with a double fixation in selected patients, we did not evaluate this technique in this series, as this modification was introduced after 2010. Percutaneous surgery is simply an operative tool, like arthroscopy, using dedicated surgical instruments and requiring specific post-operative care. Whilst the results from the present series are promising, this relatively new technique is still evolving rapidly and thus requires careful ongoing assessment.9

In conclusion, the PERC osteotomy combines a well-known metatarsal osteotomy with a novel percutaneous technique. It represents an innovative approach for the correction of hallux valgus with good clinical correction, stable fixation and resolution of symptoms, combined with the advantages inherent to percutaneous surgery. In this series, the indications were limited to moderate hallux valgus. The current study is a preliminary analysis of our technique and includes the initial cohort of patients. Finally we are recommending this technique as an alternative treatment for hallux valgus deformity.

Supplementary material
A table showing clinical results from comparable published studies is available alongside the online version of this article at www.bj.jboneandjoint.org.uk

References


