Proximal opening-wedge osteotomy of the first metatarsal for moderate and severe hallux valgus using low profile plates

Caio Nery a,*, Cibele Ressio b, Gerson de Azevedo Santa Cruz b, Rafael Silva Remor de Oliveira b, Carla Chertman b

a Foot and Ankle Clinic, UNIFESP-Escola Paulista de Medicina, São Paulo, SP, Brazil
b Foot and Ankle Surgeon, UNIFESP-Escola Paulista de Medicina, São Paulo, SP, Brazil

Level of Evidence – IV – Retrospective Case Series.

1. Introduction

The treatment of severe hallux valgus is challenging. Since the first report, several techniques have been described, but to date none of them offered the security, predictability and comfort that surgeons desire [1–5].

The association of a considerably wide intermetatarsal angle with severe hallux valgus leads many authors to recommend a proximal osteotomy or a tarso-metatarsal procedure [1–3] that can be performed in combination with an exostectomy, distal soft tissue release or an additional osteotomy.

Many kinds of osteotomies have been advocated, as wedge excisions, crescentic osteotomies and basilar chevron osteotomies. Stephens described successful basal first metatarsal osteotomy currently carried out without internal fixation in 1994 [6].

Trethowan described the first proximal opening-wedge osteotomy of the first metatarsal bone. His report, published in 1923, outlined the authors’ conviction that the addition of a bone wedge is enough for the proper correction and maintenance of the osteotomy, as long as the lateral cortex is intact, and that no kind of fixation would be necessary. These beliefs were not confirmed and the technique was gradually abandoned due to the poor stability and high nonunion and recurrence rates [7–9].

The demand for a solution allowed for the creation of more delicate and effective implants known as PMOW (proximal metatarsal opening wedge) or BOW (basilar opening wedge). These implants are offering additional possibilities to the proximal first-ray osteotomy.

The objective of this study is to present the results of the treatment of hallux valgus with the proximal metatarsal opening wedge (PMOW) osteotomy using two different screw and plate systems.

2. Methods

Between February 2005 and March 2009 a total of 50 adult patients underwent surgical correction of moderate to severe hallux valgus. All patients were treated by the senior author (CN).
Only forty-one patients (70 feet) could return for the final assessment and their data were used in the retrospective analysis of this sample. The proximal opening-wedge osteotomy of the first metatarsal using low-profile plates was performed in all of them. The mean follow-up was of 2.4 years (1–5) with 38 women (93%) and 3 men (7%), leading to a proportion of 13:1. The average age at the time of surgery was of 52 years (19–83) and the sample was composed of 36 right feet (51%) and 34 left feet (49%). The majority of patients – 29 (71%) – had bilateral deformities and both procedures – right and left – were performed in the same surgery. Twelve patients had a unilateral deformity, 8 on the right side (67%) and 4 on the left side (33%). Demographics data are summarized in Table 1.

The patients included in this study should have moderate or severe hallux valgus, defined according to the presence of, at least, one of the Mann and Coughlin parameters: hallux valgus angle (HVA) > 21°, intermetatarsal angle (IMA) > 15° and lateral sesamoid displacement (LSD) I, II or III [10,11].

According to the algorithm used in this study, patients with varus metatarsus as the only deformity underwent a proximal opening-wedge osteotomy of the first metatarsal. The simultaneous occurrence of an increased distal metatarsal articular angle (DMAA > 8°) led to an association with biplanar distal chevron osteotomy. Finally, when the hallux valgus deformity occurred with concomitant increase in the hallux valgus interphalangeal angle (IPA > 15°), adequate correction was achieved by a medial closing wedge phalangeal osteotomy – Akin procedure [11–15].

Eight feet (11%) had a proximal opening-wedge osteotomy of the first metatarsal without additional procedures. Ten feet (14%) underwent proximal opening-wedge osteotomy of the first metatarsal with the Akin procedure. Thirty-nine feet (56%) had a proximal opening-wedge osteotomy associated with a distal biplanar chevron and 13 feet (19%) received all three procedures – proximal opening-wedge, distal biplanar chevron and phalangeal Akin.

2.1. Surgical technique

A single long medial longitudinal skin incision was made from the metatarsal–cuneiform joint to the hallux interphalangeal joint and the main sites for surgical correction were exposed.

One transverse cut was made with an oscillating saw from 13 to 14 mm distal to the 1st tarsometatarsal joint, in such a way that the lateral cortex remained intact. With delicate small retractors, the fragments were displaced allowing for the opening of the osteotomy. The width of the open wedge was related to the angle of correction and a low profile plate with an adequate spacer width was used to reinforce the stability of the osteotomy. At first, two screws were placed next to the osteotomy site (proximal and distally) as perpendicular to the metatarsal plane as possible. The two remaining screws were inserted after fluoroscopy and then a bone graft harvested from the resected medial eminence was impacted in the osteotomy cuneiform area.

The current study tested two different systems to address the osteotomy site. Thirty-six feet (51%) were operated using a locking plate (Darco, USA) and thirty-four feet (49%) underwent surgery with a non-locking plate (Arthrex, USA). Both systems are composed of 4-hole low profile plates, but Darco plates are more rigid, curved and have an “H” shape, while Arthrex plates are flatter, more flexible and have “L” shape (Fig. 1).

There was no rupture of the lateral cortex in 48 feet (69%) during the procedure, while in 22 feet (31%) a violation of the lateral cortex integrity was detected. It created a focal instability that made the procedure more challenging but still feasible (Fig. 2).

After the proximal procedure, a distal capsular “V”-shaped incision was performed in all patients creating three layers: one dorsal, one plantar and one distal, which remained attached to the medial base of the proximal phalanx – an important phase to correct the hallux valgus angle during capsulorraphy.

When the simultaneous occurrence of an increased distal metatarsal articular angle was noticed, a biplanar distal chevron osteotomy was added with the resection of a medial based wedge to correct the lateral deviation of the distal articular surface [11,12]. Besides the wedge resections, the capital fragment was displaced laterally to help in the correction of the intermetatarsal angle and the osteotomy site was stabilized with one lag screw (“Bold Screw” – New Deal®, France).

In the presence of an interphalangeal deformity, an Akin osteotomy was performed. With an oscillating saw, a small medially based bone wedge was resected. In all patients, the osteotomy site was stabilized with 8 or 9 mm staples (“Solustaple” – New Deal®, France).

![Fig. 1. Special plates for proximal opening-wedge osteotomy of the first metatarsal used in this paper. Left, “H” shaped plate from Darco (USA). Right, “L” shaped plate from Arthrex (USA).](image-url)
The medial capsule was carefully repaired with inverted absorbable sutures after the two edges were brought into apposition and the redundant capsule was excised. The summary of the procedures is shown in Table 2.

2.2. Postoperative care

All patients received a sterile light compression dressing as well as an “H”-shaped dressing to keep the toe in anatomic alignment. After surgery, the patient with an intact lateral cortex was allowed to walk as tolerated in a “Barouk” postoperative shoe. The patients were advised to walk on their heel and keep their feet elevated as much as possible. Approximately 6 weeks after surgery the patients could progress to fashionable footwear.

Patients with violation of the lateral cortex were kept non-weight bearing for four weeks, when an AP X-ray was taken. Depending on the callus formation on the osteotomy site they were allowed to use “Barouk” shoes for 4 weeks. Unrestricted footwear was only possible after 8 weeks.

2.3. Clinical and radiological evaluation

Two standard dorsoplantar and lateral weight-bearing radiographic views were obtained pre and postoperatively for comparison. Measurements were then obtained electronically using the M2005 program (Tesseract, Brasil). This software measured the hallux valgus angle, the first intermetatarsal angle, the sesamoid displacement, the distal metatarsal articular angle, the interphalangeal angle and the metatarsal length, according to the technique recommended by the American Orthopedic Foot and Ankle Society (AOFAS) [16–20].

In both the pre- and postoperative period, the patients underwent physical examination and clinical assessment with use of the AOFAS hallux score [21].

2.4. Statistical evaluation

The Chi-squared test was used for the proportion analysis, while the parametric t-test was used for normally distributed data. The initial alpha level for all statistical tests was set at 0.05 and statistically significant results were marked with an *.

3. Results

The first analysis consisted on the evaluation of the deformities’ intensity according to Mann–Coughlin’s parameters. Both moderate and severe groups had similar AOFAS score pre operatively, and both groups show increased score after surgery as seen in Table 3. Therefore, it will be considered as a unique group.

The first analysis consisted of data observation, without comparison, to verify our corrections. The average, standard deviation and the statistical analysis results are shown in Table 4.

We found a statistically significant correction of the hallux valgus angle, the first intermetatarsal angle and the distal metatarsal articular angle with the chosen techniques.

### Table 2
Summary of the procedures.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal opening-wedge osteotomy</td>
<td>8 11</td>
</tr>
<tr>
<td>Proximal opening-wedge osteotomy + Akin</td>
<td>10 14</td>
</tr>
<tr>
<td>Proximal opening-wedge osteotomy + Distal Bipl Chev</td>
<td>39 56</td>
</tr>
<tr>
<td>Proximal opening-wedge osteotomy + Distal Bipl Chev + Akin</td>
<td>13 19</td>
</tr>
<tr>
<td>Darco – BOW plate system</td>
<td>36 51</td>
</tr>
<tr>
<td>Arthrex – low profile plate and screw system</td>
<td>34 49</td>
</tr>
<tr>
<td>I metatarsal lateral cortex intact</td>
<td>48 69</td>
</tr>
<tr>
<td>I metatarsal lateral cortex violated</td>
<td>22 31</td>
</tr>
</tbody>
</table>

### Table 3
Comparison according to the severity of the hallux valgus deformity.

<table>
<thead>
<tr>
<th>Severity</th>
<th>N (%)</th>
<th>Pre-OP AOFAS</th>
<th>Post-OP AOFAS</th>
<th>t Student test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>32 (46%)</td>
<td>50</td>
<td>80</td>
<td>t &lt; 0.0001*</td>
</tr>
<tr>
<td>Severe</td>
<td>38 (54%)</td>
<td>50</td>
<td>85</td>
<td>t &lt; 0.0001*</td>
</tr>
</tbody>
</table>

t Student test: $t$ = 0.924 $t$ = 0.082
We found no significant differences between pre- and postoperative groups with regard to the interphalangeal angle and the 1st and 2nd metatarsal length difference. However, the correction variable improvement was statistically significant for the AOFAS score, proving the quality of the results obtained. We also observed a good correction of the sesamoid displacement. Before the operation, 85% of the patients were classified as II or III (subluxation grade). In the follow up, 79% of the patients were 0 or I, with 32% of the feet being considered normal for this parameter. Only 20% of the feet did not have an improvement of the subluxation grade after the procedure.

Comparing patients that only underwent a proximal opening-wedge osteotomy with patients that received it combined with distal biplanar chevron, we only found a significant difference in the I and II metatarsal length. The double osteotomy presented a significantly smaller post-op mean (1 mm) than that found in the isolated base osteotomy (1 mm) with \( p = 0.043 \).

Comparing patients with and without an Akin procedure, we found a significant statistical difference in the preoperative interphalangeal angle (\( p = 0.021 \)). There was no difference between the interphalangeal angle pre and postoperatively (\( p = 0.052 \)). In the final clinical evaluations, we found 41 feet (59%) with AOFAS scores over 80 and 28 feet (40%) over 90. Only 11% of the operated feet had an AOFAS score below 70, which was considered a low incidence of bad results.

### 3.1. Complications

The complications observed in this study are summarized in Table 6. The most common were persistent edema and pain over the hardware site on the 1st metatarsal base, which were solved with local lymphatic drainage and hardware removal.

<table>
<thead>
<tr>
<th>Complications</th>
<th>BOW system</th>
<th>Low profile plate</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain over hardware site</td>
<td>4 (80%)</td>
<td>1 (20%)</td>
<td>5 (7%)</td>
</tr>
<tr>
<td>Persistent edema</td>
<td>3 (60%)</td>
<td>2 (40%)</td>
<td>5 (7%)</td>
</tr>
<tr>
<td>Nonunion</td>
<td>2 (100%)</td>
<td>0 (0%)</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>Tarso-metatarsal subluxation</td>
<td>1 (50%)</td>
<td>1 (50%)</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>Insufficient correction</td>
<td>1 (50%)</td>
<td>1 (50%)</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>Suture dehiscence</td>
<td>2 (100%)</td>
<td>0 (0%)</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>1st MT head deviation (trauma)</td>
<td>1 (100%)</td>
<td>0 (0%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Shaft fracture (trauma)</td>
<td>1 (100%)</td>
<td>0 (0%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>15 (75%)</td>
<td>5 (5%)</td>
<td>20 (28%)</td>
</tr>
</tbody>
</table>

### Additional surgery required

<table>
<thead>
<tr>
<th>Complications</th>
<th>Low profile plate</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthroplasty</td>
<td>8 (73%)</td>
<td>11 (16%)</td>
</tr>
</tbody>
</table>
Fig. 3. Nonunion: 8 weeks postoperative X-rays radiographs and clinical evaluation of a patient that underwent proximal metatarsal opening wedge osteotomy associated with an Akin procedure. The patient was treated with non-weight bearing measures until bone healing was achieved.

Fig. 4. Progressive subluxation of the 1st metatarsal-cuneiform joint: (a) preoperative X-ray and clinical appearance; (b) 4 months postoperative images – satisfactory clinical aspect; (c) 8-month postoperative images – patient referred pain and deformity recurrence – X-ray with subluxation of the 1st metatarsal-cuneiform joint – patient was dissatisfied with the clinical result and underwent a Lapidus procedure.
Two patients had nonunion. One patient was treated with reduced weight bearing until a complete radiographic union was seen. The other patient had hardware failure and underwent additional surgery with autologous bone grafting and the same postoperative management (8 weeks non-weight bearing), having achieved good results, but for the purpose of this paper the patient was considered as having had a bad result (Fig. 3).

In the follow-up, we observed progressive subluxation of the 1st metatarsal-cuneiform joint in two cases. A retrospective analysis showed joint hypermobility and ligament laxity in both cases that had been underestimated during the surgical decision. Therefore, we strongly advise paying attention to this clinical situation during the decision-making. One patient underwent a Lapidus procedure (Fig. 4) and the other patient was symptom-free and preferred to avoid additional surgery.

Two patients were dissatisfied with the clinical aspect of the correction obtained. Additional procedures were done with a distal biplanar chevron as a complement to the previous surgery.

Suture dehiscence was treated with consecutive dressings with acceptable results.

Two patients had accidental injuries during the follow-up: one had a direct trauma with sudden varus dislocation. The distal alignment of the first metatarsal was lost (distal biplanar chevron osteotomy site), but the hallux was steady and we opted for conservative treatment with good final result (Fig. 5). The other patient had a shaft fracture next to the plate’s distal edge. The displacement and shortening were unacceptable and a new intervention was necessary (Fig. 6).

4. Discussion

It is widely accepted that shaft and proximal osteotomies are capable of correcting the wide intermetatarsal angle. However, these osteotomies were usually associated with high complication rates, especially due to the difficulty in obtaining stability [1–3,22,23].

New technologies and new implants specially designed for foot surgeries appear to present a solution to this problem. Low profile plates and screws are probably turning the proximal opening-wedge osteotomy of the first metatarsal into a reliable, predictable and durable procedure[7–9].

The presently accepted approach seeks the correction of all deviations that encompass the hallux valgus complexity. Therefore it is recommended to value the intrinsic etiological factors, such as the greater first metatarsal distal articular angle and the proximal phalanx joint inclination [10–13–15].

When the bone’s blood supply source is respected, combined osteotomies can be considered safe [8,10]. Some authors believe that the use of combined techniques during the same procedure allows for satisfactory results and our results support that [8].

Parameter corrections in our data were similar to what is found in the literature. The average postoperative hallux valgus angle was of 19°, while the average postoperative intermetatarsal angle

---

Fig. 5. Traumatic dislocation of the capital fragment: 25-day postoperative X-rays taken in the emergency after a direct trauma involving the operated toe – rotational deviation of the cephalic fragment is noticed. The patient chose the conservative treatment – although there was a clear medial deviation of the distal articular facet, the overall alignment was satisfactory and the patient was asymptomatic.

Fig. 6. Shaft fracture: (a) preoperative X-ray – patient had already been operated with exostectomy with a bad result; (b) 6-week postoperative x-rays with a healed osteotomy site; (c) post trauma X-ray – shaft fracture with unacceptable lateral deviation and shortening. Both osteotomies are intact and the fracture line is next to the plate’s edge.
was of 6°. These data associated with 32% of normal sesamoid positioning present evidence that all techniques used in our study have a good correction capacity.

The combined use of the distal osteotomies – biplanar chevron and Akin – increased the correction obtained, since each procedure seeks a specific deformity (lateral deviation of the metatarsal head and interphalangeal valgus). The observation that only 11% of feet could be treated with an isolated proximal osteotomy led us to spread the idea that each deformity that composes the hallux valgus complexity should be evaluated.

Hallux valgus deformities with congruency of the 1st MTP joint are related to young patients, family history, early onset and increased distal metatarsal articular angle. Meanwhile, incongruence of this joint is seen in older patients with more severe deformities. In this present study both 1st MTP congruence and DMAA angle were determinant to the decision-making process, in the way that to analyze our results only on this parameter can create interpretative distortions. Besides that, the results make it possible to affirm that this surgery is able to increase congruency level.

The possibility of metatarsus lengthening leading to a metatarsalophalangeal joint hyper-pressure was not confirmed in our data, like in other studies [1,18,20]. Metatarsal shortening due to the osteotomy combination leading to transfer metatarsalgia was not detected either.

Both fixation systems were similar regarding correction capacity and stability. However, the Arthrex® system scored significantly higher than Darco® in the AOFAS postoperative evaluation. This difference is possibly due to the extremely low profile of the Arthrex® and it can provide security and efficiency with less local symptoms.

It was believed that the lateral cortex violation could determine higher complication rates. However, in our data, reduced weight-bearing measures protected the osteotomy site and were enough to determine results similar to the non-violated group. Therefore, these measures are highly recommended when necessary.

The complication rate presented in this study was similar to other series [7–9]. Not only was the complex deformity challenging, but also the elaborated procedures were difficult as well [23]. Nevertheless, we are glad to show that a proper observation of the patient, as well as a reliable relation with him or her, led us to solve all complications satisfactorily.

5. Conclusions

1. Proximal opening-wedge osteotomy of the first metatarsal using low profile plates is an effective, secure and reliable method for correcting a moderate or severe Hallux Valgus deformity.

2. Additional distal osteotomies – distal biplanar chevron and/or Akin procedure – are advisable and improves the complex correction.

3. Lateral cortex violation did not increase our complication rate. However, it determined a proper postoperative care.

Conflict of interest statement

No benefits in any form have been received or will be received by the authors from a commercial party, directly or indirectly, related to the subject herein.

References