

Proximal First Metatarsal Opening Wedge Osteotomy with a Low Profile Plate

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ABSTRACT

Background: Many surgical procedures have been described for the correction of metatarsus primus varus associated with hallux valgus deformity. The purpose of this study was to present the results of the proximal metatarsal opening wedge (PMOW) osteotomy using the Arthrex LPS® first metatarsal system. **Materials and Methods:** Eighty-four patients (90 feet) underwent PMOW osteotomy with distal bunionectomy. There were 78 patients (93%) and 84 (93%) feet available for followup. Mean followup was 2.4 (range, 2.0 to 3.2) years from the time of the index surgery. Pre- and postoperative clinical examination, level of activity, patient derived subjective satisfaction score, radiographic measurements, and visual analogue scale (VAS) score for pain were obtained and evaluated retrospectively. **Results:** The mean preoperative VAS score was 5.9 (\pm 2.2), compared with a mean postoperative score of 0.5 (\pm 0.8). The mean 1-2 IMA preoperatively was 14.5 (\pm 3.3) degrees, compared with postoperative measurements of 4.6 (\pm 2.8) degrees. The mean hallux valgus angle (HVA) improved from a mean of 30 (range, 22 to 64) degrees preoperatively to 10 (range, -15 to +18) degrees. The mean time to radiographic union was 5.9 (range, 4 to 14) weeks. There was one nonunion, one delayed union, mild hallux varus in two patients, severe hallux varus in two patients, recurrent hallux valgus in three patients (including the nonunion) and no instances of plate failure there was no significant difference in mean preoperative (74.8 degrees \pm 11) compared to postoperative (67.9 degrees \pm 10) total MTP joint range of motion. Ninety percent of patients reported good to excellent subjective results after the index surgery. **Conclusion:** We believe PMOW osteotomy was near ideal in terms of reliable, predictable correction and healing.

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Length of the first metatarsal was maintained and patients ambulated safely in a CAM walking boot immediately after surgery. We believe a first web space release may result in hallux varus and increased distal metatarsal articular angle (DMAA) was associated with hallux valgus recurrence.

Level of Evidence: IV, Retrospective Case Series

Key Words: Proximal Opening Wedge Osteotomy; Hallux Valgus

INTRODUCTION

There are multiple procedures and fixation techniques utilized to perform proximal osteotomy of the first metatarsal for correction of hallux valgus. Historically, the PMOW osteotomy was largely abandoned because of the technically demanding nature of the surgery utilizing a bone graft wedge, and concerns about nonunion and instability.^{3,9} Regardless of these concerns, the need still exists for a proximal, stable osteotomy that maintains the relative length of the first metatarsal in relation to the second. This is especially true for any deformity with a short first metatarsal and although a distal procedure alone may be considered for hallux valgus associated with mild intermetatarsal deformity; even distal osteotomies such as a chevron may result in some degree of length loss. The purpose of this study was to retrospectively evaluate the outcomes of hallux valgus correction utilizing the Arthrex Opening Wedge Low Profile Plate and Screw System (LPS®).

MATERIALS AND METHODS

A consecutive series of patients treated by the authors from November 2004 to November of 2007 were retrospectively evaluated. A total of 90 procedures (90 feet) on 84 patients were performed that had a minimum of 2 years since their index surgery; 78 patients (93%) and 84 feet (93%) were available for followup. Four patients had moved to another state for job reasons (all subjectively satisfied but no followup data obtained) and two patients could not be

contacted. The minimum followup was 2 years from the time of the index surgery and the mean followup for the study group was 2.4 (range, 2.0 to 3.2) years.

PMOW combined with a distal bunionectomy procedure was considered for moderate to severe hallux valgus, hallux valgus associated with a short first ray, a 1–2 IMA of more than 12 degrees, recurrent hallux valgus after a distal procedure alone or as an adjunct to a distal procedure if subtotal correction was achieved. Biomechanically, the Arthrex LPS® low profile opening wedge system has been shown to be as stable as the proximal chevron osteotomy¹¹ and initial clinical reports with the technique have been promising.^{1,11,12,13} Total MTP joint range of motion (dorsiflexion plus plantarflexion) was measured with a hand held goniometer by the treating surgeon preoperatively and postoperatively at the latest followup. Other pre and postoperative data collected included the severity of hallux valgus (Table 1)⁴, visual analogue scores (VAS) for pain, and radiographic measures⁴: 1–2 IMA, hallux valgus angle (HVA), first metatarsal declination angle, and millimeters of first ray elevation.¹⁰ Radiographs were evaluated by an independent observer (JR) based on a previously reported standardized measurement technique.⁴ Lateral cortex disruption while performing the osteotomy during index surgery and any subsequent effect on outcome was evaluated. Time to union and/or non-union based on cross-bridging bone on two orthogonal views was recorded. First metatarsal protrusion length was measured based on the method of Hardy and Clapham^{6,7} which is a method not affected by metatarsus adductus. Valgus drift was defined as more than 3 degrees (error of measurement) of radiographic increase in the postoperative hallux valgus angle but less than or equal to 5 degrees. More than 5 degrees of valgus increase noted on the postoperative radiograph was considered a recurrence.

The charts were reviewed by two independent observers (TC and JR). All patients were evaluated and the followup examination also included assessment of subjective patient satisfaction based on a previously reported scale,⁵ patient derived subjective activity level and work status. Subjective satisfaction was recorded as excellent, good, fair or poor. Analysis of variance was used to identify any significant differences ($p < 0.05$) between pre- and postoperative data.

SURGICAL TECHNIQUE

The surgical technique consisted of a 3-cm dorsal-medial incision over the base of the first metatarsal, a 3-cm one over the medial eminence, and possibly one over the first web space (Figure 1). As the technique was refined the first web space incision was noted to result in varus over-correction and furthermore, was not required to obtain the desired correction. The primary modification in the current series was to avoid the first web space release and instead pie-crust the capsule through the joint and release the dorsal adductor along the lateral sesamoid through the plantar aspect of the joint. The web space incision was therefore omitted in 80/84 feet that were evaluated.

An oblique osteotomy was made in the proximal medial metatarsal base beginning the cut about 1.5 cm distal to the first metatarsocuneiform (MTC) joint (Figures 1 and 2). The cut was then angled so that the lateral apex was positioned approximately 5 mm distal to the first MTC. Positioning the apex of the osteotomy in this fashion allowed for the dense soft tissue attachments to cover the apex, providing extra stability should the lateral hinge crack. The lateral hinge of bone and soft tissue was not disturbed in 74 feet (88% of feet). Osteotomes from the set were used to open the osteotomy site and a mini-lamina spreader was inserted to hold the desired correction of the 1–2 IMA under fluoroscopic visualization. The appropriate opening wedge plate was selected based on fluoroscopy that showed correction of the first metatarsal to be parallel with the second. The actual opening was measured with a trial wedge or plate (Figure 3) and the plate was first secured by screw fixation in the most proximal of the distal screw holes. The two distal screws were always placed perpendicular to the long axis of the first metatarsal. The proximal plantar screw was placed across the osteotomy in an oblique fashion (65/84 feet), and the second dorsal proximal screw was placed perpendicular to the plate. Both proximal screws can be placed across the apex of the osteotomy if desired (19/84 feet). The final distal screw was then placed. A similar surgical technique has been previously reported^{12,13}.

The medial capsule was opened with an inverted-L incision and closed at the conclusion of the case with non-absorbable suture. The medial eminence was excised and utilized for autologous bone graft in the proximal osteotomy. A modified McBride (49 feet) (Figure 4) or biplanar chevron

Table 1: Hallux Valgus Deformity Classified Based on Preoperative Radiographic Findings

Severity	Hallux valgus angle	1–2 Intermetatarsal angle	Dislocation of sesamoids
Normal	Less than 15°	Less than 9°	—
Mild (8 feet)	15° to 19°	9° to 11°	Less than 50%
Moderate (25 feet)	20° to 40°	12° to 15°	50% to 75%
Severe (51 feet)	40° or more	16° or more	75% or more



Fig. 1: The two-incision technique was utilized primarily. The first MTC joint is identified and the osteotomy site marked with a ruler 1.5 cm distal to the joint.



Fig. 2: Fluoroscopy demonstrating the orientation of the osteotomy and preservation of the lateral cortex if possible.

bunionectomy (35 feet) was then performed based on the distal metatarsal articular angle (DMAA) after 1–2 IMA correction. The bunionectomy consisted of excision of the medial eminence beginning the cut about 1 millimeter medial to the medial sulcus. Toes with increased DMAA (more than 15 degrees) had a distal biplanar chevron osteotomy (35 feet) (Figure 5). A coban strap dressing was applied at the time of surgery and used for the first 3 weeks postoperatively. Patients were then changed to a Velcro-closure bunion splint for the next 3 weeks. All patients were allowed full weightbearing in a CAM walking boot immediately following surgery with emphasis to keep the weight towards the heel for the first month.



Fig. 3: The plate is fit into position and the clinical and radiographic correction evaluated. The authors' goal is to correct the 1–2 IMA to less than 5 degrees if possible.

RESULTS

Seventy-six feet (90.4%) had moderate to severe hallux valgus based on both the IMA and HVA.⁴ Specifically, the bunion grades were 10% (8 feet) mild (all foreshortened first metatarsal protrusion- mean of 4 mm short), 30% (25 feet) moderate, 30% (25 feet) moderate-severe and 30% (26 feet) severe (Tables 1 and 2). No case demonstrated a loss of first metatarsal protrusion distance and foreshortened metatarsals demonstrated greater gain in first metatarsal protrusion length, although not statistically significant. There was a linear increase in correction obtained with increasing millimeters (mm) of opening wedge but the effect seemed to plateau with the 6-mm plate (Table 2). Larger plate sizes utilized (6.5 and 7 mm) did not produce more than 3.5 degrees correction per mm of opening wedge and the larger opening wedge plates did not increase protrusion distance more than 2.3 mm. These were the maximal increases respectively and the protrusion distance increase was noted to be independent of plate size. Moreover, in severe deformities 1–2 IMA correction to less than 9 degrees (normal maximum) was easily obtained with the 6 mm plate and further correction if needed was obtained with biplanar chevron bunionectomy (35/84 feet) (Table 2). There was no correlation between degree correction per mm opening wedge and protrusion distance increase for the modified McBride group (49/84 feet).

The mean VAS score was significantly decreased by 3 months postoperatively compared to preoperative scores ($p < 0.05$) (Table 4). There was no significant difference between the VAS for pain at the 3- or 6-month followup.

Range of motion was restored to near preoperative total motion by 3 months but specific data at 3 months on each patient was not available to determine any statistical significance comparing to 6 month values. By 6 months of



Fig. 4: Weight AP bearing radiographs demonstrate severe hallux valgus without an increased DMAA, with second cross over toe and clinically painful/unstable second and third MTP joints. **A,** AP radiograph shows a foreshortened first ray and lesser toe deformity. **B,** Weightbearing 3-year followup radiograph reveals good correction in the first ray, well aligned lesser MTP joints after osteotomy and flexor tendon transfer and well centered arthritic sesamoids. Despite the persistent arthritic changes in and around the MTP joint the patient rated the result as excellent and was pain-free.



Fig. 5: Weightbearing radiographs demonstrate good correction utilizing a PMOW and distal bi-planar chevron bunionectomy at 3 years postoperatively. **A,** Preoperative weightbearing AP radiographs bilateral feet demonstrate severe hallux valgus with an increased DMAA on the right foot. **B,** Postoperative weightbearing AP radiographs of bilateral feet show good alignment on the right foot which was rated as excellent by the patient. There is no shortening of the first ray and the second metatarsal osteotomy and lateral capsule repair has resulted in a stable painless toe. **C,** Preoperative lateral radiograph of the same patient reveals a mild dorsal osteophyte, normal first metatarsal declination and no first ray elevation. **D,** Postoperative lateral radiograph of the same patient demonstrates no first ray elevation and clean resection of the dorsal metatarsal osteophyte and arthritic dorsal metatarsal head.

Table 2: Comparison of Severity of Hallux Valgus to Postoperative Parameters Evaluated

Severity of hallux valgus (feet)	Mild 10% (8)	Moderate 30% (25)	Moderate to severe 30% (25)	Severe 30% (26)
Mean degrees correction/mm opening wedge	2.7 (range 2.2–3.2)	2.9 (range 2.4–3.4)	3.2 (range 2.6–3.5)	3.3 (range 2.8–3.5)
Mean 1 st protrusion distance preoperative (mm)	Minus 4 mm (range –5 to –3.5)	Minus 1.8 mm (range –2.5 to +1)	Plus 0.8 mm (range –1.5 to +2)	Minus 0.5 mm (range –1 to +2)
Mean protrusion distance increase (mm)	2.1 mm (range 1.8 to 2.3)	2.1 mm (range 1.5 to 2.3)	1.8 mm (range 1.5 to 2.3)	1.8 mm (range 1.5 to 2.3)
Most common plate used for correction	3 mm opening wedge	5 mm opening wedge	5 mm opening wedge	6 mm opening wedge
Percent (feet) that had bi-planar chevron	12.5% (1)	32% (8)	48% (12)	54% (14)

Table 3: Feet with Postoperative Complications

Complication	Feet
Symptomatic plates	10
Hallux varus (5° or less)	2
Hallux varus (>5°)	2
Numbness at incision site	4
Valgus recurrence >5°	3
Valgus drift 5° or less	2
Screw breakage	3
Screw loosening	2
Prolonged edema	2
Persistent MTP pain	2
Non-union (metal allergy)	1
Delayed union	1
Ganglion cyst	1
Sesamoid pain	1

followup all MTP joints had maximized their total range of motion with an overall mean decrease of 6.9 degrees (range: maximal gain of 12 degrees to maximal loss of 12 degrees) (Table 4). There was no statistical difference between pre and postoperative total motion (dorsiflexion plus plantarflexion). Ten feet had improved total motion (range, total MTP improvement 5 to 12 degrees) and 60 feet were measured within 3 degrees of their preoperative total joint motion and 14 feet had more than 3 degrees loss of motion. There was a mean of 6.9 degrees decrease in MTP joint dorsiflexion (range: maximal gain of 12 degrees to a maximal loss of 12 degrees).

The change in the mean IMA and HVA from pre-op to the last available post-op visit was statistically significant

(*p* < 0.05). A mean correction of 3 degrees per millimeter of opening wedge was noted in the 1–2 IMA (Table 2) and the most commonly used plate was the 5 mm opening wedge (60 feet). There was no significant difference in any category (MTP motion, pre/postop IMA, pre/postop HVA, 1–2 IMA correction, return to work, VAS scores or subjective satisfaction) between patients that had modified McBride compared to biplanar chevron bunionectomy.

The mean time to radiographic union with osseous cross bridging seen on two orthogonal views of the foot was 5.9 (range, 4 to 14) weeks (Figures 4 and 5). First ray elevation based on the metatarsal declination angle or measured elevatus (mean increase of 0.8 mm) did not vary significantly comparing preoperative to postoperative values (Figure 5, C and D). Disruption of the lateral cortex evident on index surgery radiographs occurred in 12% of PMOW osteotomies (10 of 84 feet). There were no adverse sequelae from inadvertent disruption of the lateral cortex during osteotomy. None of these cases were associated with delayed or non-union, and there was no loss of 1–2 IMA correction postoperatively.

Parameters for long term maintenance of correction were defined as follows: HVA of 0 to 15 degrees, no increase or decrease of HVA greater than 5 degrees, and no increase 1–2 IMA greater than 2 degrees. There were 78 patients (84 feet) available with minimum 2-year followup, and 76 feet (90.5 %) maintained correction as defined above after the index surgery. Notably, 70 of 84 (83%) patients had returned to full self rated activity level by the time of their 3-month followup visit. At the final followup visit, all patients except two (2.6%) had resumed full activities. The two patients who had not returned to full activity both had MTP arthrodesis for symptomatic hallux varus. Preoperatively, 50 patients worked outside the home. Six weeks postoperatively (range,

Table 4: Pre- and Postoperative Parameters (statistical significance **)

Parameter	Mean Preoperative	Mean Postoperative
VAS**	5.9 ± 2.2	0.5 ± 0.8
MTP total motion	74.8° ± 11	67.9° ± 10
1-2 IMA**	14.5° ± 3.3	4.6° ± 2.8
HVA**	30° (range 22 to 64°)	10° (range -15 to 18°)
1 st Protrusion (McBride: 49 feet)	0.9 mm ± 3.8	1.9 mm ± 2.3
1 st Protrusion (Chevron: 35 feet)	0.8 mm ± 4.5	1.6 mm ± 2.1

2 to 6 weeks), 40 (80%) patients had returned to full work duties, and by 3 months postoperatively 100% had returned to full work duties.

Good (30 feet) to excellent (46 feet) patient self-rated satisfaction was noted in 90.5% of feet (76 of 84 feet) and 89.7% of patients (70 of 78 patients) after the index surgery. Three patients rated their result as fair but satisfied: two had valgus drift of 5 degrees or less (final HVA of 12 and 14 degrees) and one had varus overcorrection (5 degrees varus).

Complications

Complications of PMOW osteotomy are summarized in Table 3. The most common complication was bursitis associated with the internal fixation plate (10 patients). The three patients that had valgus recurrence were severe deformities and a poor capsule to repair. Moreover, all 3 patients had an increased DMAA (greater than 15 degrees) not corrected at the time of the index surgery.

Five patients rated their result as poor and required secondary procedures. There were 3 patients that had valgus recurrence of greater than 5 (range, 7 to 15) degrees and one of these included the first metatarsal nonunion. The

nonunion was revised utilizing a modified Lapidus procedure with bioabsorbable screws (an allergy to the metal plate was verified by skin testing) and healed with a subjective good result. The two other patients with valgus recurrence were each revised with an Akin procedure, resulting in a subjective good result. There were two patients that had severe varus overcorrection (15 degrees varus) (Figure 6). The hallux varus was addressed with a first MTP arthrodesis in each patient and both were satisfied with subjective self-rated good results.

Both the delayed union and nonunion had loss of correction of the 1–2 IMA with an increase of 2 degrees and 4 degrees, respectively, but there were no instances of hardware failure. The delayed union (moderate deformity) healed at 14 weeks utilizing a bone stimulator and subjectively rated the result as good.

Removal of plates or screws occurred in 18% (15 feet). Ten patients had a symptomatic plate with bursitis (this included two patients not satisfied with their procedure prior to removal) requiring removal. Prominent screws were removed from two patients under local anesthesia in the

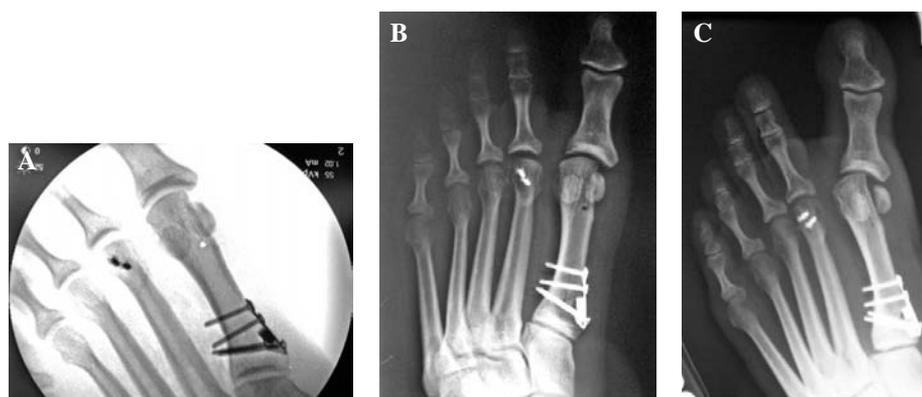


Fig. 6: The progressive deformity of hallux varus is demonstrated in one patient with serial AP weightbearing radiographs. **A**, Simulated weightbearing AP radiograph shows immediate postoperative fluoroscopic view with good correction utilizing a PMOW with modified McBride bunionectomy and associated open first web space release. The medial eminence was resected 1–2 mm medial to the medial sulcus. The second cross over toe is now well aligned after metatarsal osteotomy and lateral capsule repair. **B**, Radiograph demonstrates the 4.5-week postoperative radiograph after the patient had been walking in a regular shoe without protective dressings against advice and felt a “pop”. A rigid bunion splint was prescribed for full time use in a cam walking boot. The patient was instructed on touch down weightbearing. **C**, Radiograph reveals the 8-week postoperative appearance and the patient continued in a regular shoe without supportive dressing. Severe varus deformity was noted and MTP joint arthrodesis was recommended.

office. One patient had a symptomatic hardware associated with an exostosis at the metatarsal base. Symptomatic hardware with delayed union of the osteotomy was experienced by one patient. The delayed union healed with a bone stimulator- although valgus recurrence of 8 degrees and increase in IMA of 2 degrees occurred. This patient was completely satisfied with the surgical result after removal of symptomatic hardware.

DISCUSSION

Proximal metatarsal opening wedge osteotomy (PMOW) utilizing the Arthrex LPS® system was generally easy to perform and obtained reliable, measurable, and predictable correction. The oblique osteotomy achieved a mean of 3 degrees correction in the 1–2 IMA per mm of opening wedge. The procedure resulted in a high proportion (70 of 78 patients: 90%) of good and excellent patient self-rated results after the index surgery. Maximal pain relief occurred around 3 months after surgery as there was no significant difference between the VAS for pain at 3 and 6 months postoperatively. Clinically, most patients had complete resolution of their swelling at this point. Of the two who did not, one of these patients went on to have a non-union and the other was a delayed union.

Eight patients had suboptimal subjective results (five poor and three fair). Five of these patients required minor surgical revision following the index procedure (two Akin procedures, three plate/screw removals) and their final subjective self-rated satisfaction was good-excellent. This would improve the final subjective satisfaction with the PMOW osteotomy as good-excellent in 96.4% of feet (81 of 84) or 96.1% of patients (75 of 78). Three patients (3 of 78 or 3.9%) required major revision (two MTP arthrodeses and one Lapidus procedure) to obtain a good-excellent subjective self-rated result.

Subsequent postoperative varus has been avoided after initial experience showed that the typical first web space release resulted in overcorrection. The technique was modified so that the lateral capsule was pie-crusting through the joint and the dorsal adductor attachment of the lateral sesamoid was incised as well. Sesamoid reduction was easily obtained in the cases (80 feet) without a first web space incision.

The valgus drift noted in two patients and valgus recurrence noted in three patients after the index surgery was likely related to two factors. Namely, an increased DMAA (all greater than 15 degrees) noted in three patients and poor joint capsule quality due to severe deformity or metabolic factors. Based on fluoroscopy after 1–2 IMA correction, concomitant biplanar chevron osteotomy in 35 of 84 feet (42%) was performed to correct the DMAA to near 0 degrees at the index surgery. An increased DMAA has been shown previously to be a factor in recurrent or persistent hallux valgus.^{2,3} The poor quality joint capsule was repaired with

suture anchor augmentation in all revision cases. The above strategies led to near complete resolution of postoperative valgus drift or recurrence. The DMAA in 49 of 84 feet (58%) that had modified McBride bunionectomy was not affected by PMOW osteotomy.

The most common problem postoperatively was symptomatic plate or screws and a decreased incidence was noted when the plate was applied in a more dorsomedial position rather than a directly medial position. Moreover, the dorsal most of the proximal screws was placed perpendicular to the long axis of the metatarsal so that it did not cross the apex of the osteotomy, and the plantar proximal screw was placed obliquely across the osteotomy site. These techniques minimized bursitis that developed over the dorsal limb of the plate that was encountered early in the series.

Poor patient selection resulted in the nonunion complication as that patient exhibited a previously unknown metal allergy and also had notable midfoot arthritis with hallux valgus preoperatively. Revision with a Lapidus procedure resulted in a successful result. Even with the nonunion, the plate and screws did not break, but the wedge became disassociated from the bone and recurrence of a widened 1–2 IMA was evident. The same patient had documented osteoporosis. The delayed union that occurred was in a patient who was diagnosed with breast cancer 3 weeks after the index surgery and subsequently underwent mastectomy and had concomitant chemotherapy. This resulted in delayed healing, valgus drift (2 degrees increased 1–2 IMA) and increased plate prominence. After hardware removal the patient was satisfied with the result.

PMOW osteotomy was a straight-forward procedure yielding excellent, reliable correction and allowed early weightbearing due to the stable nature of the construct. There were no instances of postoperative cortical hinge disruption or malunion associated with early weightbearing in a CAM walker. Even when the lateral cortex was disrupted during the index surgery (12% of cases or 10 of 84 feet) there was no loss of correction, fixation failure, first ray elevation or shortening. Bicortical screw purchase was obtained in all cases to minimize risk of failure and the plantar proximal screw was placed across the apex of the osteotomy distally to enhance the stability of the oblique cut. The mechanical stability of the Arthrex opening wedge construct has been shown to be comparable to proximal chevron osteotomy¹¹ and the authors have no hesitation in recommending full postoperative weightbearing in a CAM walking boot.

There seemed to be a linear relationship of increased correction with increasing opening wedge. This effect appeared to plateau at the 6-mm opening wedge construct. A similar finding was reported by Cooper et al.¹ but at the 5-mm construct. With a larger sample size in the present study it appears that the effect is not limited to the 5 mm wedge but to the 6-mm wedge plate. However, the likelihood of requiring greater than a 6-mm opening wedge to obtain correction is low and excellent overall deformity

correction was obtained for severe hallux valgus utilizing the 6-mm opening wedge and concomitant distal bi-planar chevron osteotomy.

The effect of lengthening the first ray with PMOW is minimal and not statistically significant (mean 1.9 mm increase in protrusion distance) comparing both modified McBride and chevron groups. Increased protrusion distance was not well correlated with greater opening wedge ($r = 0.4$) but one confounding factor may be an offset in protrusion increase due to shortening with the distal bi-planar chevron as this osteotomy was not evaluated as a stand alone procedure in this study. Cases with biplanar chevron bunionectomy demonstrated no or minimal increase (mean of 1.5 mm; range of 0 to 2.5 mm) in first metatarsal protrusion distance. Although not statistically significant, patients that had modified McBride bunionectomy had a greater increase in first metatarsal protrusion distance (mean of 2.1 mm; range of 1 to 3.5 mm). Some amount of shortening undoubtedly occurs with biplanar chevron bunionectomy but the actual decrease in protrusion distance could not be determined in the current study as biplanar chevron bunionectomy without PMOW was not evaluated. Regardless, there were no cases of shortening, and many radiographs (42 of 84; 50%) showed no change in first metatarsal length.

There was no significant difference comparing pre to postoperative MTP joint range of motion which suggested that there was no "jamming effect" on the MTP joint due to the apparent increase of first metatarsal protrusion distance. However, there was an insignificant mean decrease in total MTP joint motion (maximal loss was 12 degrees) and dorsiflexion (maximal loss was 12 degrees). Some patients gained total MTP motion and dorsiflexion. Jones et al.⁸ reported decreased range of motion (primarily dorsiflexion) in cadaveric hallux valgus specimens after proximal crescentic osteotomy. The joint forces resulting from first ray realignment and probable contracture of the plantar metatarsal head supporting tissues were hypothesized to be causes for the loss of dorsiflexion. The current study found no difference in subjective satisfaction or VAS pain scores between patients that had loss of motion and those that did not. Only one patient subjectively felt postoperative stiffness and objectively had loss of 5 degrees and 8 degrees of dorsiflexion at the MTP joints on each foot at the latest followup. Moreover, there was no significant difference in any postoperative outcome measure between patients that had concomitant bi-planar chevron or modified McBride bunionectomy.

CONCLUSION

We believe PMOW osteotomy is near ideal in terms of predictable correction and healing and has a low incidence of major complications. After making minor changes to the technique, a notable decrease in recurrence, hallux varus, and

prominent, painful plates and screws was noted. Due to the successful results obtained both in the initial postoperative period and after 2-year followup, the stable nature of the construct was apparent and patients could be safely allowed weightbearing as tolerated in a CAM walker immediately after the procedure. Plate or screw removal can be minimized with the previously mentioned techniques. However, many patients choose to have their plates and screws removed regardless if they are symptomatic or not. Many surgeons remove all forms of hallux valgus fixation in their office as a routine but we chose not to do that in this series. The PMOW osteotomy maintained correction at the 2-year minimum followup. In this study, mild deformity was associated with the shortest protrusion length and though distal osteotomy alone could have been used to correct the hallux valgus, PMOW obtained successful correction without creating further shortening. The goal was to avoid creation of lesser metatarsal transfer lesions. The procedure was easy to perform with a minimal learning curve.

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