Section A -Research paper

Medial Opening Wedge Osteotomy and Dome Osteotomy in Management Hallux Valgus Deformity

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Abstract:

The condition of hallux valgus is considered as deformities affecting females more than males, characteristically manifested as lateral deviation of the big toe and widening of first and second inter -metatarsal angle with a deformity of second toe in some severe cases. Whereas the hallux valgus deformity is progressive and involves several stages causing progressive degeneration of the joint, moderate to sever pain and ends with progressive sublaxation of first metatarophalangeal joint which interfering with activity and quality of life for patients, challenging surgeons regarding optimal management. Wedge osteotomy procedure that has been the gold standard for advanced hallux vallgus other newer procedures such as dome osteotomy has demonstrated promising early patient outcomes.

Keywords: Hallux Valgus, Wedge Osteotomy, Dome Osteotomy.

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Introduction:

The treatments of hallux valgus deformities are not all equal. With >100 surgical procedures described in the literature, no procedure is adequate to correct all bunion deformities. The treatment of moderate-to-severe deformity [hallux valgus angle (HVA), >20 degrees; intermetatarsal angle (IMA), > 13 degrees] is challenging and considers the use of either a proximal metatarsal osteotomy or a metatarsocuneiform arthrodesis with a distal soft tissue procedure **(1)**.

Numerous proximal osteotomies have been described, with each technique touted for its ability to correct deformities of various magnitude and each with its unique set of complications. These proximal osteotomies include the Scarf, crescentic, the Ludloff, the modified Mau, the chevron, the closing lateral wedge osteotomy, and now, the proximal medial opening wedge (figure 1). With the introduction of numerous proximal metatarsal osteotomy plates, the technique for medial opening wedge osteotomy may be the ideal proximal osteotomy for correcting moderate-to-severe deformities **(2)**.

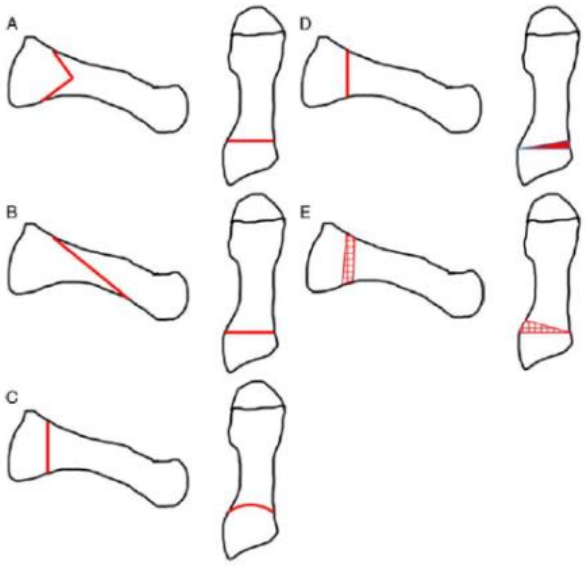

Figure (1): Anteroposterior and lateral views of various proximal osteotomies **(2), A,** Proximal chevron osteotomy, **B,** Ludloff osteotomy, **C,** Proximal cresentic osteotomy, **D,** Proximal closing wedge osteotomy, **E,** Proximal opening wedge osteotomy.

Historically, little has been written about the proximal first metatarsal osteotomy. **Smith et al. (3)** reported excellent functional results while noting excellent correction and high patient satisfaction. These osteotomies were reported to correct average preoperative IMA of 15 to 18 degrees to 8 to 11 degrees postoperatively. In adolescent bunions, the osteotomy resulted in high recurrence rates.

Scranton and Zuckerman (4) summarized their review findings of bunion surgery in 50 feet in 31 adolescents. The authors intended to investigate the outcome of surgical correction of bunion deformity with primus varus and hallux valgus in a younger cohort. The 50 surgeries were performed by 8 surgeons utilizing 4 different surgical procedures: the McBride or modified McBride; the opening wedge proximal metatarsal osteotomy; the closing proximal metatarsal osteotomy and modified Lapidus procedure.

A meta-analysis to assess corrective power and complications of proximal first metatarsal osteotomies for hallux valgus deformity was published by **Schuh et al. (5)** including 2843 feet. They compared the correction of the IMAs and HVAs and complications of proximal crescentic, Ludloff, proximal opening wedge, proximal closing wedge, proximal chevron, and a group of other proximal osteotomies not fitting into one of the above. They showed that proximal osteotomies achieved a correction of IMA of 8.1 degrees [proximal opening wedge osteotomy (PMOW) 7.2 degrees] and correction of HVA of 20.1 degrees (PMOW 19.6 degrees). A total of 534 complications (18.7%) occurred, with 364 (12.8%) categorized as major and 92 (3.2%) categorized as minor. Hallux varus and recurrence were the 2 most common complications representing 4.3% and 3.5% of the complications, respectively. Major complications in the PMOW group were 14.3%, but the breakdown of these complications was not provided. Of the

techniques considered, the proximal chevron yielded overall the best angular correction and complication profile. In addition, they demonstrated a higher corrective power of proximal osteotomies compared with meta-analysis data on diaphyseal osteotomies.

Glazebrook et al. (6) performed a prospective, randomized trial comparing the PMOW with wedge-plate fixation with proximal chevron osteotomy for hallux valgus with increased IMA. They reported no significant differences in any of the patients' clinical outcome measurements between the 2 procedures. The PMOW lengthened, and the proximal chevron osteotomy shortened the first metatarsal. IMA improved significantly, from 14.8 to 9.1 after a PMOW and from 14.6 to 11.3 after a proximal chevron osteotomy. Operative times were found to be similar. It was determined that opening wedge and proximal chevron osteotomies have comparable radiographic and clinical outcomes for pain, satisfaction, and function. PMOW was preferred by the orthopaedic surgeons involved in this study because it was subjectively less technically demanding.

Indications and contraindications of Medial Opening Wedge Osteotomy:

As there are many choices in the treatment of bunion deformities, the surgeon must feel comfortable with the technique selected in each individual case. **Watson et al. (7)** did not perform the PMOW in all bunion deformities. Over the years, they have settled on using this procedure on patients presenting with a first-second IMA between 13 and 16 degrees and an HVA between 25 and 35 degrees (figure 2).

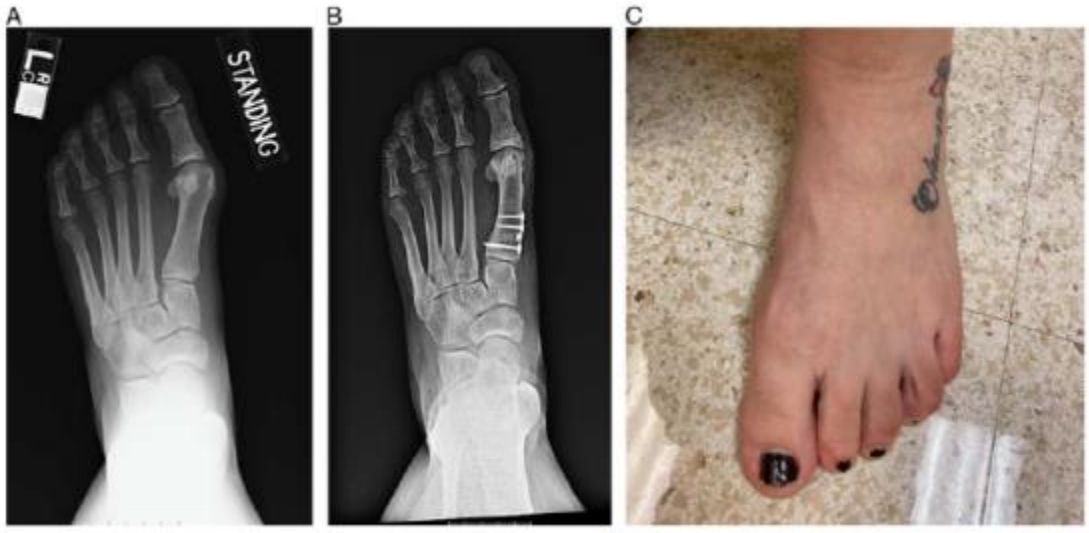

Figure (2): Ten-year follow-up of proximal opening wedge osteotomy without a distal biplanar chevron osteotomy. Although adding the distal osteotomy would likely have prevented some of the recurrences we are seeing, this patient remains very happy with her long-term outcome **(7)**, **A,** Preoperative anteroposterior radiograph demonstrating 31 degrees hallux valgus angle and 15.5 degrees intermetatarsal angle, **B,** Ten-year follow-up anteroposterior radiograph showing slight recurrence and loss of hallux valgus angle now measuring 18.5 and 6.9 degrees intermetatarsal angle, **C,** Ten-year clinical follow-up image.

As **Iyer et al. (8)** demonstrated, failures may be seen in those with greater IMA and HVA and those with an increase in distal metatarsal articular angle (DMAA). They defined a recurrence of deformity as a hallux valgus drift of >5 degrees. **Watson et**

al. (7) have shown that almost all patients now fit into an opening wedge of 3.5 to 4.0 mm. This will correct the IMA by 8 to 12 degrees, and pushing the envelope past this point may result in recurrent deformity.

Thus, **Watson et al. (7)** utilized the PMOW as a middle ground procedure: lesser deformities are treated with a distal chevron osteotomy or a mini-endobutton technique and deformities greater >16 degrees IMA or HVA of ≥35 degrees are treated with a Lapidus-type procedure combined with a distal soft tissue procedure. If there is evidence of an increased DMAA then adding a biplanar closing wedge chevron osteotomy distally has helped avoid some of the complications previously reported.

Contraindications to this technique are an arthritic first TMT joint, painful hallux metatarsophalangeal (MTP) joint arthrosis, and first-ray hypermobility. Relative contraindications are age above 65 years old, osteoporosis, inflammatory arthropathies, and neuromuscular disorders. Patients with an increased DMAA may still be treated with an opening wedge osteotomy but may also require concomitant procedures such as a distal biplanar chevron osteotomy **(9)**.

Watson et al. (7) have also employed this technique to aid in revisions of previously failed bunion surgery. Specifically, they found this to be an ideal operative procedure in revising recurrent bunions in those that experienced iatrogenic shortening of the first ray. They have revised several patients fitting this indication with great success (figure 3).

Figure (3): **A and B,** Anteroposterior and lateral preoperative radiographs show a previously failed scarf shaft osteotomy with a shortened and plantarflexed first ray. The patient has 21.5 degrees hallux valgus angle and 14.0 degrees intermetatarsal angle as a residual deformity with transfer metatarsalgia, **C and D,** Anteroposterior and lateral postoperative radiographs show postoperative correction of intermetatarsal angle and residual hallux valgus angle: 5.1 degrees intermetatarsal angle and 6.4 degrees hallux valgus angle. This patient was an ideal candidate for the proximal opening wedge osteotomy given that we could gain length to her first metatarsal to combat her transfer metatarsalgia and improve alignment. At 1-year postsurgery, the patient remains very happy with her outcome **(7).**

Technique:

Surgical success is conditionally dependent on proper patient selection, so we

describe the technique with a patient for an illustrative example (figure 4). The surgical technique begins with a small dorsolateral incision located over the base of the great toe proximal phalanx. Dissection is carried down through the webspace, and the adductor tendon is identified as it attaches to the base of the proximal phalanx. Using a small hemostat, dissection under the tendon is completed, and transaction of the tendon off the phalanx is completed. The tendon is then dissected sharply off the lateral aspect of the fibular sesamoid. The capsule between the metatarsal head and the fibular sesamoid is split with tenotomy scissors under direct vision **(7)**.

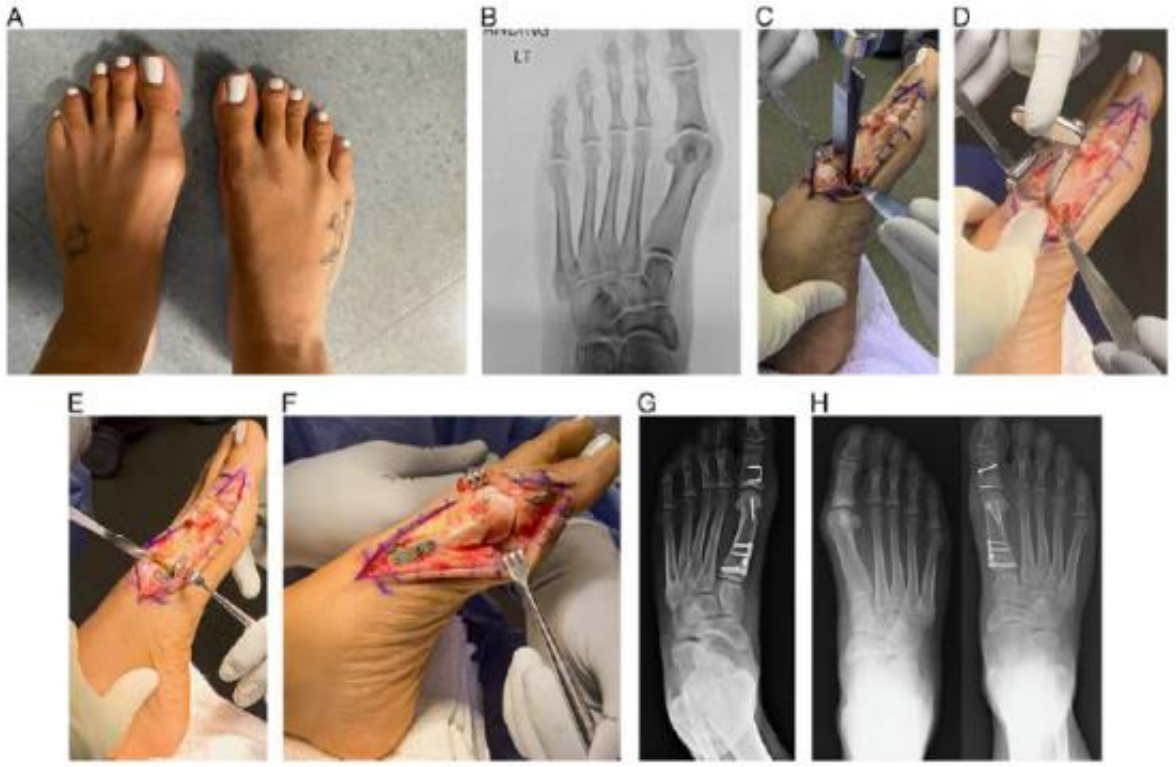

Figure (4): A, Clinical picture showing the 1-year postoperative result on the right foot and preoperative left foot, **B,** Preoperative left foot anteroposterior radiograph. Note an increase in distal metatarsal articular angle, **C,** After completing the oblique osteotomy at the base of the first metatarsal, the series of osteotomes are placed as shown and tapped into place, establishing an opening wedge, **D,** Use of the small spreader aids in opening the wedge, **E,** Provisional fixation of the plate to check correction with fluoroscopic imaging, **F,** Final construct with proximal opening wedge osteotomy with cancellous graft placed. Note the distal biplanar chevron osteotomy and an Akin proximal phalanx osteotomy, **G,** Final anteroposterior radiograph of the left foot, **H,** This patient had previously undergone the same procedure on the right foot 1 year prior. Preoperative anteroposterior and postoperative anteroposterior right foot depicted at 1 year postoperatively. **(7)**

Once this is completed, **Watson et al. (7)** then made one long medial incision extending from the mid-portion of the proximal phalanx and extending to the first TMT joint. They found this incision more cosmetically acceptable for patients, especially those that prefer to wear sandals. Once through the skin, the dorsal cutaneous nerve is dissected and protected with dorsal retraction throughout the procedure. A straight medial capsular incision is made to allow exposure of the large medial eminence.

Resection of the medial eminence is then completed with a saw blade in line with the metatarsal shaft. Care is taken to resect minimal bone at the level of the joint to avoid instability leading to hallux varus. Saving the resected medial eminence can be helpful for harvesting autograft for the PMOW.

Once distal work is completed, attention is then turned proximally. Identification of the first TMT joint is made, and dissection of just enough of the medial metatarsal base is completed to allow for the osteotomy. Homan retractors are placed to protect dorsal and plantar structures. Using a short sagittal saw blade (measuring 1 cm in width), an oblique osteotomy is made at the base of the first metatarsal angled toward the proximal metatarsal **(7)**.

Typically, **Watson et al. (7)** started this bone cut about 15 mm distal to the first TMT joint. The osteotomy is typically made in an oblique fashion angling the cut proximally. The osteotomy is stopped short of the far cortex to allow for a hinged opening of the first metatarsal. The saw blade is perpendicular to the long access of the bone and penetrates the bone to a depth of 10 to 12 mm. Light hand pressure, while cutting, will allow the surgeon to feel the far cortex and prevent overzealous violation of the lateral wall. Once the bone cut is completed, small osteotomes are used sequentially from largest to smallest until the wedge opens enough to place a small distractor. Use a small spreader to open the wedge. On the basis of preoperative weight-bearing radiographs, the surgeon determines a starting point for plate fixation and trial. A 3.5 or 4.0 mm plate is typically applied to the medial bone off the rim on the plantar aspect of the metatarsal.

Watson et al. (7) provisionally fix this with olive wires and then check fluoroscopic images simulating weight-bearing by pushing the foot into the base of the C-arm. If more correction is necessary, they typically increased by 0.5 mm increments. Again, the majority of patients now receive either a 3.5 or 4.0 mm wedge plate. They have seen 2 to 3 degrees correction of the IMA with each 1 mm of the opening wedge. Once the correct plate size is determined, fixation is completed with 2 screws distally and 2 screws proximally. Locking options are now available, but the authors typically use a nonlocking LPS set. Most commonly, shaft screws measure 16 mm, and proximal screws measure 20 to 22 mm in length. Care should be taken to avoid the placement of screws into the first TMT joint.

The bone graft is next harvested from the calcaneus through a small 1 cm incision, just distal and anterior to the distal fibula. Dissection is carried bluntly down to the bone where retractors are placed, and the use of a 7 mm reamer is used to obtain adequate graft for packing the opening wedge site. The correction and placement of hardware are next confirmed by

fluoroscopic imaging. The DMAA is evaluated next to see if there is still clinically significant valgus stemming from an increased DMAA. If the surgeon believes an increase in DMAA is a contributing factor, then a distal biplanar cut is performed to correct the head position and minimize the risk of recurrent deformity.

Alternatively, some surgeons prefer a closing wedge Riverdin osteotomy, and both should accomplish correction. The decision for the addition of an Akin closing wedge osteotomy is made based on the presence of hallux interphalangeus. Sometimes it is helpful in obtaining a bit more clinical correction. Finally, with the hallux held in a neutral position, capsular closure is completed with 2-0 Vicryl suture. Care is taken to correct any toe pronation if present with this soft tissue closure **(7)**.

Postoperative management:

A bulky gauze bunion strapping is placed in the operating room, and the extremity is fit and immobilized into a short CAM walking boot. Heel weight-bearing is allowed, and the dressings are changed at the first postoperative visit 3 to 5 days after surgery to a Coban and gauze wrap figure-of-eight dressing. **Watson et al. (7)** often closed the skin with a 3-0 Monocril suture and, therefore, do not need to remove sutures as they absorb after about 6 weeks. After 4 weeks of bunion strapping, a large toe separator is used with a sock, and patients are allowed full weight-bearing in the CAM boot. Postoperative radiographs should be obtained to make certain that no hallux varus is occurring and no loss of fixation at the PMOW. Most patients are in regular tennis shoes by 8 to 10 weeks, and fashionable shoes after 10 weeks are allowed.

Active and passive range of motion of the hallux MTP joint is started after the first postoperative visit. Patients are encouraged to perform a range of motion exercises in the dressings but are allowed to come out of the dressings if needed. In addition, if the difficulty is noted with a postoperative range of motion, then formal physical therapy is instituted.

Complications:

The most frustrating complication to surgeons and patients alike is a recurrent deformity (figure 5). Correctly selected patients, as discussed under the indications section, will help prevent some of these recurrences **(7)**. As **Iyer et al. (8)** discussed, failures of this procedure were in patients with larger HVA and those with larger DMAA. In all bunion surgery, recurrent deformities can be seen. It is helpful to discuss this with patients as part of the preoperative informed consent.

Figure (5): Anteroposterior radiograph showing a failure of proximal opening wedge osteotomy at 1.5 years postoperatively. Note the recurrence of

hallux valgus and encroachment on the second toe requiring a revision **(7)**.

Initially, **Watson et al. (7)** saw cases of hallux varus, but this has, in large part, been eliminated by less medial eminence resection and a less aggressive lateral release. They have seen some cases of painful hardware, and all respond to simply removing the hardware once the PMOW has healed adequately. One case of plantarflexion through the osteotomy was seen requiring a revision procedure. This can be avoided by checking postoperative lateral radiograph for any signs of dorsiflexion or plantarflexion. The concern for joint stiffness has been reported for PMOW.

Any postoperative stiffness experienced by patients has resolved with physical therapy. Prior kinematic gait investigation before and after surgery identified that a hallux valgus deformity imparted structural and functional problems to the kinematic chain. Subsequently, functional problems are unaddressed by surgery32 and may partially explain the resolution of symptoms with physical therapy **(7)**.

Dome (Proximal Crescentic) Osteotomy

Proximal crescentic osteotomy (PCO) had good outcome concerning decreasing pain, correcting HV and intermetatarsal angles, and improving function and patients' satisfaction **(10)**.

Surgical technique:

The crescentic osteotomy consists of a distal lateral release and bunionectomy prior to the proximal osteotomy. Firstly, a dorsal incision was made in the inter-metatarsal space between 1st and 2nd ray. Release of the adductor hallucis tendon, the deep transverse inter-metatarsal ligament and lateral capsule were executed. The second incision was made midline medial over the medial eminence to remove the medial eminence and perform a capsulorrhaphy. The third incision was made dorsally over the proximal end of the first metatarsal and extended a few millimetres over the medial cuneiforme. The proximal osteotomy for each group was made through this incision.

A proximal crescentic osteotomy about 15 mm distal to the TMT-joint, with the concavity pointing proximal was made. The osteotomy was done in a plane perpendicular to the first metatarsal bone. A 3 mm cannulated AO titanium screw was used for stabilization, directed from proximal–medial–dorsal to distal– lateral. Capsule tightening was performed (figure 6). Before skin closure, the tourniquet was removed and haemostasis was secured. The HVA and IMA corrections were verified by fluoroscopy intraoperatively **(11)**.

Figure (6): Pre- and postoperative weight bearing X-rays after crescentic osteotomy **(11)**

Postoperative treatment:

Patients followed the postoperative procedure, which was one week with partial weight bearing and 5 weeks in static walker, gradually allowing full weight bearing. Sutures were removed 14 days postoperatively and a toe alignment splint was used permanently for 6 weeks after removal of the stitches. All patients returned to postoperative evaluation after 6 weeks, 4 months and 12 months, respectively. MTP joint mobility exercises were initiated 3 to 4 weeks after surgery. No physiotherapy rehabilitation programme was initiated. The patients were followed with clinical and radiological evaluation after 6 weeks, 4 and 12 months. All operations were performed by 4 senior orthopaedic foot and ankle surgeons.

Clinical evaluation was performed using the American Ortho-paedic Foot and Ankle Society (AOFAS) score, visual analogue scale (VAS). Scores and radiological measures were recorded preopera-tively and 4 and 12 months following the operation. Antero-posterior (AP) weight bearing views were taken preoperatively, 4 and 12 months postoperatively. Fluoroscopy was used during the operation to assure the desired correction **(11)**.

The X-rays were evaluated by the same foot and ankle surgeon measuring the hallux valgus angle (HV), inter-metatarsal angle (IM), radiological healing and length

of the 1 compared to 2 metatarsal length. No absolute length parameter (tracking ball) was available on the X-rays, thus the relation between the 1st and 2nd metatarsal was used as a measure instead of absolute length **(11)**.

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