CHAPTER 17

RADIOGRAPHIC AND CLINICAL ANALYSIS OF THE PROXIMAL WEDGE SHELF OSTEOTOMY FOR CORRECTION OF LARGE INTERMETATARSAL ANGLE HALLUX ABDUCTO VALGUS DEFORMITY

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INTRODUCTION

Hallux valgus is a very common adult forefoot deformity. The pathophysiology of the bunion deformity is numerous including abnormal first ray biomechanics, abnormal pronation with an unstable first ray, dorsiflexion of the first ray or metatarsal primus elevatus, a long first ray, and an abnormal intermetatarsal angle between the first and second metatarsal or met primus adductus as well as other reasons.[1] The number of ways to address and correct this deformity both conservatively and surgically are just as numerous.[1-5] While used often for smaller deformities, soft tissue correction and distal metatarsal osteotomies are not considered adequate for some of the larger and more severe abnormalities.[3,6-9] This can often undercorrect, and lead to recurrence of the deformity. Correction of moderate to severe deformity is often addressed by the surgeon with a combination distal soft tissue procedure and proximal first metatarsal osteotomy. This allows for greater angular correction of deformity due to a greater corrective arc center of rotation as well as other advantages noted by many other authors.[1,7-9]

The closing abductory wedge osteotomy has been employed for correction of such a deformity for many years. It was initially described by Loison and performed by Balacesceu as a transverse cut wedge across the metaphyseal base.[10,11] This was later modified by Juvara and again by Ruch by changing to a more oblique osteotomy from proximal-medial to distal-lateral, stabilized with screw fixation.[12-15]

The Scarf, Mao, and Ludloff procedures are all diaphyseal metatarsal osteotomies that lend themselves to screw fixation in a dorsal to plantar direction. This aids the surgeon with ease of fixation through better exposure for screw application.[16-18]

The crescentic osteotomy was a newer proximal osteotomy developed by Mann to provide more rotation at the proximal aspect with lesser shortening complications. This cut was later modified again to include a plantar shelf for ease of fixation, increased bony apposition, and greater stability than a straight through crescentic cut.[19,20]

In 1994 Jimenez took concepts from all of these osteotomies and created the wedge shelf osteotomy. This cut incorporates the closing wedge osteotomy in a transverse direction for removal of less bone, the bone to bone contact of the diaphyseal osteotomies in the metaphysis of the first metatarsal, and the plantar shelf concept of the crescentic shelf correction (Figures 1, 2).[21]

The purpose of this study is to radiographically, clinically, and subjectively evaluate one surgeon's outcomes from the wedge shelf osteotomy for correction of moderate to severe hallux abducto valgus deformity with a large metatarsus primus adductus in a short term follow-up ranging from 6 months to 5 years.

METHODS

A retrospective review was done on 16 patients (20 feet) that underwent surgical correction of a moderate to severe bunion deformity, hallux valgus, and metatarsus primus

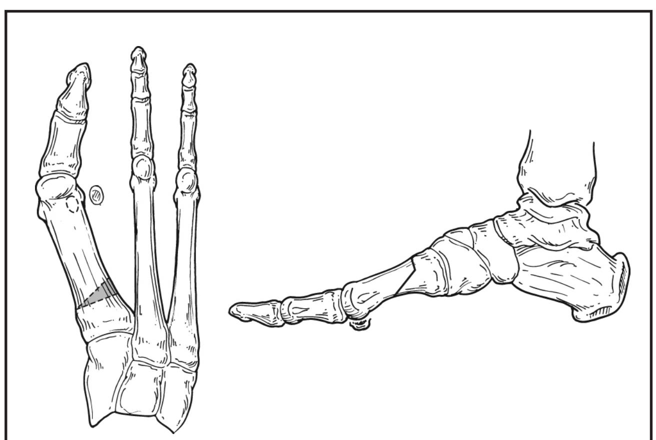

Figure 1. The wedge shelf osteotomy diagram from dorsal and lateral views.

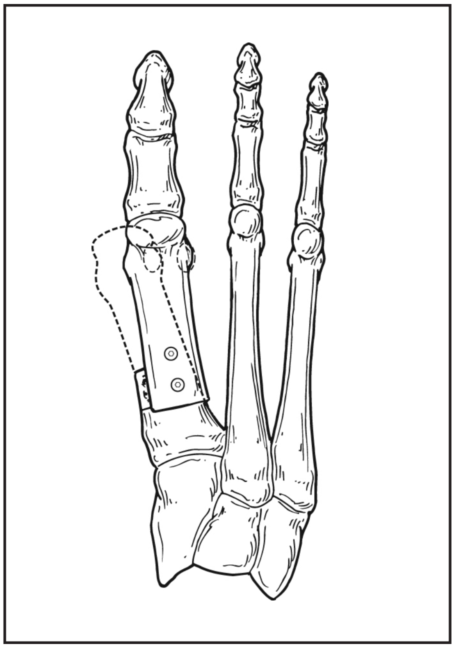

Figure 2.Proposed surgical correction by wedge shelf osteotomy with 2 screw fixation.

adductus between 2002 and 2006 by senior author JMF. The procedure performed was a significant distal soft tissue procedure combined with a proximal closing wedge type osteotomy that is described in detail under the surgical procedure section. Clinical indications for surgery included pain over the bunion deformity without significant degenerative joint disease, and difficulty wearing and fitting into shoes as well as failure of nonsurgical conservative care. Conservative therapy included shoe modification, padding, strapping, orthotic treatment, and nonsteroidal anti-inflammatory drugs (NSAIDs). Analysis included pre and postoperative radiographs, clinical examinations, and postoperative questionnaire. The surgical patients were 2 males and 14 females. The average age of the patient was 47 years and ranged from 21 to 75 years. There were 13 right feet and 7 left feet that underwent correction. The average follow-up for the patients was 2.75 years (range 6 months to 5 years.)

Four of the patients had bilateral surgical procedures, but they were addressed individually with at least 6 months separating the surgeries. Three patients had ancillary procedures done at the same time that were hammertoe corrections. Two of the patients were revisions from previous attempts at surgical correction by different surgeons. One of these was an unsuccessful oblique closing base wedge osteotomy and the other was a distal metatarsal osteotomy/Austin.

Radiology Evaluation

Immediately following surgery, nonweightbearing films were evaluated for healing every two weeks by means of displayed trabeculations and callus at or around the osteotomy site. Following visualized signs of healing, weightbearing radiographs were obtained. Follow-up measurements were made on final and most recent films obtained for each patient. Angular measurements were made pre and postoperatively on weightbearing films for radiographic analysis including intermetatarsal angle, hallux abductus angle, tibial sesamoid position, metatarsal length, and metatarsal adductus angle to aid in calculation of true intermetatarsal angle on antero-posterior views.[22-25] Lateral radiographs were analyzed for Seiberg index and first metatarsal declination angle to examine for elevation postoperatively.[26]

Clinical Evaluation

In addition to history and physical exam, a preoperative foot score was tallied utilizing a modified ACFAS first metatarsophalangeal joint scoring system which helped to quantify patient subjective assessment of pain, disability, cosmesis, and motion (Table 1).[27] A postoperative profile score was also obtained utilizing the same questionnaire. Patients were also ultimately asked if they would undergo the procedure again and if they would recommend the procedure to a friend. All patients were personally examined by the senior author JMF.

Surgical Technique

The technique used is only slightly modified from its original description by Jimenez in 1994. The patient is placed on the table in a supine position. Anesthesia is achieved by surgeon's choice. This particular surgeon prefers to use general anesthesia. The leg is then prepped and draped in its usual sterile manner. A pneumatic ankle tourniquet can be used at this time, but is not absolutely necessary.

A linear skin incision is made dorsally measuring approximately 8 centimeters starting just distal to the metatarsal cuneiform joint and extending distally to the base of the proximal phalanx of the hallux. The incision is next deepened through the subcutaneous tissues by sharp and blunt dissection. All neurovascular and vital structures (EHL tendon, Medial Dorsal Cutaneous Nerve) crossing the operative site are identified ligated or retracted out of the field.

Attention is next paid to the first metatarsal head medially where a capsular incision is made and periosteum is reflected back from the surgical neck. The medial

Table 1

MODIFIED ACFAS 1ST MTPJ SCORING SYSTEM (27)

1. Before Surgery how much did the pain in your foot limit your daily activities? (max 30 points)
   ___No pain with normal activity (30)
   ___Slight or occaisional pain, no compromise in activity (22)
   ___Moderate pain, slight effect on activity (14)
   ___Pain with serious limitations of activity (6)
   ___Pain with total limitation of activity (0)
2. How would you rate the appearance of your big toe and joint before surgery? (max 5 points)
   ___Liked it very much (5)
   ___I mostly liked it (4)
   ___Not sure (neutral) (3)
   ___Mostly didn't like it (2)
   ___Dislike very much (0)
3. Before Surgery how frequently did you have pain while wearing shoes? (max 15 points)
   ___Able to continuously wear any type of shoe (15)
   ___Able to wear any type of shoe most of the time (10)
   ___Able to wear only walking, athletic, or casual shoes (5)
   ___Able to wear only orthopedic, custom made, or special order shoe (0)
4. Before Surgery did you limp from the pain? (max 5 points)
   ___Yes (0)
   ___No (5)
5. How much does the pain in your foot limit your daily activities now? (max 30 points)
   ___No pain with normal activity (30)
   ___Slight or occaisional pain, no compromise in activity (22)
   ___Moderate pain, slight effect on activity (14)
   ___Pain with serious limitations of activity (6)
   ___Pain with total limitation of activity (0)
6. How would you rate the appearance of your big toe and joint now? (max 5 points)
   ___Liked it very much (5)
   ___I mostly liked it (4)
   ___Not sure (neutral) (3)
   ___Mostly didn't like it (2)
   ___Dislike very much (0)
7. How frequently do you have pain while wearing shoes now? (max 15 points)
   ___Able to continuously wear any type of shoe (15)
   ___Able to wear any type of shoe most of the time (10)
   ___Able to wear only walking, athletic, or casual shoes (5)
   ___Able to wear only orthopedic, custom made, or special order shoe (0)
8. Do you limp from the pain now? (max 5 points)
   ___Yes (0)
   ___No (5)
9. Radiographic analysis (max 18 points)
   HA angle (6)
   ___31+ (0) ___21-30 (3) ___0-20 (6)
   ___-1 to -3 (2) ___ >-3 (0)
   IM angle (6)
   ___20+ (0) ___11-19 (3) ___0-10 (6) ___<0 (0)
   First metatarsal declination angle (6) (center of head/center of base)
   ___16-24 (6) ___25-29 (3) ___>29 (0)
   ___10-15 (3) ___<10 (0)
10. Function (max 27 total)
   Hallux purchase (paper pullout: easy, resistant, not moveable) (10)
   ___Not Moveable (10) ___Resistant (5) ___Easy (0)
   Range of Motion: 1st Ray (17)
   Dorsiflexion of 1st MPJ
   ___>60 (11) ___46-59 (8) ___36-45 (4) ___<36 (0)
   Plantarflexion of 1st MPJ
   ___>0 (4) ___<0 (0)
   IPJ extension
   ___extend to 0 (2) ___<0 (0)
11. Would you have this procedure again?
   ___Yes
   ___No
12. How would you rate your satisfaction with the procedure?
   ___Very Satisfied (would highly recommend)
   ___Satisfied (Would recommend)
   ___Dissatisfied (would not recommend)
   ___Very Dissatisfied (would definitely not recommend)
13. Would you recommend this procedure to a friend?
   ___Yes
   ___No

eminence is then resected flush with the neck of the first metatarsal utilizing an oscillating saw. The area is then lavaged and attention is directed to the first interspace. The dissection is carried deep into the first interspace through blunt and sharp dissection where the conjoined tendon of the adductor hallucis muscle is identified and incised. The fibular sesamoid is then mobilized from the plantar aspect of the first metatarsal freeing it from the lateral collateral and sesamoid ligaments. If the sesamoid cannot be freely mobilized, it is excised.

The proximal part of the procedure is addressed next. A transverse periosteal incision is made across the first metatarsal 0.5 centimeters distal to the metatarsal cuneiform joint and carried in a plantar direction 2-3 mm along the side of the base. The periosteal incision is then extended at a 45 degree angle to the transverse incision in a plantar distal direction toward midshaft. A freer elevator is next used to free up the periosteum from the area. A Kirschner-wire (K-wire) can now be used to angulate cuts and serve as an axis guide if driven medial to lateral 2-3 mm plantar to the dorsal cortex of the first metatarsal. A transverse dorsal to plantar osteotomy can next be made with an oscillating power saw extending 2-3 mm deep into the bone or to the K-wire. The distal dorsal osteotomy is then performed with apex medial and base 2 mm to 4 mm) lateral down to the corresponding 2-3 mm level. The amount of wedge needed to be resected can be measured preoperatively with a template. Thereupon a medial to lateral osteotomy made at approximately 45 degrees to the original 2 cuts; from distal plantar to proximal dorsal intersecting the apex or the laterally based dorsal wedge is completed. This cut frees up the entire dorsal aspect of the first metatarsal as well as the small triangular wedge.

Utilizing a bone clamp the osteotomy site is closed down and the metatarsal shaft is abducted to become flush with the proximal aspect of the wedge cut. Ideally this is attempted to transform the first metatarsal shaft nearly parallel to the second metatarsal shaft A 0.062 inch smooth K-wire is then driven 0.5 cm from the most proximal dorsal aspect of the distal metatarsal osteotomy across the plantar shelf to aid in stabilization of the osteotomy. A 0.045 inch smooth K-wire is next driven from dorsal to plantar medial across the osteotomy to create a temporary 3-point fixation design. The bone clamp can then be removed and a drill hole is made from dorsal to plantar medial across the plantar shelf. This is then overdrilled, countersunk, measured, and tapped and can now be fixed utilizing a 2.7 mm or 3.5 mm cortical screw depending upon measurements. The 2.7 mm cortical screw from Synthes can only reach a maximum distance of 24 mm and the first metatarsal base can range in width from 22 to 28 mm in a dorsal to plantar direction. This is checked with flouroscopy for appropriate fixation purchase and the bone clamp is reapplied. The 0.062 inch K-wire can next be removed for second screw application proximally in a dorsal to plantar direction. Again using AO technique the osteotomy can be traversed using a 3.5 mm or 4.0 mm screw depending upon measurement. The osteotomy is checked with fluoroscopy for stability following dorsiflexion and plantarflexion of the first metatarsal phalangeal joint (Figures 3-10).

After capsular closure, final images are taken and the surgical site is closed in anatomic layers using surgeon's suture of choice. The area is last injected with 0.5% marcaine plain for postoperative analgesia and is dressed with a nonadherent and dry sterile dressings followed by application of a nonweightbearing below-knee cast.

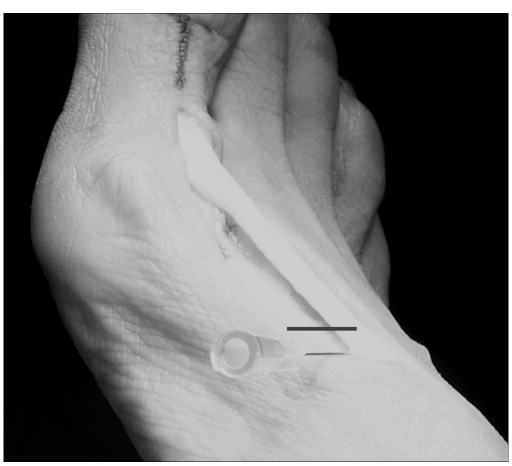

Figure 3. After extended bunion dissection, locate MC joint and measure out 1.0 cm.

Figure 4. Make dorsal cuts in a v shape pattern to correct deformity as measured from templates one third of the way through the shaft from dorsal to plantar.

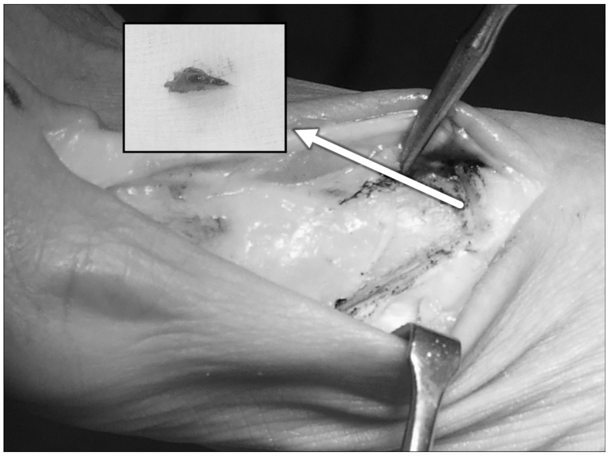

Figure 5. Remove wedge of bone and correct both through rotation closure of wedge osteotomy and translation of shaft over plantar shelf.

Figure 6. Make plantar cut at 45 degree angle to wedge to create a shelf.

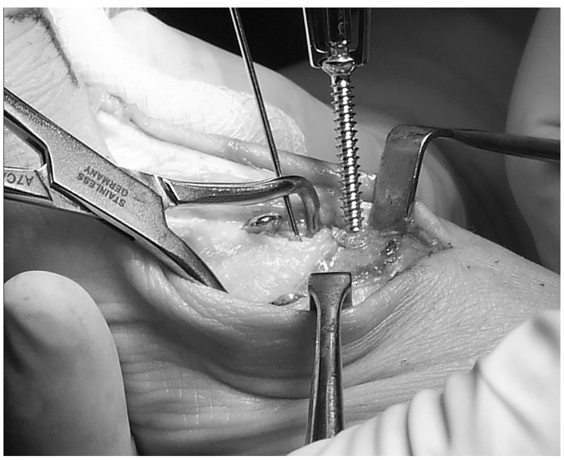

Figure 7. Hold with temporary fixation and insert screws (2.7 or 3.5 depending upon depth measurements) in AO lag technique.

Figure 8. The DP view of fixation and correction with resultant medial shelf overhang. This is followed by rasping any sharp edges smooth and closure by surgeon's choice.

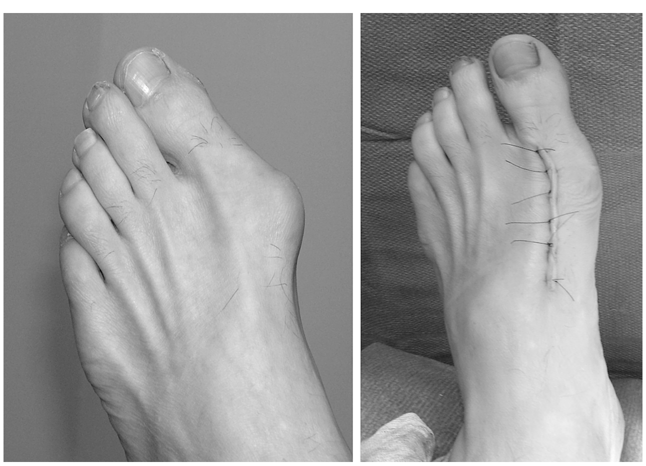

Figure 9. Pre and postoperative clinical pictures for wedge shelf osteotomy.

Figure 10. Pre and postoperative radiographs for the wedge shelf osteotomy.

The patient postoperatively is to remain nonweightbearing and will follow up routinely at 2 week intervals for postoperative checks and radiographs to monitor healing of the osteotomy. This typically extends from 6-7 weeks of nonweightbearing in a below-knee cast followed by transition to weightbearing in a surgical shoe and eventually to shoe gear with functional orthotic.

RESULTS

Radiographic

Radiographic evaluation was conducted with weight bearing preoperative and postoperative radiographs. The postoperative films utilized were obtained from the patient's last visit after the surgery in which the patient was full weightbearing. The average postoperative time was 2.5 years. Radiographs that were nonweightbearing were not included in the measurements. The hallux abductus angle, intermetatarsal angle, true intermetatarsal angle, sesamoid position, and first metatarsal protrusion distance were all measured on the dorsal-plantar radiographs. The first metatarsal declination angle, and Seiberg's index were all measured on the lateral films.

The hallux abductus angle (HAA) decreased significantly from preoperative to postoperative films. The average preoperative value of the HAA was 31.7 degrees ranging from 18 to 42 degrees. This was decreased to an average of 11.6 degrees ranging from -1 to 24 degrees. This was calculated to be an average reduction of hallux abductus of 20.1 degrees.

The intermetatarsal (IMA) and true intermetatarsal angle (TIMA) also decreased a considerable amount from preoperative to postoperative films. Preoperative IMA was on average 17.3 degrees and ranged from 15 to 20 degrees. This was corrected to a postoperative measurement averaging 7.6 degrees and ranging from 4 to 13 degrees. This was an average reduction of the IMA of 9.7 degrees. The TIMA was reduced similarly. This measurement took into account any metatarsus adductus deformity that may contribute to a larger than visualized IMA. The TIMA had a preoperative average of 18.6 degrees ranging from 15 to 23 degrees. This was reduced to a postoperative average of 8.9 degrees ranging from 4 to 14 degrees. This was an overall average reduction of 9.7 degrees of TIMA value.

The tibial sesamoid position ranged from 5 to 7 preoperatively and was on average rated at 6.5, which locates it fairly lateral to the bisection of the first metatarsal. Postoperative radiographs measured the tibial sesmoid postion as an average of 2.6 ranging from 1-5.

Although there is not a very accurate means of measuring metatarsal length on radiograph, on average the metatarsal protrusion distance of the first metatarsal shortened by an average of 2 mm from preoperative measurement to postoperative values.

First metatarsal declination angle was measured on weight bearing lateral radiographs to monitor for any elevation that this procedure may have caused. The declination angle changed from an average of 19.15 degrees preoperatively to an average of 19.45 degrees postoperatively. This was an average increase in metatarsal declination/plantarflexion of the first metatarsal of 0.3 degrees. The values ranged from 12 to 30 degrees and from 12 to 27 degrees respectively.

Using the Seiberg Index (SI), some radiographic positioning issues may be avoided when measuring for first ray elevation when compared with the first metatarsal declination angle measurement. The average SI score for preoperative radiographs was an elevation of the first metatarsal of 0.2 points/mm ranging from 1 mm elevated to 2 mm declinated with respect to the shaft of the second metatarsal. This was barely changed on average postoperatively resulting in a SI score of 0.25 points/mm elevated. The range postoperative was between 1 mm elevated and 1 mm declinated. This resulted in an overall change of 0.05 points/mm elevated postoperative.

Clinical/Subjective

A questionnaire was dispensed to all postoperative patients that asked them to rate their preoperative and postoperative feelings about their bunion deformity with respect to pain and symptoms. This was based upon the modified ACFAS first ray scoring system. In the questionnaire patients were asked to rate their pain, appearance, limitations, and satisfaction with the procedure. Postoperative questionnaire follow-up ranged up to 5 years postoperatively and averaged 2.5 years following their procedure.

When asked about pain on a numerical scale ranging from 0 to 10, 10 rating as the worst pain imaginable and 0 representing no pain at all, patients rated their preoperative pain as an average of 7.1 ranging from 2 to 10. When re-queried about their pain postoperatively, patients rated their pain as an average of 1.2 ranging from 0 to 5 out of 10 after they had their procedure. This shows an overall improvement in average pain following this corrective procedure to a level that might be tolerable compared with preoperative levels.

Patients were asked to rate how their pain affected their daily activities, given 5 choices that corresponded to numerical values on the questionnaire. Thirty points were assigned to answers that read no pain with normal activity. Twenty-two points were given to answers that corresponded to slight or occasional pain, no compromise in activity. Fourteen points were given to answers that were moderate pain with slight effect on activity. Six points were scored for answers of pain with serious limitation of activity, and zero points were given for pain with total limitation of activity. On average, after calculation, patients claimed that preoperatively their pain was a score of 11.3 out of a possible 30 points. This value most closely corresponded to an average answer of moderate pain that slightly affected activities of daily living. This score when calculated for postoperative answers improved to 23.1/30, which corresponded to occasional or mild pain that resulted in no compromises to daily activities. This showed an improvement that corresponds to the improvement in average numerical pain values that patients chose on the previous rating scale.

Patients were also asked to rate the appearance of their big toe and joint prior to and following surgery. These scores were out of a possible 5 points, numerical values corresponding to 5 different answers. Five points were awarded for liked it very much, 4 for mostly liked it, 3 for not sure, 2 for mostly didn't like it, and 0 for disliked it very much. The average preoperative score after conversion from verbal to numerical values was 0.93/5, which most closely corresponded to disliked it very much. Answers ranged from 0 to 2. Postoperatively, patients numerical score was changed to 4.4/5, which most closely represented mostly liked it. These scores ranged from 2 to 5. This shows an overall improvement in satisfaction of appearance of the great toe following surgical correction.

Patients were also asked about functional limitations in shoe gear. This was based on a 4-answer tiered system that was out of a maximal 15 points. Fifteen was assigned to an answer of able to continuously wear any type of shoe, 10 points were given to answers that matched to able to wear any type of shoe most of the time, 5 points for able to wear only walking, athletic, or casual shoes, and 0 points were allotted for answers of able to wear only orthopedic, custom made, or special order shoes. Preoperatively patients scored an average of 6/15 that most closely represented ability to only wear athletic, walking, or casual shoes due to deformity. This improved post-operatively to an average score of 10.3 that was closest to able to wear any type of shoe most of the time.

When asked if pain caused patients to limp pre or postoperatively, 6 limped from pain and 5 did not preoperatively. This improved as well postoperatively, resulting in 1 patient limping from pain and 10 not limping.

Dorsiflexion and plantarflexion were measured pre and postoperatively. This did not change much on average between the 2 time periods. The average preoperative clinical measurement of dorsiflexion was 51.45 degrees. This increased slightly to an average 53.05 degrees. Plantarflexion for all patients pre and post-operatively was greater than 0 degrees. Some original measurements were less, but improved with increased time postoperatively, which can be attributed to stretching and passive range of motion exercises.

Patients were also questioned concerning their overall opinion of the surgical procedure and the results. These responses included very satisfied, satisfied, not satisfied, and very dissatisfied. Five patients were very satisfied, 5 were just satisfied, 1 was dissatisfied, and no patients polled were very dissatisfied. Ten patients would have the surgery again and would recommend the procedure to a friend and one would not do either.

These values were all taken into consideration to compose a comprehensive total score that when added with radiologic correction becomes the modified ACFAS first MPJ score. Preoperative average value for the modified ACFAS score was 40.13 out of a possible 100 points for maximum score. This was significantly improved to an average postoperative score of 82.7 points out of 100.

LITERATURE REVIEW/ DISCUSSION

A variety of surgical procedures for correction of high intermetatarsal angle bunion deformities have been proposed over the past 100 years.[1] Each procedure has its own distinct profile of advantages as well as disadvantages. It is important to thus realize that there is no one perfect procedure for one deformity. It has been shown that there has been greater patient dissatisfaction with distal metaphyseal osteotomy when compared with basilar or more proximal procedures for correction of larger deformities.[7-9]

The pure transverse closing abductory wedge osteotomy was first described by Loison in 1901[10] and performed by Balacescu in 1903.[11] This procedure lent itself to good correction of large intermetatarsal angle bunion deformities with a proximal point of reference, but fell short when it came to elevation, shortening, and most importantly fixation technique. Rigid fixation is required for this osteotomy, but its design does not inherently lend itself to screw application.[1-3]

In 1918, Ludloff described another through-and-through osteotomy in the first metatarsal diaphysis from proximal-dorsal to distal-plantar.[18] This osteotomy, like its similar but reverse cut, the Mao, described in 1926[17] allows great bone to bone contact, shifting and rotational correction, but is a diaphyseal cut that can often have poorer healing and necessitates screw fixation.[3] It has been shown that diaphyseal cuts/fractures of long bones heal poorly in comparison with ones that occur in the metaphysis of similar bones.

Modification of the closing wedge osteotomy was first made by Juvara in 1919 and then further altered in 1932.[12-14] This modification altered the osteotomy into 2 long oblique cuts that extend out into the metaphyseal/diaphyseal junction. Due to the length of the oblique cuts this transformed osteotomy lends itself to more stable forms of fixation. In 1977 Zlotoff commented on the shortening resulting from this correction.[28] Haendel and Lindholm,[29] Schuberth,[30] and Banks[31] all attributed transfer pressure and lesions associated with this correction to elevation of the first metatarsal due to early weight bearing rather than the earlier believed shortening phenomenon. Screw fixation was also scrutinized in 1983 by Denton and Kuwada[32] whose article addressed the need for screw fixation, proper screw orientation across the osteotomy, as well and nonweightbearing to improve the integrity of the cuts. In attempts to prevent iatrogenically induced elevatus, cut angles were next examined by Palladino to address whether cuts should be made with respect to the shaft or the weightbearing surface to prevent this elevation.[33] This surgical approach to correction of a large IM angle bunion deformity, while sound is found to be technically challenging due to the importance of maintaining a medial hinge for stability. The hinge can cause problems if it is too thick, which prevents bony apposition medially, and if it is too thin, cracking and losing a point of fixation for stability.[1,3,4] The screws also need to be applied at an oblique angle to the shaft of the metatarsal and have to be applied from the side, so if the hinge were to break with only one screw in place, an elevatus deformity would most likely occur.

Lapidus felt that the deformity needed to be addressed at its apex, which he believed to be the instability at the metatarsal cuneiform joint. In 1934 he described his fusion of this joint in its corrected position to relieve bunion pain and large metatarsus primus adductus deformity.[34,35] This procedure works well for feet with an unstable first MC joint, but according to Mann et al this is infrequent and fusion can many times lead to pseudoarthrosis, and loss of foot flexibility, as well as nonunion and complications from malposition.[6]

The proximal chevron osteotomy, which is a reverse cut "V" with apex proximally directed, was first described in 1929 by Kotsenburg[36] and then later experimented with by Sammarco.[37] This procedure gained an orthopedic following in the 1990s. While this is an inherently stable osteotomy, the arms are often too short for solid compressive oblique screw fixation, and its proximal location results in more of a lever arm than the distal Austin style osteotomy. There is a high potential for dorsal arm fracture with this surgical procedure.[1-3]

The Scarf osteotomy is a diaphyseal shaft osteotomy that is inherently stable due to its "Z" shaped configuration. It was first performed by Gudas[16] and later modified by Chang to reverse the direction of the distal and proximal arms in 1992.[38] This provides a solid diaphyseal bone fusion, and is often limited to an IM angle of 18 degrees. Complications with correcting a large IM angle risk a troughing phenomenon.

The crescentic osteotomy, originally described by Mann in 1981[19,20] faces the same problems with fixation as the original Loison transverse wedge since it is a through-and-through osteotomy. There was no means of fixation that could achieve a properly placed screw for optimal compression across a curved cut.[1-3] The surgery does provide a good correction of the IM angle and following its modification which added a plantar shelf for better compressive screw fixation, it emerged as one of the procedures of choice in certain circles.[3] The osteotomy provides correction with minimal shortening, but due to its arcuate cut has no stable stopping point in a transverse plane.[16]

In 1994 Jimenez[21] described an osteotomy that was a proximal cut that combined the plantar shelf of the crescentic shelf osteotomy for better stability and fixation, the basics of correction from the closing base wedge, and the bone to bone contact of a diaphyseal osteotomy in the metaphyseal region. This procedure has not yet been analyzed in detail throughout the literature.

CONCLUSION

This study shows results that are favorable with respect to the wedge shelf osteotomy for successful correction of large IM angle bunion deformity and ease of doral screw fixation. An overall improvement in radiographic values and clinical scores was witnessed from these patients when comparing preoperative and postoperative responses.

There are several limitations to this study. It is a retrospective analysis and may not accurately represent some of the original opinions of patients both before and at the time of surgery. It asks the patient to recall feelings that may be up to five years in the past. Preoperatively, some details of the biomechanical exam that may aid in evaluation of clinical improvement were omitted. A prospective randomized trial would have a stronger validity to rate the performance of this osteotomy.

As discussed earlier, there is no great measurement of metatarsal length that has been documented in the literature; therefore it is hard to evaluate the exact amount of shortening that may be experienced with this procedure versus radiographic angle alterations.

The average time to followup was 2.5 years decreasing the strength of this study to measure long term success of the procedure. A study based upon five year followup would improve our knowledge of long term outcome.

When critically analyzed on these select patients the wedge shelf osteotomy was shown to improve radiographic results of IM angle, hallux abductus angle and tibial sesmoid position while not significantly altering first metatarsal elevation as shown by metatarsal declination angle and SI. Clinically, the procedure showed a promising improvement in reported pain level, activity level, and functional status of the foot. Almost all of the patients that responded would undergo the procedure again and would recommend the procedure to a friend. This procedure allows for good bone to bone contact in the metaphyseal region, adequate bone to bone contact in the diaphyseal region, allows for easy dorsal screw application for stability and compression, and can correct deformity closer to its apex. All procedures are however not without their complications.

Two patients developed a hallux varus following their original procedure on the first metatarsal. This was most likely a complication of overcorrection as both had markedly low IM angles postoperatively. Only one of these patients was dissatisfied with their results due to a more drastic varus deformity and a transfer lesion that developed under the middle toe. She claimed to be in the same amount of pain postoperatively that she was in preoperatively, and would not undergo the procedure again. She also never consulted with the surgeon, JMF, about the postoperative pain or toe position. The other varus was asymptomatic and mild, resulting in no other transfer lesions. This patient along with the other questionnaire responders was satisfied and would have the procedure again. A shortening of the first metatarsal averaging 2 mm was measured which corresponds to shortening witnessed with many other base procedures. One patient had a postoperative period DVT. Although the nature of the cause for this was directly undetermined, it may be a result of postoperative casting with a resultant associated decrease in activity and limitation of motion in the leg.

Based on the results obtained from this small study, the wedge shelf osteotomy can be utilized as another way of addressing a larger bunion deformity with IM angles as large as 20 degrees and HAA up to 38 degrees. For desired correction, the surgeon can both rotate the metatarsal shaft to decrease the intermetatarsal angle, as well as slide the metatarsal shaft over laterally to aid with correction of wider forefoot deformities. The advantages of this procedure include ability to correct in more than one plane by ability to use different axis guide orientation, good bone to bone contact, and ease of fixation with two screws in an easily visualized area from dorsal to plantar to promote primary bone healing.

It is essential to realize that there is no one perfect procedure for one biomechanical or skeletal abnormality. The surgeon must weigh their options for correction based upon their own past results and circumstances surrounding the surgery that affect the patient including age, degree of deformity, previous attempts at surgical correction, radiographic analysis, and compliance. Overall, this study shows that the wedge shelf osteotomy should be considered as a viable corrective option for large IM angle hallux valgus deformities and might be another tool in the surgeon's armamentarium to address this common problem.

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