CHAPTER **5**

OPENING BASE WEDGE OSTEOTOMY OF THE FIRST METATARSAL: A Revitalized Procedure

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INTRODUCTION

Correction of the more severe hallux valgus and metatarsus primus adductus deformities has always been a challenge. In many cases, the deformity is addressed at the metatarsophalangeal joint with McBride type joint repair combined with proximal osteotomy or even arthrodesis. However, most foot surgeons would agree that proximal osteotomies are technically difficult to perform and are plagued by relatively high complication rates. Arthrodesis of the first metatarsocunieform joint works well in some situations but can significantly shorten the first ray resulting in problems with metatarsalgia. In cases involving a relatively short to normal length first metatarsal in combination with a large inter-metatarsal angle any additional shortening due to an osteotomy or arthrodesis can be a very significant problem. Osteotomies of the metatarsal have been thought to "always" cause some degree of shortening of the first metatarsal relative to the lesser metatarsals. In this scenario, the opening base wedge is a very valuable procedure because it lengthens the first metatarsal relative to the lesser metatarsals. The disadvantages of the procedure are that it requires bone grafting and fixation can be difficult. However, new innovations and concepts with regards to this procedure may soon bring it back to the mainstream of foot and ankle surgery. The basic geometric and anatomic factors that make the opening base wedge preferred over the closing wedge procedure in some clinical situations will be discussed. The surgical technique and use of specialized fixation will also be addressed.

REVIEW OF THE LITERATURE

The literature related to opening wedge osteotomy for hallux valgus repair is relatively meager. Most early authors that advocated the procedure report it as simple and effective with few complications. One interesting conclusion was made by Limbird et al stating, "the opening wedge proximal osteotomy is an excellent alternative to the more demanding, and frequently less reliable, distal osteotomies.[1]" Trethowan first described the procedure in 1923 utilizing the medial eminence of the first metatarsal head as the graft.[2] Longroscino combined Trethowan's technique with a distal metaphyseal osteotomy to correct the proximal articular set angle.[3] Bonnie and McNab attempted to fixate the osteotomy by screwing the distal first metatarsal to the second metatarsal.[4] Later, Stamm, finding that the medial eminence is often poor quality bone proposed a combination procedure using the base of the first proximal phalanx as the graft after performing a Keller resection bunionectomy.[5] None of the very early authors found that internal fixation was necessary to stabilize the transverse osteotomy. More recently, Armaneck et al reported their experience with transverse opening base wedge and advocated using a mini-external fixator to stabilize the osteotomy.[6] In 1981, Youngswick described staple fixation to hold open a transversely oriented osteotomy to allow insertion of the bone graft.[7] Sollitto et al combined an unfixated transverse opening wedge osteotomy with total silicone implant arthroplasty.[8]

GEOMETRY 101

Shortening of the first metatarsal following osteotomy has received a fair amount of consideration in foot surgery texts and journals. Mann used the shortening of the first metatarsal by the closing base wedge as the main reason to advocate cresentic osteotomies.[9] Interestingly, all pre and postoperative x-rays shown as examples had markedly shortened first metatarsals following the cresentic procedure. Banks et al showed that the first metatarsal shortens only slightly in overall length following closing base wedge osteotomy.[10] Prior to this, somewhat erroneous conclusions about significant shortening caused by closing base wedge

were made based on x-ray measurements. Elevation of the first metatarsal, usually caused by early return to weightbearing, was felt to be the cause of this artifact on AP films that appeared as significant shortening of the first metatarsal. However, relative length of the first metatarsal to the lesser metatarsals was not addressed. It is this author's judgment, that relative length is the important factor when discussing outcomes in this matter.

It should be noted that in many cases shortening might be a desirable effect. Mancuso et al studied the effect of first metatarsal length in hallux valgus in the etiology of hallux valgus. They found that 77% of patients with hallux valgus had first metatarsals equal in length or longer than the 2nd metatarsal versus only 28% in a normal foot population.[11] This author does not suggest that opening wedge osteotomy replace the closing wedge or Lapidus procedure in patients with relatively long first metatarsals.

Most authors do not explain how or why the opening wedge procedure lengthens the metatarsal. In most discussions, the simple fact that the surgeon is adding a bone wedge rather than removing one appears the assumption for the resultant lengthening or shortening. However, the true reason the opening base wedge procedure "lengthens" the metatarsal and, for that matter, the reason the closing wedge "shortens" it has little to do with the addition or extraction of the wedge.

The reason the opening wedge procedure lengthens the first metatarsal relative to the second metatarsal is rather simple geometry. Figures 1 and 2 explain how the first metatarsal lengthens or shortens relative to the lesser metatarsals. These figures show that the location of the axis of rotation is the main factor in relative lengthening or shortening of the first metatarsal. Figure 1 depicts a more medial axis or hinge resulting in relative shortening as the metatarsal starts its circular rotation about the axis. In figure 2, moving the axis of rotation more lateral results in a moment of relative lengthening of the first metatarsal compared with the second metatarsal.

In either the opening or the closing wedge, the greater the angular correction the more lengthening or shortening that will occur relative to the lesser metatarsals. This occurs regardless of the orientation of the osteotomy i.e. oblique or transverse. However, an oblique wedge procedure requires a

Figure 1. This illustrates why a closing base wedge osteotomy causes relative shortening of the first metatarsal. The blue lines represent a traditional oblique closing base wedge osteotomy. The red line is the radius of the circle that the first metatarsal will pass around when the bone wedge is removed and the osteotomy is rotated through the arc dictated by the chosen axis. Note that the first metatarsal almost immediately begins to shorten relative to the lesser metatarsals.

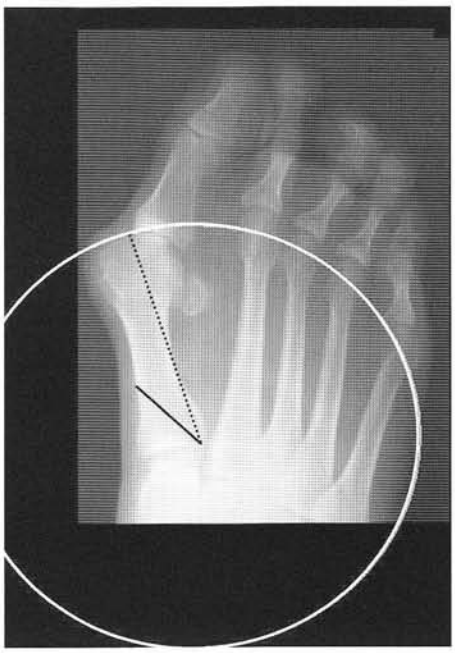

Figure 2. Conversely, this figure explains how the opening base wedge osteotomy will actually lengthen the first metatarsal relative to the 2nd metatarsal. The blue line represents an oblique opening wedge osteotomy of the first metatarsal. Again, the red line represents the radius of the circle that the first metatarsal will rotate around as the osteotomy is opened. Note that moving the metatarsal about the more laterally located hinge results in almost immediate lengthening of the first metatarsal relative to the lesser metatarsals

larger wedge than a transversely oriented osteotomy to effect the same amount of correction. (Figure 3A & 3B).

ADVANTAGES AND DISADVANTAGES

The advantage of the proximally executed first metatarsal osteotomy is that it allows for greater correction of the intermetatarsal angle. However, the oblique closing wedge has a unique problem with large intermetatarsal angles. The metatarsal can be significantly narrowed when large wedges are removed. This is exacerbated in already narrow metatarsals to the point of precluding the use of this procedure. The opening wedge procedure does not have this disadvantage.

The location of the hinge axis for an oblique opening wedge osteotomy has several advantages over the oblique closing base wedge and the transverse opening wedge for that matter. Since hinge failure is one of the most common complications of proximal wedge osteotomies this is very significant.

In either the opening or closing osteotomy the hinge can be oriented to plantarflex the first metatarsal as it is rotated laterally. However, in the closing base wedge this necessitates the hinge being located more dorsally on the first metatarsal where few soft tissue attachments exist to lend support to the hinge. In the oblique opening base wedge procedure the hinge is placed proximal plantar and lateral to induce plantarflexion. The plantar lateral aspect of the first metatarsal base has strong ligamentous structures combined with the insertion of the peroneus longus tendon adding stability to the hinge in the event of fracture.

Another advantage of the oblique opening base wedge has over the closing base wedge is the ease of the fixation. By design, the closing wedge procedure creates a large medial fragment and a small lateral fragment. Screw fixation must converge into the small fragment significantly limiting the surgeon's angular choices and often requires rather close proximity of the screw heads. In the oblique opening wedge procedure the smaller fragment is medial and the larger fragment lateral allowing significantly more angular choices of screw path and even divergence of the screws as they cross the osteotomy.

The most obvious disadvantage of the opening wedge procedure is that it requires bone grafting of some sort to obtain angular correction. This creates the need for an additional procedure for harvesting the graft or necessitates the use of allogenic graft. The patient's own calcaneus is a good source of graft for this procedure and probably is the best choice for this procedure since delayed or non-union is a chief concern.

In the past, the bone graft had to be configured fairly exact to obtain the desired amount of correction. New plate systems that maintain the desired opening have allowed less precise wedge grafting and even packing with small fragments of autogenous or allogenic graft. An opening wedge

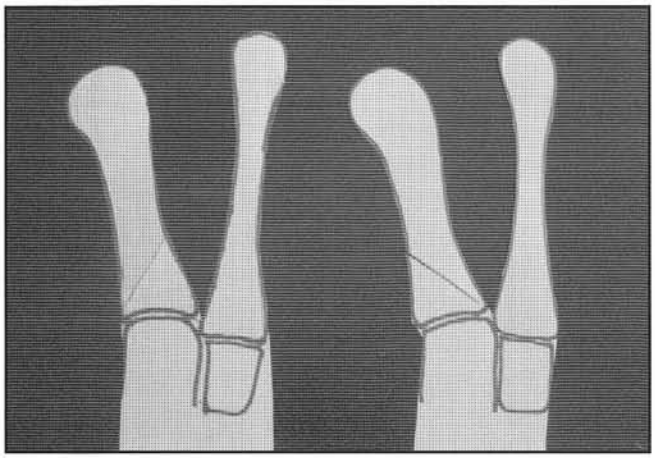

Figure 3A These paper models are a graphic illustration of the differences in the oblique base wedge procedures. The figure on the left represents the closing base wedge with a medial apex. The figure on the right represents an opening base wedge with a lateral apex.

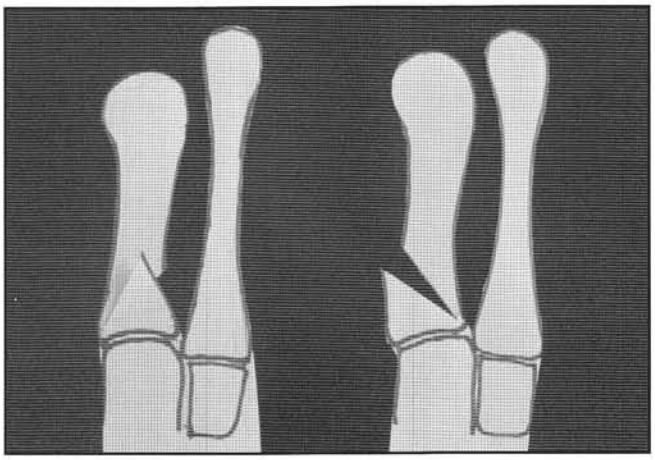

Figure 3B. Even to the naked eye the differences in the relative length of the first metatarsal segment versus the 2nd metatarsal are readily evident. The opening base wedge procedure causes a visible relative lengthening of the first metatarsal while some shortening occurs with regards to the 2nd metatarsal with the closing base wedge.

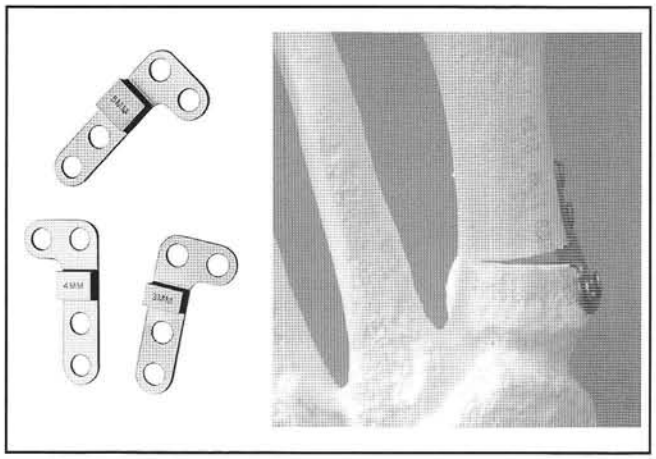

Figure 4. The opening wedge plate from Arthrex employs a block to maintain the opening while allowing the placement of bone graft within the wedge. Various size blocks in 1mm increments are available to maintain different size openings.

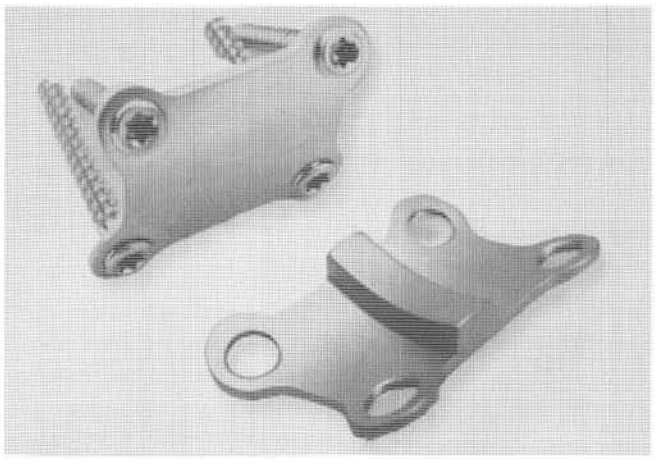

Figure 5. The Darco BOW (Burgards Opening Wedge) plate. This method utilizes a more substantial plate with locking screws for added stability.

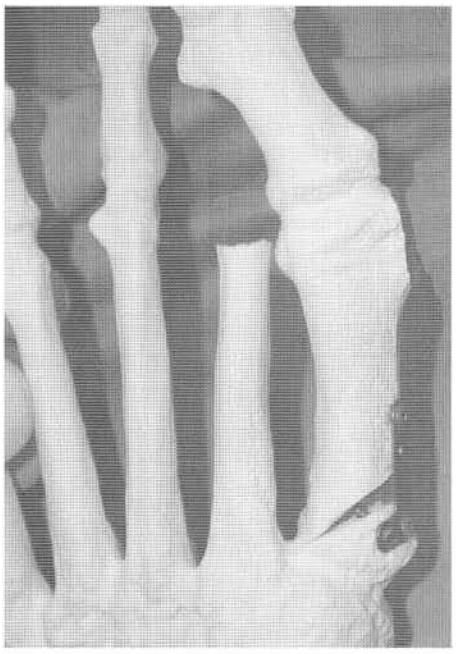

Figure 6. This depicts the Arthrex opening wedge plate utilized in an oblique base wedge. Note that performing the procedure obliquely allows interfragmental screw fixation.

plate has been developed by Arthrex and by Darco. Both plate systems make use of a block to maintain the wedged opening and allow packing with bone graft (Figures 4 and 5).

TRANSVERSE VS. OBLIQUE

Finally, the orientation of the osteotomy is important to discuss at this point. The opening wedge plates described above have sought to alleviate the difficulty in fixating a transversely oriented osteotomy. This plate has a buttress incorporated into the plate that holds open the osteotomy allowing better stabilization and less exact graft sizing since the plate itself maintains the wedge opening. Currently the plate is described for use with a transverse osteotomy of the first metatarsal base for metatarsus primus adductus correction. However, its use in oblique base wedge also appears promising (Figure 6).

Performing the opening base wedge procedure transversely rather than oblique results in the loss of the stability of the hinge since there are no significant soft tissue structure attached to the lateral cortex of the first metatarsal base. Also, if the hinge fractures with a transverse osteotomy the interposed wedge graft would tend to distract the osteotomy. Bending the plate may help in this situation but the final result will likely be compromised. It may seem paradoxical that a transverse wedge is less stable than an oblique wedge. However, this premise is actually more relevant to the closing wedge procedure.

CASE PRESENTATION

The patient was a 47-year-old male with severe hallux valgus combined with a relatively short first metatarsal segment. His chief complaint was pain in the ball of the foot after prolonged standing or walking. Figure 7 shows the preoperative appearance of the foot. Hammertoe deformities combined with the short first metatarsal contributed to this patient's metatarsalgia.

Figure 7A. Preoperative radiograph depicts this complicated scenario very well. The patient's chief complaint is actually metatarsalgia beneath the second and third metatarsophalangeal joints. The relatively short first metatarsal combined with a large intermetatarsal angle obviates the need for a base procedure that does not cause additional shortening of the first metatarsal.

CONCLUSION

The opening base wedge osteotomy of the first metatarsal fills a need in the spectrum of clinical presentations of hallux valgus and metatarsus primus adductus. The procedure's niche is for those patients that have a short first metatarsal combined with a larger intermetatarsal angle. It may also be useful in patient undergoing joint replacement or double osteotomy of the first metatarsal. New fixations methods have made this procedure more reliable and less difficult.

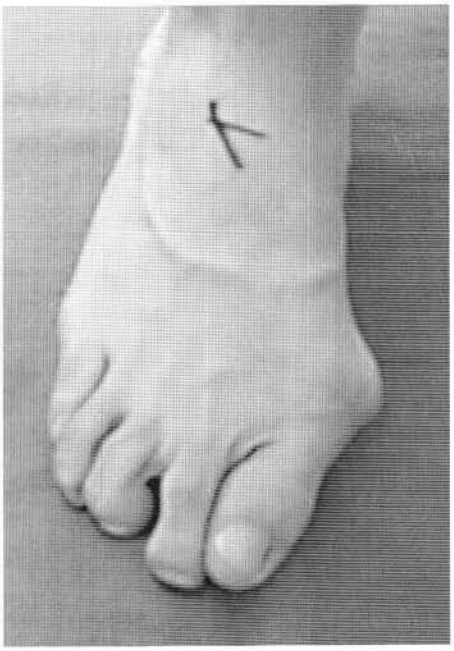

Figure 7B. Preoperative appearance includes digital contractures combined with severe metatarsus primus adductus and hallux valgus.

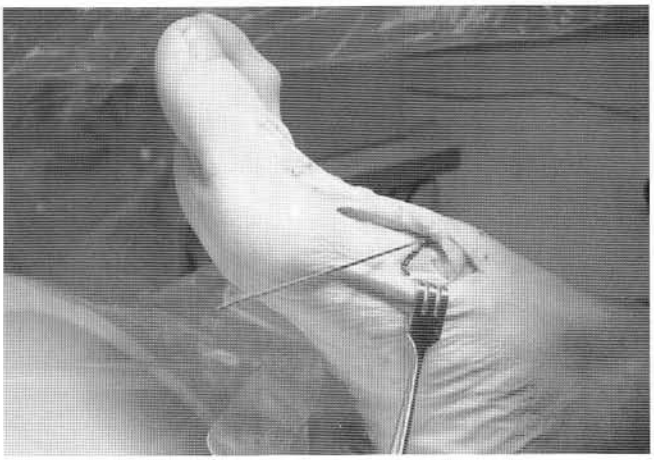

Figure 7C. This depicts the use of intra-operative radiographs and a free k-wire to determine the proper angle of the osteotomy

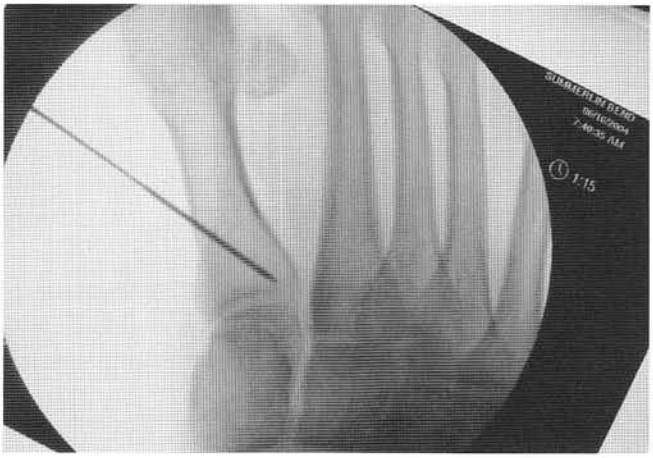

Figure 7D. Intra-operative x-ray is used to aid in the osteotomy alignment. The apex of the opening wedge should be distal to the joint and within the plantar-lateral tubercle that serves as the attachment of the peroneus longus tendon.

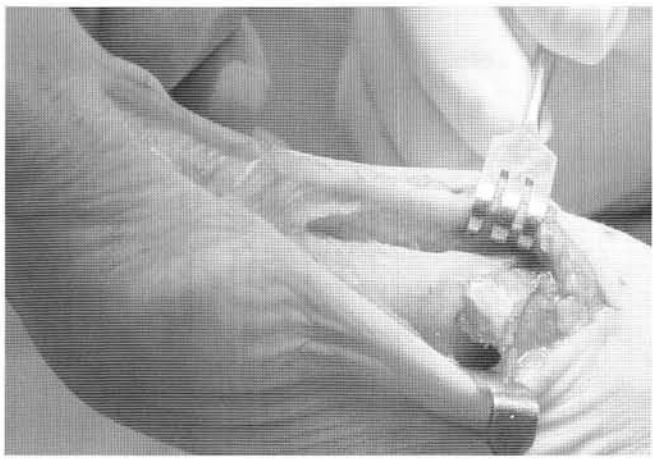

Figure 7E. The bone graft harvested from the lateral calcaneal tuber is shown in place.

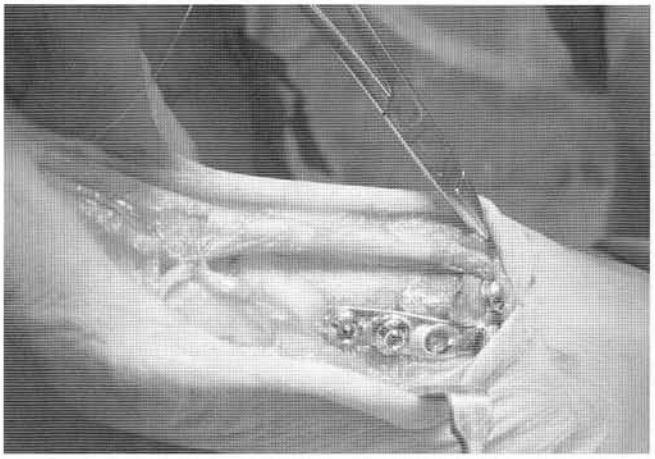

Figure 7F. A simple Synthesis small "L" plate has been applied as fixation.

Figure 7G. Postoperative x-ray following completion of the opening wedge osteotomy with plate fixation.

Figure 7H. This figure is a computer generated representation of the shortening of the first metatarsal that would have occurred if a closing wedge osteotomy had been performed on the same patient.

REFERENCES

1. Limbird TJ, DaSilva RM, Green NE: Osteotomy of the first metatarsal base for metatarsus primus varus. *Foot Ankle* 1989;9:158-62.
2. Trethowan J. Hallux Valgus. In Choyce CC, ed. *A System of Surgery* New York; 1046-1049, 1023.
3. Longroscino D. Il trattamento chirurgico dell' aluce valgo. *Chir Organ Mov* 1948;32:81-96.
4. Bonney G, McNab L. Hallux valgus and hallux limitus; a critical survey of operative results. *J Bone Joint Surg* 1952;34:366-85.
5. Stamm T. The surgical treatment of hallux valgus. *Guy's Hosp Rep* 1957;106:273-9, 1957.
6. Amarnek DL, Juda EJ, Oloff IM, Jacobs AM. Opening base wedge osteotomy of the first metatarsal utilizing rigid external fixation. *J Foot Surg* 1986;25:321-3.
7. Youngswick FD. Opening abductory wedge osteotomy of the first metatarsal base, Chapter 13. In *Textbook of Bunion Surgery* ed. J Gerbert pp. 251-264 Futura New York, 1981
8. Sollitto RJ, Hart TJ, Sergi AR. Opening base wedge osteotomy with first metatarsophalangeal joint implantation arthroplasty-A retrospective study. *J Foot Surg* 1991;30:165-72.
9. Mann RA. Distal soft tissue procedure and proximal osteotomy for correction of Hallux Valgus deformity. *Orthopedics* 1990; 13(9) 1013-1018.
10. Banks A, Cargill R, Carter S, Ruch J. Shortening of the first metatarsal following closing base wedge osteotomy. *J Am Podiatr Med Assoc* 1997;87:199-208.
11. Manusco JE, Landsman MJ, Carioscia M. The Zero-Plus first metatarsal and its relationship to bunion deformity. *J Foot Ankle Surg* 2003;42:319-26.