DOUBLE OSTEOTOMIES OF THE FIRST METATARSAL

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In 1948, Logroscino[1] described a double osteotomy of the first metatarsal for hallux valgus repair. He described the procedure with two components: (1) either an opening or closing wedge osteotomy at the base of the first metatarsal, and (2) Reverdin-type osteotomy at the head of the first metatarsal. He also discussed the alternative of using the wedge from the Reverdin for the opening wedge osteotomy at the base of the first metatarsal. It appears from the literature that the Logroscino procedure did not quickly catch on, perhaps because of the technical complexities of the procedures being performed at that time.

Kelikian stated that "we fail to see the advantage of these double osteotomies. They create unnecessary problems of maintenance of position and prolong the convalescence to say nothing of the added surgical trauma."[2] Nonetheless, as the base osteotomy gained popularity within the profession, double osteotomies became more frequently performed. Sometimes these were performed in the classic Logroscino fashion with a closing base wedge osteotomy and a Reverdin-type osteotomy. Other times they were performed with a closing base wedge osteotomy and Akin osteotomy, not a true Logroscino.

As problems began to develop in patients who had base wedge osteotomies, the Logroscino gradually fell out of favor. The incidence of lateral metatarsalgia associated with base wedge osteotomies was significant enough that many surgeons began to abandon the base wedge osteotomy in favor of the more stable capital osteotomies. The amount of shortening with a double osteotomy was also a concern. The focus of this paper is to discuss the theoretical and technical considerations when performing two osteotomies in the first metatarsal.

INDICATIONS

Hallux Valgus

The indications for double osteotomies are primarily hallux valgus and hallux limitus. With respect to hallux valgus, double osteotomies are most commonly performed in adolescent hallux valgus and in hallux valgus with metatarsus adductus (Figs. 1A-1C). The need for a double osteotomy in juvenile and adolescent hallux valgus is necessitated by significant deforming forces which cause a relatively high intermetatarsal angle, and the development of a high proximal articular set angle during growth of the foot. In addition to heredity, the most common causes of juvenile hallux valgus are metatarsus adductus and hypermobile flatfoot.[3] In both of these situations, correction of the intermetatarsal angle down to approximately zero is important. When metatarsus adductus is present, there is an even greater likelihood that there will be a deviation of the proximal articular set angle.[4,5] Correcting both of these deformities through one head osteotomy is sometimes possible, but usually ends up compromising the complete correction. As an example, a translocation distal L-type bunionectomy can correct for a proximal articular set angle and can reduce the apparent intermetatarsal angle. However, it does not move the entire first metatarsal laterally and thus does not achieve the same degree of correction (i.e., reduction of the first metatarsal cuneiform angle) as does a base wedge osteotomy.

Similarly, an off-set V-type osteotomy can also be performed to correct for a proximal articular set angle deviation and increased intermetatarsal angle.[6] The off-set V is limited in its ability to correct the proximal articular set angle. The swiveling maneuver which corrects for the proximal articular set angle is only possible if the head is impacted back into the shaft. This creates excessive

Figure 1A. Preoperative AP X-ray of adolescent onset hallux valgus in a twenty-year-old female.

Figure 1B. Postoperative AP X-ray at 2 years after closing base wedge and Reverdin osteotomies.
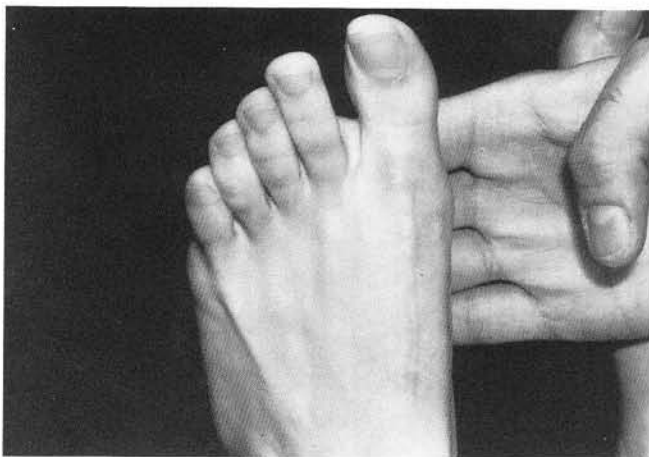

Figure 1C. Clinical view at two years postoperative.

shortening of the first metatarsal and also creates a lateral jamming of the dorsal wing into the second metatarsal. Both of these factors limit the ability of the off-set V osteotomy to correct for both a high proximal articular set angle and a high intermetatarsal angle.

It is also important to recognize that historically the recurrence rate for juvenile hallux valgus has been quite high.[7] There are probably a variety of reasons for this, but undoubtedly inadequate correction of all aspects of the deformity ranks high on the list. Procedures that compromise on the correction of either the intermetatarsal angle or the

proximal articular set angle are more likely to result in recurrence of deformity.

Hallux valgus is often associated with metatarsus adductus.[8] In this foot type, there is generally a very high hallux abductus angle and often a high proximal articular set angle. This type of deformity is managed in a fashion very similar to that of juvenile and adolescent hallux valgus. The inter-metatarsal angle is reduced as much as possible in order to produce rectus alignment between the first metatarsal and the remainder of the medial column, the metatarsus primus varus angle. In addition, in order to maintain the reduction of the hallux abductus angle, a Reverdin or other type of proximal articular set angle correcting osteotomy is also performed. The recurrence rate in hallux valgus surgery in metatarsus adductus is also quite high, and requires aggressive correction.

Hallux Limitus

A second indication for double osteotomies is hallux limitus surgery (Fig. 2). The full scope of hallux limitus surgery is beyond a discussion within this paper. Nonetheless, elevatus of the first ray (either structural or functional) is a primary reason for the development of hallux limitus.[9] As the limitations of endoprosthetic devices have become apparent, there has been an increasing search for

reconstructive techniques for the repair of hallux limitus. This search has centered around the use of osteotomies to correct alignment in the first ray, as well as a variety of head procedures designed to both change the angulation of the articular cartilage and also to promote free range of motion.

A frequent combination of procedures is the use of a plantarflexory base osteotomy in conjunction with a Waterman-type osteotomy. This allows for realignment in the sagittal plane, as well as realigning the articular cartilage to provide more dorsiflexion. Most commonly, these reconstructive types of hallux limitus procedures are performed on younger patients with degenerative joint disease that is salvageable. In these patients, the bone stock is usually quite good. However, hallux limitus reconstructive surgery mandates a return to early range of motion. This creates additional technical burdens for the performance of secure fixation in double osteotomies in hallux limitus repair.

ANGULAR RELATIONSHIPS

There is one very basic relationship that must be appreciated in order to fully understand the use of double osteotomies: When there is deformity present in the metatarsal head, it will be exaggerated by corrections performed at the base (Figs. 3A, 3B). For example, when a patient with a high intermetatarsal angle and a high proximal articular set angle, has a base wedge osteotomy performed, the apparent deformity in the proximal articular set angle actually increases with respect to the second

metatarsal, as the first metatarsal moves laterally. Therefore, the base wedge addresses and corrects one primary concern in this type of hallux valgus (i.e., the intermetatarsal angle or metatarsus primus varus angle) but may actually exaggerate the proximal articular set angle.

Similarly, the deformity that is present in the articular cartilage of hallux limitus usually involves a plantar angulation of the functional articular cartilage of the metatarsal head. When a plantarflexory base osteotomy is performed in
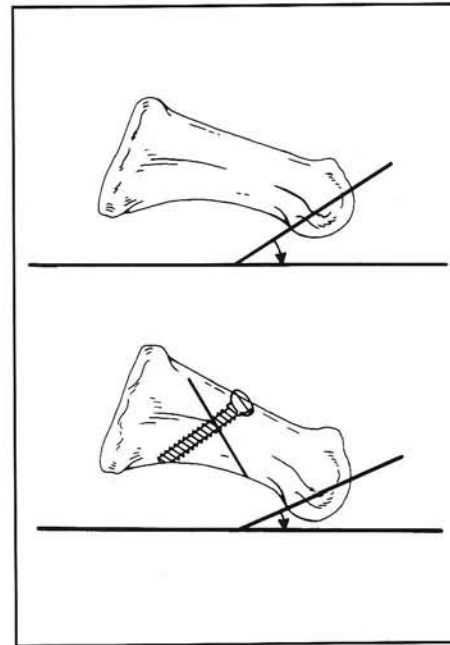

Figure 3A. Illustration of the effect of a closing base wedge osteotomy on the tangential articular set angle (relationship of PASA to the second metatarsal).

Figure 2. Preoperative lateral x-ray of hallux limitus. Note the deviation of cartilage in a plantar direction.
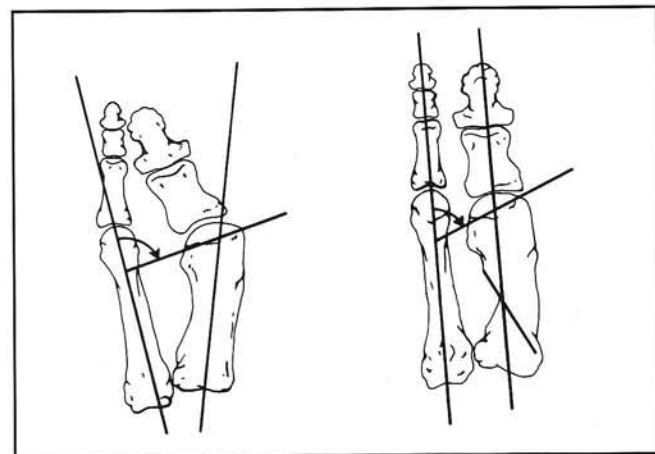

Figure 3B. Diagram illustrating the effect of a plantarflexory base wedge osteotomy on cartilage angulation.

order to correct elevatus deformity of the first ray, this head angulation deformity is actually exaggerated. This increases the need for a Waterman-type osteotomy. Without appreciation of this very basic relationship, it will be difficult to understand the considerations involved in double osteotomies.

Technical Considerations

The sequence of procedures is quite important. In hallux valgus surgery, the initial dissection is performed with exposure of the metatarsal head and a sequential release as indicated. The metatarsal head is then evaluated for proximal articular set angle deformity and the medial exostosis removed. Attention is then directed to the base of the first metatarsal where the closing base wedge osteotomy is performed. When performing the closing base wedge osteotomy, an axis guide with proper alignment is strongly recommended in order to prevent any inadvertent dorsiflexion of

the metatarsal.[10] Dorsiflexion and shortening in a double osteotomy configuration can combine to create significant dysfunction of the first ray and medial column.

Occasionally, intraoperative X-rays may be performed to confirm the radiographic alignment and the position of fixation. Once the surgeon is confident of the intermetatarsal angle correction, the first metatarsal head is then reinspected. Any continuing deformity in the proximal articular set angle is then evaluated. At this point, an osteotomy to correct the proximal articular set angle can be performed. This can either be done with a straight Reverdin-type osteotomy or a Reverdin-Green-type osteotomy. The author's preference is to perform the Green modification in most of these instances in order to protect the sesamoid apparatus (Figs. 4A-4E).

This particular sequence of procedures does require that the first metatarsal be very stable after

Figure 4A. Hallux valgus repair in adolescent onset hallux valgus with closing base wedge osteotomy and Reverdin. Note the severe deformity in this preoperative AP x-ray.
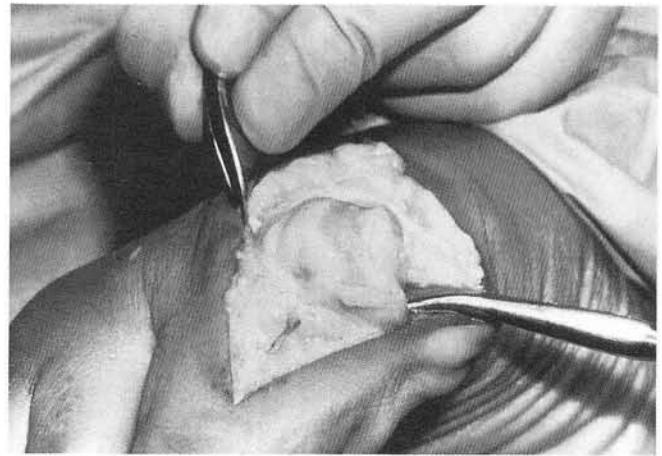

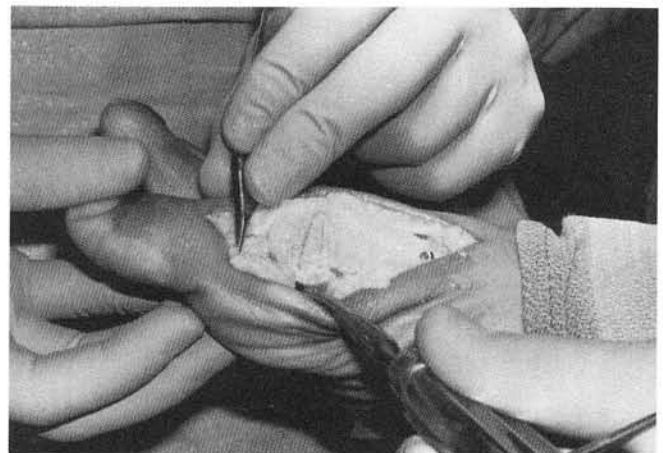Figure 4B. Intraoperative photo demonstrates a high PASA.

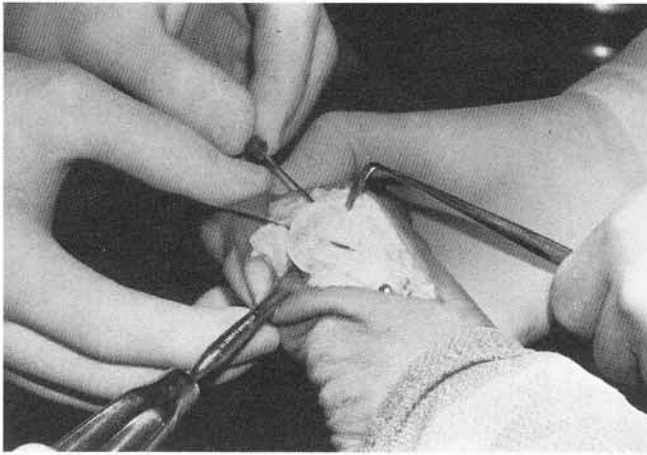Figure 4C. Intraoperative lateral view demonstrating Reverdin cuts.

Figure 4D. Intraoperative photo showing placement of the absorbable pins.

Figure 4E. Postoperative x-ray showing full correction of the deformity.

fixation of the osteotomy. It is the most logical sequence in order to insure proper correction of the angular relationships. Although this is the author's personal preference for the sequence of procedures, clearly it is possible to perform the capital osteotomy first, if one has the experience and ability to visualize what the effect of the closure of the intermetatarsal angle will mean to the proximal articular set angle. Some surgeons may prefer to perform these procedures in the latter sequence in order to minimize the risk of disruption to the first metatarsal base osteotomy fixation.

Hallux Limitus

Similarly, in hallux limitus surgery, the author usually establishes the sagittal plane alignment of the metatarsal by performing the plantar flexory osteotomy first. After satisfactory alignment of the first metatarsal, the first metatarsal head is inspected, and then it is determine how much of a Waterman-type osteotomy to perform (Figs. 5A,5B).

Fixation

The proper fixation of double osteotomies is critical to the success of the procedures. In hallux limitus surgery, the prime requirement is that the fixation be stable enough to allow passive early range of motion exercises, usually beginning two or three days postoperative. In order for reconstructive hallux limitus surgery to be successful, early range of motion is critical. Similarly, with a double osteotomy, the security of the fixation must be such that it will allow this early range of motion. In hallux valgus surgery, the requirement for early range of motion is less important. However, the performance of a capital osteotomy
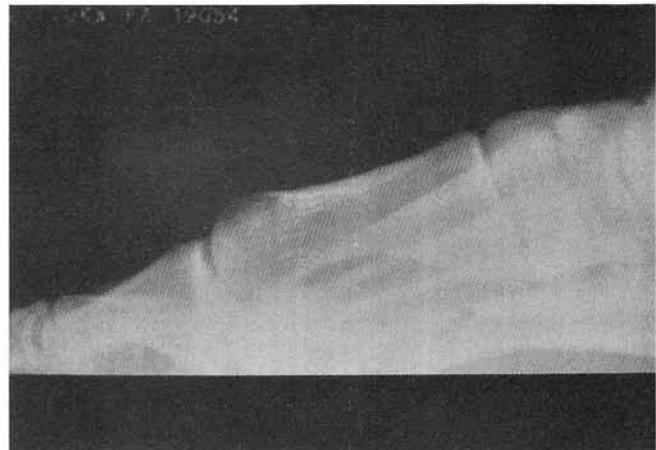

Figure 5A. Twenty-three-year-old male with hallux limitus and elevatus. Note the elevatus on this preoperative lateral view.
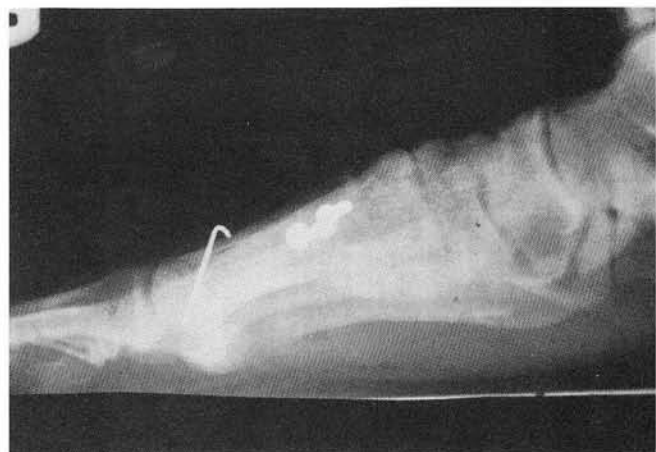

Figure 5B. The double osteotomy correction is demonstrated in this postoperative lateral x-ray.

such as a Reverdin or Green-Reverdin may cause some limitus, if the joint is simply immobilized in a cast for six weeks. Therefore, range of motion exercises are encouraged relatively early in hallux valgus surgery as well.

As a practical matter, it is important to insure that there are at least two good points of fixation for the base osteotomies. For a closing base wedge osteotomy for hallux valgus repair, this usually consists of the use of two screws, a 3.5 mm and a 2.7 mm screw.[11] In the plantarflexory osteotomy for hallux limitus, this also generally consists of two screws (variable type depending upon the size and cortical density of the first metatarsal). In both of these osteotomies, the objective is to maintain an intact osteotomy hinge. The hinge will be positioned proximal and medial for the closing adductory base wedge osteotomy, and will be positioned dorsal and proximal for the plantar-flexory base wedge osteotomy. When the hinge is intact, there are in effect three points of fixation available. Combined with non-weight bearing, this usually is more than adequate to insure the stability of the osteotomy during range of motion exercises. The stability of the capital osteotomy is also important. The author's preference is to use buried K-wire fixation or crossing absorbable poly-diaxanone pin fixation. Ideally, the author prefers to have the fixation buried at both the base and the head in order to allow for easy excursion of the soft tissues. In addition, this prevents the soft tissue swelling caused by external pins, and allows for a greater psychological feeling of security in the patient during passive range of motion exercises. The Waterman osteotomy can be performed either as a triangular wedge or as a shortening truncated wedge. With the triangular wedge, the plantar cortex is left intact and remains as a point of fixation. With the shortening truncated wedge, two points of fixation are important in order to insure maintenance of stability. The Green modification of the Reverdin is relatively stable, and one buried pin seems to be more than adequate.

All of the previous considerations are important in the execution of the double osteotomy. An additional concern is maintenance of the blood supply to the first metatarsal. Whenever two osteotomies are performed, the risk of disrupting the blood supply is increased significantly. This is one of the reasons why stability of the osteotomies is so important. Continued movement of the osteotomies will result in disruption of the blood supply. A very distal Reverdin-type osteotomy may be particularly vulnerable to this type of vascular compromise. In addition, it is even more important in this type of situation to insure that the base wedge osteotomy is not so distal so that it disrupts the laterally penetrating nutrient artery to the first metatarsal.

POSTOPERATIVE CARE

The postoperative care for double osteotomies generally consists of six weeks of non-weight bearing in a below-knee cast. With hallux limitus procedures, the cast is removed at two or three days and bi-valved or windowed locally in order to allow the patient access to the first metatarsopha-langeal joint. Limited early range of motion exercises are begun at this time. After ten to fourteen days, when the incision line is stable, the range of motion exercises are significantly increased.

In hallux valgus surgery, the range of motion exercises do not usually begin until ten or fourteen days postoperatively at which time the cast is bi-valved. At two or three weeks, the patient is allowed to bathe the foot and the foot is supported in an elastic stockinette as well as a bunion splint. Nonsteroidal anti-inflammatory drugs and physical therapy modalities can be prescribed to keep the patient comfortable enough to continue the range of motion exercises.

Radiographs are obtained immediately post-operatively, and then at about two weeks and six weeks. If the two-week radiographs reveal any callus formation or displacement of the fixation devices or osteotomies, then the range of motion exercises are significantly curtailed. This would be an unusual event if all of the above criteria are followed for the osteotomy design and fixation. Weight bearing usually begins around five to seven weeks depending upon the type of osteotomy, the quality of the bone, the security of the fixation, and the reliability of the patient. Sometimes transition to full activity is made possible using a walking cast.

COMPLICATIONS

Complications of double osteotomies can generally be broken down to the following categories: short-ening, aseptic necrosis, and limitus. There are, of course, a variety of other complications that can

occur, and are associated with the component osteotomies, but these three are the complications that are more likely to result from the synergistic effect of two osteotomies.

Shortening

Shortening can be an important consideration. Most often, the amount of shortening created by a double osteotomy and hallux valgus repair is compensated by plantarflexion of the first metatarsal. Nonetheless, the digital length pattern must be visualized, because a long second toe may end up with a subsequent digital deformity as a result of shortening of the hallux. There are ways to avoid this shortening, such as performing an opening wedge osteotomy at the base of the metatarsal. The author does not have any significant experience with this type of procedure, and has always felt that opening wedge osteotomies are less predictable in terms of the correction achieved because of the unpredictability of the amount of the bone graft absorption. In addition, bone graft healing takes significantly longer than primary fracture healing. Finally, the shortening can usually be adequately compensated by manipulation of the first metatarsal in the sagittal plane.

In hallux limitus surgery, shortening is generally beneficial, in that it helps to decompress the first metatarsophalangeal joint. An opening wedge osteotomy can be considered, particularly at the base of the first metatarsal or at the first cuneiform. However, it is important not to create new jamming of the first metatarsophalangeal joint caused by adding length to the first ray segment.

Aseptic Necrosis

The risk of aseptic necrosis can also increase with the performance of a double osteotomy. This seems logical in that the greater disruption of the blood supply to the first metatarsal would seem to increase the risk of aseptic necrosis. And indeed preliminary studies seems to indicate that this is true (D. Scot Malay, State College, Pennsylvania, personal communication). Soft tissue preservation, and proper fixation of the osteotomies can help to decrease the risk of aseptic necrosis.

Limitus

Limitus deformity can also occur through double osteotomies. This can be the result of greater soft tissue trauma, but is most commonly associated with the performance of the distal head osteotomy. In the author's experience, post operative limitation of motion at the first metatarsophalangeal joint is more often linked to performance of a true Reverdin-type osteotomy. Early range of motion is important in order to insure that the sesamoids do not become frozen in position.

SUMMARY

The performance of double osteotomies of the first metatarsal is an important way of managing more severe deformities of the forefoot. The successful application of double osteotomies requires understanding of the mechanics of the osteotomies and the angular relationships, as well as gentle soft tissue handling, finesse in the execution of the bone cuts, and skill in the application of internal fixation in order to achieve stability of the osteotomies. The procedure of double osteotomies is a mainstay of hallux valgus repair in the adolescent, and in the patient with metatarsus adductus, as well as in the management of reconstructible hallux limitus deformities.

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