CHAPTER 25

HALLUX VALGUS: Surgical Management of the Shortened First Metatarsal with Opening Base Wedge Osteotomy

Bradley D. Castellano, D.P.M.

Methods of reducing the first intermetatarsal angle during hallux valgus repair are numerous and diverse. These methods can typically be subdivided into transposition osteotomies, closing wedge osteotomies, and opening wedge osteotomies. The opening wedge osteotomy is probably the least commonly utilized for several reasons, not the least of which is that bone grafting is required. It is also generally considered more technically difficult to perform. However, in some clinical circumstances this method can be very useful if not essential in achieving a stable forefoot platform with a functional metatarsal parabola. The opening base wedge with and without an intact hinge will be reviewed and its application in clinical situations described.

HISTORY

In 1863 the first description of bone grafting was made by Wolff.[1] He described an *osteoplasty* procedure utilizing bone implanted in a surgical site to promote bone production in that site. Opening wedge osteotomies for correction of hallux valgus were first described in 1923 by Trethowan.[2] In this procedure, an opening transverse base wedge is described. Trethowan then resected the medial eminence of the first metatarsal head and shaped this bone fragment into a wedge to be placed in the proximal osteotomy. Fixation of the osteotomy was not discussed. In 1952, Bonney and McNab modified Trethowan's procedure by adding fixation.[3] In their procedure, the first metatarsal was fixated to the second metatarsal with a screw placed medial to lateral through the first metatarsal head into the second metatarsal head. Stamm performed a proximal phalangeal base resection and utilized that bone to fabricate the wedge.[4] This procedure decompresses the first metatarsophalangeal joint. The first to describe a double first metatarsal osteotomy was Logroscino.[5] Both opening and closing base wedge procedures were described, combined with a subcapital closing wedge (Reverdin-type) osteotomy. His procedure addressed the common problem of increased proximal articular set angle that occurs with proximally based procedures. In 1991, Sollito reported on the use of opening base wedge osteotomy combined with first metatarsophalangeal joint implant arthroplasty. The first metatarsophalangeal joint was thought to be decompressed by the implant arthroplasty, thereby negating the lengthening of the first metatarsal.[6]

INDICATIONS AND CONTRAINDICATIONS

Opening wedge procedures have been described as useful for a limited number of clinical situations. In general, this procedure is used in moderate to severe cases of metatarsus primus adductus. However, the procedure may also be helpful in the opposite deformity in which the first intermetatarsal angle is less than zero. The most commonly cited indication for opening wedge osteotomy is for the relatively short first metatarsal.[7] Recent discussions into the accurate diagnosis of a shortened first metatarsal may reduce the true incidence of this clinical finding.[8] However, many congenital or iatrogenically shortened first metatarsals do exist. It is patients with this deformity that may benefit from an opening wedge or lengthening type procedure. A relative indication may also exist in the patient with previous surgery at the distal end of the first metatarsal with minor shortening or other malposition. In these patients, an opening wedge procedure might be chosen to prevent any further shortening of the first metatarsal (Figs. 1A, 1B).

Contraindications relative to this particular procedure should include a relatively long first ray

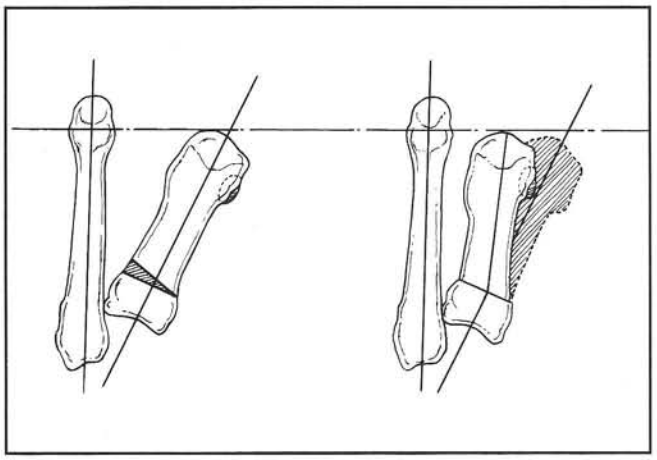

Figure 1A. Demonstration of a closing base wedge procedure (left) and an opening base wedge procedure (right). Note that the intermetatarsal angles and relative metatarsal lengths are the same for each figure.

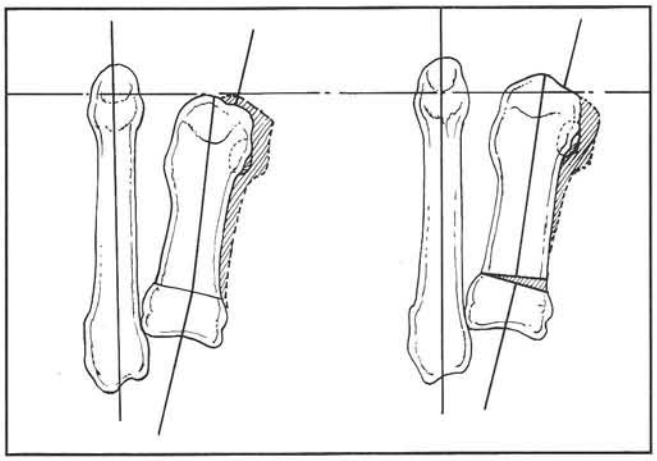

Figure 1B. The same degree of intermetatarsal angel correction has been achieved with each procedure. Note that the first metatarsal length relative to the second metatarsal has remained approximately the same for the closing base wedge procedure (left). However, the opening wedge procedure has resulted in a readily visible increase in the length of the first metatarsal relative to the second metatarsal (right).

segment unless a second procedure expected to shorten the first metatarsal is planned. The increased length of the first metatarsal following opening wedge procedures can result in limitation of motion of the first metatarsophalangeal joint. Therefore, it is not a good choice where hallux limitus already exists.

Decreased or even marginal circulatory status may result in delayed healing or even total lack of incorporation of bone grafts. Relative contraindications to opening wedge procedures might include obesity or debilitated patients unable to complete a prolonged postoperative period of non-weight bearing. Finally, chronic osteomyelitis of the surgical site must first be eradicated before considering any grafting procedure.

PREOPERATIVE PLANNING

Opening wedge osteotomy of the first metatarsal base is in many ways similar to the closing base wedge procedure. Apical axis guide and hinge orientation remain important in the planning and execution of the opening wedge procedure. Careful preoperative evaluation and planning should include:

1. Clinical evaluation of first metatarsophalangeal range of motion. Limited range of motion will only be exacerbated by the opening wedge procedure. If this procedure is to be utilized, decompression of the joint may also be required.
2. Bone density and quality evaluation as seen in preoperative radiographs.
3. Relative length of the first metatarsal compared to the remaining metatarsals.

Realistic prediction of the amount of lengthening that will occur with an opening wedge procedure may require creation of templates. Remember that a larger wedge will not only increase the amount of relative lengthening but will also decrease the intermetatarsal angle more substantially. It is important to maintain a positive intermetatarsal angle to prevent the complication of hallux varus. While an intact hinge is very helpful in maintaining stability of the osteotomy, it may not always provide the desired result of significant lengthening of the first metatarsal. A through and through osteotomy with insertion of a cuneiform shaped graft will allow greater lengthening without over-correcting the intermetatarsal angle. Another advantage of this method is that multi-planar corrections can be achieved with fairly simple modifications of the bone graft shape (Fig. 2).

SURGICAL TECHNIQUE

Incisional Approach

In most cases, the incision will be placed dorsomedially, extending from the medial cuneiform to the mid-shaft region of the first metatarsal. If first metatarsophalangeal joint dissection is required, the incision is often contiguous from the proximal phalanx to the medial cuneiform. Soft tissue dissection is often complicated by the medial dorsocutaneous nerve that courses over the base of the first metatarsal. Retraction of the nerve in a medial direction is often possible, but in some cases this nerve must be sacrificed. The tibialis anterior tendon is left intact but will be visible at the proximal medial portion of the incision. The deep fascia is incised longitudinally and the extensor hallucis longus tendon is retracted laterally to allow exposure of the metatarsal. The periosteum may be left intact to increase perfusion at the graft interface and support the medial hinge.

Osteotomy Configuration

The next decision is the orientation of the osteotomy. Most early authors describe a transverse osteotomy. The advantage of this osteotomy is stability. However, creating a more oblique osteotomy allows greater ease in applying interfragmental compression across the graft interface with lag screw fixation (Figs. 3A-3E). Therefore, preferred fixation methods may dictate the orientation of the osteotomy.

The opening wedge osteotomy is created with a lateral hinge. A Kirschner-wire of 0.045 inch diameter can be inserted to act as an axis guide for this procedure. It is important to keep in mind when planning the hinge axis that the osteotomy will be opened rather than closed. A more dorsally oriented hinge will actually dorsiflex the distal metatarsal. *Therefore, surgeons familiar with the closing base wedge procedure must adapt their thinking when planning an opening wedge procedure.*

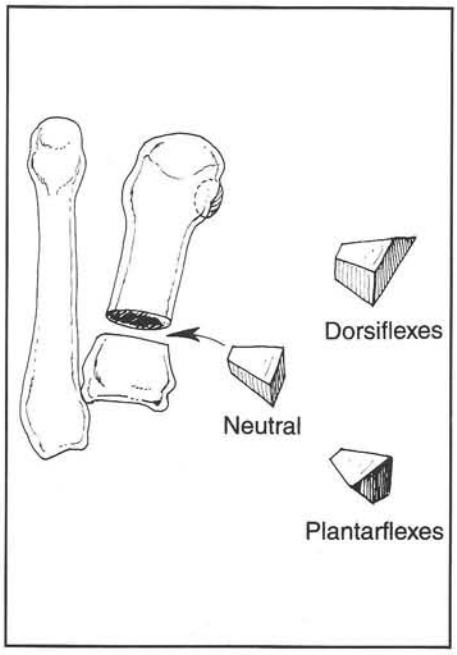

Figure 2. A depiction of graft shape manipulation that can be used to alter the position of the distal aspect of an osteotomy.

Figure 3A. A 39-year-old patient with recurrent hallux valgus deformity. Note the significant shortening seen on the dorsoplantar view.

Figure 3B. Medial oblique view.

Figure 3C. Immediate postoperative radiograph with opening osteotomy of the first metatarsal base.

Figure 3D. Postoperative view. Both interfragmental compression and axial stabilization has been achieved with lag screw and plate fixation.

Figure 3E. Oblique radiograph at 3 months postoperative. Note the dissolution of the graft site with blurring of the graft margins.

Graft Harvesting

In most cases, opening wedge procedures of the foot require relatively small donor sites. Therefore, there are few indications for use of less optimal allografts or even bone graft substitutes. The resected medial eminence of the first metatarsal head provides a readily available source of autogenous graft material. Unfortunately, it is generally poor quality bone. If implant arthroplasty is combined with opening wedge osteotomy, the phalangeal base can be an excellent alternative. Numerous other anatomic locations have been described for obtaining autogenous bone graft materials.

The posterior superior margin of the calcaneal tuberosity provides both cortical support and cancellous osteogenic properties.[9] This site is readily available and accessible during the procedure. The incision is placed lateral along the calcaneal tuberosity. The sural nerve should course anterior to the incision and generally is not exposed. The periosteum is left intact over the graft site to aid in revascularization and osteogenesis. The margins of the graft are first marked by drilling with a 1.5mm power drill. The lateral and superior cortices of the calcaneus are harvested to provide cortical strength to the graft. Once the outlined areas are cut, an osteotome can be used to pry the graft loose. The graft is stored in a blood-soaked sponge until it is to be inserted into the osteotomy site.

Other possible sites to obtain autogenous graft from the distal lower extremity include the tibial malleolus and fibular shaft.[10] Allogenic graft such as iliac crest may also be utilized if satisfactory autogenous graft cannot be obtained.

Fixation

As with all proximal osteotomies of the first metatarsal, fixation must be appropriate and substantial. The forces acting to disrupt the osteotomy and graft can be significant, even in the sufficiently immobilized lower extremity. Pin fixation has been shown to be adequate for many clinical situations. Its major advantage is simplicity. However, more than one pin will usually be necessary, and the pins should diverge in their course to increase the degree of stability they achieve. Power driven staples can sometimes be employed. Only relatively small grafts can be utilized with this form of fixation since the staple must span the graft site with enough margin to prevent fracture into the osteotomy site. Both pin and staple fixation are best utilized in intact hinge situations.

Osteotomies without an intact hinge will often require a much greater degree of stabilization. Appropriately applied screw and plate fixation can control the normal forces that act to displace a through and through osteotomy. However, the surgeon should plan to use these forms of fixation before creating the osteotomy for several reasons. First, the transversely oriented osteotomy makes achieving interfragmental compression difficult. Therefore, if compression at the graft interface is the goal, a more obliquely-oriented osteotomy should be created. Second, if the osteotomy is to be fixated without crossing the tarso-metatarsal joint, it must be placed distal enough to allow for fixation in the proximal segment of the metatarsal. The disadvantage to this approach is that more obliquely-oriented osteotomies allow proximal shift with a tendency toward inadequate stabilization. The main disadvantages of plate fixation are increased technical difficulty, and the usual necessity of a second surgery for retrieval of the fixation.

Plate and screw fixation can also be used in the intact hinge osteotomy. Some degree of axial compression may be achieved utilizing off-set drilling. However, the surgeon risks applying shear across the hinge, fracturing this point of stabilization.

POSTOPERATIVE MANAGEMENT

Patients are placed in a compression cast immediately postoperatively to promote hemostasis and control edema. The first dressing and cast change is generally done in less than two weeks. This allows the immediate postoperative edema to resolve before application of the regular below-knee cast. The patient must remain non-weight bearing for at least the first two to three months following the procedure, and should be prepared for even longer periods if necessary. A period of partial-weight bearing in a fracture orthosis walker type device is then recommended to gradually expose the osteotomy to the stresses of ambulation. Eventual full-weight bearing in supportive shoes is allowed following determination of adequate healing and stability of the osteotomy.

RADIOGRAPHIC EVALUATION OF BONE GRAFTS

Graft incorporation is monitored with serial radiographs. It is important that the radiographic technique remain constant during these evaluations to prevent misinterpretation of relative densities of the graft and osteotomy sites. As the patient progresses, the radiographs should be taken without heavy bandages or cast materials that distort the degree of density the graft attains as incorporation occurs.

Autogenous bone grafts initially will appear similar in density to the surrounding bone. The margins between the recipient site and graft are generally easy to distinguish. In the early postoperative period (weeks 1 to 4) the graft will appear to increase in density relative to the surrounding bone. This is due to hyperemia of the surgical site with lack of perfusion to the bone graft itself. At 4 to 8 weeks, the margins of the graft become obscured and ill-defined. The graft itself becomes increasingly osteopenic, especially in its cancellous areas. This occurs as the graft becomes revascularized and osteoclastic remodeling begins to occur. At 8 to 12 weeks, osteoblastic activity begins to dominate the radiographic image, and increasing density of the graft gradually occurs. Complete incorporation of the graft with dissolution of all margins may not occur for a period of up to one year postoperatively.

DISCUSSION

Opening wedge osteotomy of the first metatarsal has been presented for the correction of moderate to severe hallux valgus. The procedure is suggested when relatively high intermetatarsal angles are associated with a relatively short first metatarsal. This procedure should be considered in cases requiring significant intermetatarsal angle reduction that is not likely to be corrected with distal metataphyseal osteotomy. Although some lengthening with distal metataphyseal osteotomy is possible, significant lengthening is usually at the expense of intermetatarsal angle reduction. Proximal closing wedge type procedures provide adequate reduction of even large intermetatarsal angles. However slight, closing wedge procedures do cause some shortening that, combined with a pre-existing relative deficiency in length of the first metatarsal, can become clinically significant.

Bone grafting techniques have become better understood and are no longer considered an esoteric method of addressing complicated osseous deformities. Readily available graft material exists in the distal lower extremity. Harvesting of graft material adds little morbidity to the procedure.

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