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## **THE SCARF-MEYER “Z” MIDSHAFT OSTEOTOMY**

The Scarf-Meyer first metatarsal osteotomy, used for the correction of metatarsus primus adductus associated with hallux abducto valgus, has gained new popularity with the advancement of internal fixation techniques. Originally described in 1922 by Meyer, the osteotomy quickly fell out of use due to its high rate of complications such as non-union or delayed union because of the lack of adequate fixation of the surgical fracture.

Recent advancements in osteosynthesis however, have produced a variety of internal fixation methods and allowed the rebirth of more aggressive osteotomies, such as the "Scarf", according to Mark Shaffer in 1993, and Marcinko, in 2005-06. Technically, a scarf joint is a carpentry term that refers to a joint made by chamfering (beveling or grooving), halving, notching or otherwise cutting away two pieces of bone to correspond to each other and secure them after overlapping. Recent podiatric medical literature refers to this procedure with the eponym "Z bunionectomy" (referring to the configuration of the osteotomy) or the "Scarf bunionectomy".

A most extensive current study of this procedure appears to have been done by Schwartz and Groves, in 1987, and reported by Gudas in 2002. They studied 230 Meyer-Scarf osteotomies performed with internal threaded Kirschner wire fixation. After reviewing the literature and through personal communication in 2005-2006, Gudas and Reilly are also credited with resurgence of the osteotomy. Their technique employed two 2.7 mm cortical screws for rigid internal fixation. The procedure has also been-modified by A. Kelikian after reviewing additional cases.

### **SURGICAL TECHNIQUE**

The incision for the Meyer-Scarf midshaft osteotomy is placed either medially or dorso-medially along the first metatarsal shaft, extending distally over the first MPJ, to the base of the proximal phalanx. Dissection is carried to the joint capsule retracting neurovascular structures. The capsule may be incised linearly or in an inverted "L" fashion. Medial exostectomy is performed in the standard fashion, in preparation for the midshaft osteotomy. Lateral sesamoid release or excision may be approached from a lateral or plantar-medial direction and is facilitated with a retractor.

The osteotomy is best described as a mid-diaphyseal osteotomy that extends from the distal metaphysis of the first metatarsal to its proximal metaphysis. Its length is dependent upon the angular correction necessary to reduce the primary deformity.

From a medial perspective, the osteotomy has a "Z" configuration in the bone, with a horizontal component through the diaphysis and two angulated osteotomies at the proximal and distal margins respectively. The distal osteotomy is angulated in a dorsal-proximal direction while the proximal osteotomy is angled plantar-distally. The horizontal component is made with a 2/3 dorsal - 1/3 plantar relationship within the shaft of the first metatarsal, along its axis, to increase the inherent stability of the osteotomy. This also helps reduce the risk of diaphyseal fracture. Distal and proximal cuts are made 60-80 degrees from the perpendicular.

Tension and compression components are created at the osteotomy according to Pauwell's tension band principle, created by the opposing forces of body weight and ground reactive forces. The osteotomy achieves inherent stability when absorbing these tensile and compressive forces, by both the thick dorsal ledge created by the osteotomy within the first metatarsal and the ligamentous and capsular structures kept intact at the first metatarsal-cuneiform joint (MCJ) articulation.

The "neutral" osteotomy is performed by first inserting a smooth .062 inch K-wire from a medial to lateral direction, at the distal and proximal apices of the three arms of the intended "Z" cut. The K-wires serve the purpose of establishing a planar relationship to the osteotomy (lengthening, shortening, plantarflexion or dorsiflexion), reducing the incidence of "stress risers" at the apical cuts, and determining the osteotomy length. It is important to insert the wires parallel to each other while directly viewing them from both the dorso-plantar and distal-proximal directions. The wires are then used to guide the surgeon and maintain a single plane within the first metatarsal.

Once these three cuts are completed, the K-wires are removed and any residual bone preventing free displacement of the fragments is osteotomized. This most commonly occurs at the lateral-proximal-inferior apex. The fragment is then positioned to reduce both the intermetatarsal angle (IMA) through lateral transposition, and the proximal articular set angle (PASA), through "swivel". Temporary fixation is achieved with a bone clamp. At this point, the osteotomy may be permanently fixed with a variety of techniques such as threaded K-wires or standard 2.0 mm cortical AO/ASIF screws. This will provide rigid fixation and compression across the fracture and allow for change to a 2.7 mm cortical screw if the purchase power of the 2.0 mm screw is inadequate.

The internal threaded K-wire technique is performed using the 1) Pre-drill holes are made with a .045 inch smooth K-wire, or drill bit of comparable size, through the dorsal and plantar cortices. Two .062 inch threaded K-wires are inserted through both cortices. The trochar points of the K-wires are cut plantarly and retrograded, leaving one or two threads exposed through the plantar cortex. The wires are cut flush on the dorsal cortex to prevent soft tissue irritation.

The 2.0 or 2.7 mm cortical screw fixation is performed using standard AO/ASIF technique. If a combination screw and pin technique is preferred, it is best to place the screw at the proximal or "tension" side of the osteotomy with the pin placed distally. This reduces the incidence of hardware migration created by the tensile forces. Once the osteotomy is permanently fixed, the remaining first metatarsal is smoothed and remodeled to facilitate a normal anatomical contour. The soft tissue planes are closed in a routine fashion.

### **SURGICAL CRITERIA AND INDICATIONS**

Criteria for the Meyer-Scarf osteotomy are similar to other distal metaphyseal osteotomies, such as the chevron, Reverdin-Green-Laird displacement osteotomy or other "in-between" procedures. Because of osteotomy location however, the surgeon may consider the angular criteria used for proximal osteotomies, such as the Mau or Ludloff procedures, or other hinge axis procedures such as the closing or opening base wedge first metatarsal osteotomies. High intermetatarsal angles or proximal articular set angles may be effectively reduced by this single osteotomy. One should be aware however, that the IMA is reduced at the expense of an increased PASA. In other words, the greater the IMA correction achieved, the smaller the PASA correction allowed. IMA correction is limited by the width of the first metatarsal shaft (i.e., shaft width allows increased lateral displacement). PASA correction also influences IMA correction. If an aggressive swivel is required to reduce a large PASA, a smaller amount of lateral displacement is allowed due to bone-to-bone "contact surface" loss and possible abutment against the base of the second metatarsal. If necessary, the proximal-lateral corner of the distal fragment may be resected to allow increased swivel and lateral migration.

### **COMPLICATIONS AND CONTRA - INDICATIONS**

Complications associated with distal metaphyseal osteotomies, such as capital fragment elevation, or metatarsal length derangements, are rarely also seen with the Meyer-Scarf osteotomy. This is attributed to both inherent stability sans rigid fixation of the osteotomy, and the precise surgical control achieved when performing the actual bone cuts. There is much "freedom" to move the fragments upon each other in the direction determined by the described "K-wire plane technique". Delayed or non-unions have not yet been reported in the literature and avascular necrosis is theoretically possible because of the extensive soft tissue delamination required to isolate the entire metatarsal shaft. The most common complication reported is screw irritation or pin bursitis resulting from fixation hardware migration. Diaphyseal fracture of the horizontal component into the MCJ has been seen. This resulted in dorsal and proximal migration of the distal segment.

There are no specific precautions intrinsic to the Meyer-Scarf osteotomy and its contra-indications are similar to those of any other metatarsal osteotomy, regardless of location.

## **DISCUSSION AND RESULTS**

The inherent stability of the Meyer-Scarf mid-shaft osteotomy allows immediate partial weight-bearing in a post-operative shoe with three point crutch assisted gait, regardless of the bi-laterality of surgery. Objectively, less joint stiffness occurs at the first MPJ during the post-operative period. This translates into better patient compliance and confidence in the operative foot, allowing aggressive range-of-motion exercises and mobility. All bandages are removed after about four weeks or upon incision healing and hydro-therapy exercises instituted.

With the patient in a sitting position, the foot is placed in warm water and 15 toe-raise repetitions performed two-three times daily. Patients are allowed to return to wearing a supportive sneaker when swelling in the forefoot allows a comfortable fit, in five to eight weeks. It is interesting to note that edema may be more intense or prolonged with this procedure due to the extensive soft tissue dissection required to expose the first ray segment. This is especially true with the novice surgeon who may not be as adept in proper soft tissue dissection handling techniques.

Post-operative radiographic evaluation is performed at one, three, six and twelve week intervals. The practitioner should pay close attention to fixation and osteotomy migration. Bone callus is rarely seen although bone "bridging" will occur in the first intermetatarsal space between the lateral flare of the swiveled fragment and the first metatarsal. This does not represent consolidation of the osteotomy site but rather remodeling of the lateral cortex. If bone callus does appear, it is seen on the anterior-posterior

## **TECHNICAL ASSESSMENT**

Very favorable results have been obtained through use of the Meyer-Scarf osteotomy in last several years. The principles and precautions outlined must be observed in order to prevent serious complications while the surgeon must also evaluate such parameters as patient compliance, general medical health status, activity level and a host of other factors, as outlined by Haber and O'Mara, when considering this or any other HAV procedure.

Specifically however, a "trough" effect, similar to that which occurs with a chevron osteotomy, has been seen regarding the Scarf osteotomy and occurs if the capital fragment is displaced laterally with minimal swivel. This creates a situation where the medial cortex of the plantar (distal) fragment is completely within the medullary canal of the dorsal (proximal) segment. This position results from failure to ensure cortical surface contact. It is most evident when tightening the cortical screws used for fixation and can be prevented by evaluating the osteotomy's "reaction" to compression made by the temporary bone clamp, prior to permanent fixation. If the dorsal-medial cortex is "drawn" into the plantar-medial medullary canal, the bone clamp may be released to reposition the fragment and avoid this phenomenon. Bone grafting may be used for support.

It must be remembered that the IMA is corrected at the expense of PASA and vice versa. Therefore, if faced with high measurements for both component angles, dual proximal and distal osteotomies should be considered instead of the Meyer-Scarf osteotomy. If one attempts to "get-by" or over extend the limits of the procedure, the potential for fragment displacement or disappointing results is increased

Finally, when performing the internal threaded K-wire technique of fixation, it is important to first pre-drill the dorsal and plantar cortices with the .045inch smooth wire. Although not categorically proven, it is believed by many authorities that the threaded K-wire will "hold" or maintain the compression achieved by the temporary bone clamp. If the threaded wire is inserted into the bone without benefit of a "starter" guide hole, the wire will spin at the dorsal cortex until it cuts into the bone.

It will also then spin at the plantar cortex until the trochar point cuts into the bone and drive itself through the plantar bone. While the wire tip spins at the plantar cortex waiting to "bite", the dorsal hole is stripped by the continual spinning in-one place. This reduces the holding power of the wire and can result in loose fixation.

### **SCARF MODIFICATIONS**

The Inverted Scarf may provide greater resistance to weight-bearing disruption and provide additional stability. Cuts are made "upside down", when compared to original configurations (proximal-dorsal to distal-plantar), with care taken to avoid the sesamoid complex. Additional research studies are ongoing by (Gonda, Bauer, and Hillstrom) and FARC, Inc.

### **CONCLUDING REMARKS**

The stability achieved with the Meyer-Scarf midshaft osteotomy, due to fixation techniques and the intrinsic stability of its "Z" configuration, allows load sharing by the surgical fracture. This translates into primary bone healing when appropriately performed. The potential for implant fatigue is reduced while the bone absorbs compressive forces. Although the IMA is reduced, the PASA may be increased and the previously hoped universal applicability of the procedure, to every HAV deformity, is negated. Vogler's concept of the "Z" osteotomy as a "compromise osteoplasty" of the first metatarsal seems true. It is also hoped that this information proves valuable to those who study for board certification examinations.

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