Frontal plane rotation of the sesamoid apparatus during the Lapidus procedure: A novel approach

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Statement of Purpose

Demonstrate a novel approach in correcting frontal plane rotation of the sesamoid bones during the Lapidus procedure for Hallux abductovalgus deformities via manipulations and no incisions.

Introduction and literature review

Lapidus popularized the first metatarsocuneiform arthrodesis in 1934 as he believed that the majority of the deformity was due to an arrest in development of the first metatarsocuneiform joint, causing a metatarsus primus varus deformity (1). The indications have strayed from those originally proposed for the Lapidus to include: hypermobility, juvenile hallux abducto valgus, revisional hallux abducto valgus surgery, hallux limitus, hallux rigidus, met primus varus, met primus elevatus, arthrosis of the first metatarsal-cuneiform joint and medial column stability (2). The procedure is able to predictably stabilize the first ray while preserving length and strength of the hallux.

Numerous surgical indications have brought about diverse surgical adaptations of the Lapidus procedure. Through the evolving modifications of the Lapidus, several improvements have been made to decrease complications and maximize post-surgical outcomes. However, ideal position of the sesamoids is often overlooked. The results of a three-dimensional kinematic analysis in a cadaver model demonstrated that the sesamoid apparatus plays a significant role in the biomechanical function of the first ray, and that less than optimal realignment of the sesamoid apparatus could lead to adverse retrograde forces with threat of recurrence (3).

Root et al. described four primary factors necessary for normal function during the propulsive phase of gait; one of which was normal sesamoid position (4). The anatomy of the seasmoids is just as complex as their function: housed within an intricate network of ligaments, tendons, and capsular structures, all of which function uniformly about the first metatarsophalangeal joint (5). With this in mind, any deformity which exists, or is created surgically amongst the sesamoids, must be addressed if optimal correction of first ray function is to be attained.

Inman valued the importance of tangential weightbearing radiographs in order to evaluate the frontal plane rotation of the metatarsosesamoid joint (6). Meyr et al. confirmed that the metatarsosesamoid joint rotation should be measured to accurately evaluate the position of the sesamoids (7). A study of 106 patients with hallux valgus deformity treated with the Lapidus procedure concluded that the complete reposition of the sesamoid bones is mandatory to obtain good and excellent results. The study confirmed that the clinical outcome was significantly influenced by complete repositioning of the sesamoid bones rather than the reestablishment of the normal hallux valgus angle or normal first intermetatarsal angle (8). Ramdass and Meyr concluded that sesamoid position did not change in the frontal plane when measured relative to the stationary second metatarsal, but did change in the frontal plane when measured relative to the stationary weight-bearing surface (9).

Frontal plane manipulation of the great toe under fluoroscopy. Note the great toe is manipulated into a neutral position and the sesamoids follow.

Established frontal plane correction of the sesamoids with manual manipulation of the hallux on the MTPJ

Sesamoid anatomy with stabilizing soft-tissue structures of ligaments, tendons, and capsule

Technique

A 6 cm incision is made over the metatarsal cuneiform joint and the tarsal metatarsal ligaments are resected to expose and prepare the joint. **No first MTP joint dissection is performed and the lateral soft tissue structures of the joint are left undisturbed**.

The frontal plane is addressed by de-rotating the hallux out of valgus in order to make the nail plate parallel with the ground. This allows for the entire hallux, sesamoid and first metatarsal complex to be rotated into a neutral position as one unit. This rotation will be clinically evident at the tarsal metatarsal joint as well as under fluoroscopy. The sesamoid correction can be observed under fluoroscopy A 2.0 mm K-wire is introduced from the metatarsal and through the cuneiform to maintain this reduction.

The sagittal plane reduction technique is performed by stabilizing the hindfoot, while dorsiflexing the first metatarsal phalangeal joint, thereby initiating the windless mechanism. This hindfoot stability allows for retrogrograde forces to the plantar tarsal metatarsal joint and allows for the first metatarsal to plantarflex, while remaining parallel to the lesser metatarsals. Once the hallux, sesamoid, and metatarsal are rotated to a neutral desirable position (frontal plane reduction); and the first metatarsal sagittal plane is corrected, the surgeon can use his thumb against the first metatarsal to manually reduce the first inter-metatarsal angle in the transverse plane. A second 2.0 smooth K- wire is used to stabilize the reduction and position into the medial first metatarsal head and into the lesser metatarsals. This serves to prevent de-rotation in the frontal plane and maintains reduction in the transverse plane. If further correction in the frontal plane is needed, the K-wire can be inserted into the first metatarsal's medial and lateral cortices with the K-wire angled in the direction of inferior medial to superior lateral. Once the K- wire penetrates the far cortex of the first metatarsal, the wire can be used to rotate the metatarsal into a more neutral position and be further driven into the lesser metatarsal to stabilize the position.

Fixation is established by an interfragmentary 3.5 mm cortical screw and a medial 1/3 tubular locking plate with screw construct to maintain the reduction in all three planes. The plate functions as a "large washer" in reducing the IM angle, thereby providing both stability and deformity correction.

Pre-and Post-operative correction of the sesamoids with improved alignment at the first MTP joint. Note valgus correction of the toe and sesamoids.

Pre-and Post-operative clinical evaluation – Note the valgus correction of the great toe.

Discussion and Analysis

We report an expanded concept in the surgical procedure of the Lapidus with attention to the frontal plane rotation with respect to the sesamoids. A deformity is most effectively corrected at its origin (10). The Lapidus arthrodesis is a predictable and biomechanically sound procedure. The interplay between first ray anatomy and surrounding structures emphasizes the importance of proper anatomical alignment when performing first ray procedures such as the Lapidus.

The resulting reduction of the first metatarsal head over the sesamoid apparatus allows the plantar fascia and the collaborating windlass mechanism to stabilize the medial column of the foot (11). A fully corrected first ray allows the foot to engage the windlass mechanism, thereby maintaining the functional length and realignment of the metatarsal with the hallux and the sesamoid apparatus (12).

A controlled prospective study containing radiographic and long-term clinical outcomes with regards to frontal plane rotation of the sesamoids after a Lapidus procedure would be most favorable to follow our study. In addition, this study would also benefit from an objective measurement to accurately assess the precise improvement of frontal plane rotation pre-and post-operatively.

Frontal plane correction of the sesamoid apparatus through the Lapidus procedure restores the first ray function and thus, a more efficient gait cycle with a more predictable outcome.

References

1. Ray Ronald G. First metatarsocuneiform arthrodesis: technical considerations and technique modification. J Foot and Ankle Surgery. 41(4): 260-272, 2002.
2. Mote G.A., Yarmel Daniel, Treaster Amber. First metatarsal-cuneiform arthrodesis for the treatment of first ray pathology: a technical guide. J Foot and Ankle Surgery. 48 (5): 593-601, 2009.
3. Rush S. M., Christensen J.C., Johnson C. H., Biomechanics of the first ray. Part II: metatarsus primus varus as a cause of hypermobility. A three-dimensional kinematic analysis in a cadaver model. J Foot and Ankle Surgery. 39 (2): 68-77, 2000.
4. Root M.L., Orien W.P., Weed J.H., et al: Biomechanical Examination of the Foot, Vol 1. Los Angeles, Clinical Biomechanics, 1971.5.
5. Gerber, Micheal, Roberto, Patrick D. Sesamoids. Chapter 10. Hallux Valgus and Forefoot Surgery. 153-162.
6. Inman V.T. Hallux valgus: a review of etiologic factors. Orthop Clin North Am. 5:59-66, 1974.
7. Kuwano T. , Nagamine R., Sakaki K., Urabe K., Iwamoto Y., New radiographic analysis of sesamoid rotation in hallux valgus: Comparison with conventional evaluation methods. Foot Ankle Int. 23 (9): 811-817, 2002.
8. Metzdorf A., Strehle J.K., Early complications of the modified Lapidus procedure for hallux valgus treatment in adults. The Foot. 11: 38-44, 2001.
9. Ramdass Roland, Meyr Andrew J. The multiplanar effect of first metatarsal osteotomy on sesamoid position. J Foot and Ankle Surgery. 49: 63-67, 2010.
10. Lapidus, P.W. The operative correction of metatarsus primus varus in hallux valgus. Surg. Gynec. Obstet. 58: 183-191, 1934.
11. Roukis Thomas S., Landsman Adam S. Hypermobility of the first ray: a critical review of the literature. J Foot and Ankle Surgery. 42(6):377-390, 2003.
12. Christensen J.C., Jennings M.M. Normal and abnormal function of the first ray. Clin Podiatr Med Surg. 26:355-371, 2009.