How I Use a 3-Dimensional Approach to Correct Hallux Valgus with a Distal Metatarsal Osteotomy

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KEYWORDS

• Metatarsal osteotomy • Minimally invasive technique • Weight-bearing CT

KEY POINTS

- The role of uniplanar osteotomy for the correction of multiplanar deformity in hallux valgus is a developing and promising concept.
- Careful consideration should be given when considering the concept of preexisting pronation of the metatarsal.
- Recent computed tomography studies indicate that there is little or no rotation of the metatarsal itself.
- A multiplanar osteotomy should aim to correct the rotation caused by soft tissue imbalance at the tarsometatarsal and metatarsophalangeal joints rather than in the metatarsal itself.

The concept of metatarsal rotation was established in the 1950s by Hicks.[1] This work was based on the rather rudimentary biomechanical testing available at the time in 5 normal amputated feet. He found that the first ray can move through pronation and supination as it extends and flexes, and abducts and adducts. It is established that this multiplanar movement is present at the tarsometatarsal joints.[2] Although it is likely that other joints also contribute to this overall motion, perhaps to a much greater extent than the first tarsometatarsal joint, with as much as 90% coming through other joints, in particular the navicular cuneiform.[3] However, Hicks' description of total pronation of the first ray of $22^\circ \pm 8^\circ$ was widely accepted.

From this knowledge of the plane of motion of the first ray and the degree of pronation associated with this dorsiflexion and adduction, it naturally led to the assumption

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that the first metatarsal head pronates in hallux valgus.[4] Eustace and colleagues[5] investigated this in a number of studies beginning with a cadaveric study in which they found that the plantar tuberosity of the base of the first metatarsal moved laterally (or everted) with closed chain pronation of the foot. Furthermore, they also demonstrated in another clinical study that first ray pronation was intimately associated with medial longitudinal arch height and that it increases with the first ray elevation seen in hallux valgus.[6] This study used weight-bearing radiographs to establish whether the first metatarsal pronates in hallux valgus. By measuring the position of the inferior tuberosity, Eustace and associates were able to show not only that the first metatarsal pronates, but that, as the intermetatarsal angle increases, so does the pronation. They later demonstrated similar findings in MRI investigation of hallux valgus.[7]

More recent studies have also appeared to support these findings. In a study by Mortier and colleagues[8] of weight-bearing radiographs, the mean radiologic pronation was 12.7° ± 7.7° (range, 0°–40°), although contrary to the findings of Eustace and colleagues there was no correlation M1M2 divergence and pronation. They also found that sesamoid rotation was always found in the presence of pronation, but pronation was not always to be seen with sesamoid rotation, suggesting that sesamoid axial displacement is the root cause of rotational displacement. Mortier and colleagues[8] also performed an anatomic study that showed that very few of the first metatarsals heads were pronated in relation to the base (4 of 20), suggesting that the pronation is at the first tarsometatarsal joint as opposed to metatarsal torsion. However, although this concept has become well-established,[9–17] in Lapidus *The author's bunion*, there was evidence to the contrary.[18] D'Amico and Schuster[19] also showed that the loaded foot did not behave in the manner of the axes reported by Hicks.[1]

The validity of weight-bearing radiographs for measuring rotation had already been called into question by studies using roentgen stereophotogrammetry,[20] and this has been supported with the advent of weight-bearing computed tomography (CT) scans. Collan and colleagues[21] published the findings of the first biomechanical study using weight-bearing CT in hallux valgus. This study compared patients with hallux valgus with a control group in both weight-bearing and non-weight-bearing CT scans. They showed that there was no significant pronation of the first metatarsal but that there was significant pronation of the proximal phalanx (33° ± 3°). Similarly, Geng and colleagues[22] found that most medial cuneiforms pronated more that the first metatarsal and the first tarsometatarsal joint was usually supinated, especially in patients with hallux valgus. Furthermore, Kimura and colleagues[23] demonstrated 4.9° ± 3.6° of supination of the metatarsal relative to the cuneiform at the tarsometatarsal joint and 4.6° ± 3.4° of pronation of the proximal phalanx relative to the metatarsal at the metatarsophalangeal joint. Therefore, the introduction of weight-bearing CT seems to contradict the earlier findings of studies that relied on weight-bearing radiographs in relation to first metatarsal pronation.

The concept that it is the phalanx that pronates is interesting and would correlate with the MRI study conducted by Eustace and colleagues[5] that showed the tendon shift that occurs in hallux valgus. The senior author (AP) described this as subluxation of the hallucal rotator cuff and this results in pronation of the toe.[4] Perhaps this may also result in pronation of the first metatarsal as it slips medially off the sesamoid sling. The rationale for a lateral release is based on reestablishing normal mechanics in this area by releasing the suspensory ligament of the sesamoid and if required the abductor halluces, thus allowing the adductor hallucis to have a stronger effect on the toe (**Fig. 1**A).

The first ray is an inherently unstable array that relies on fine soft tissue balance to maintain its alignment and function fully. The senior author uses a minimally invasive

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