

## Point-Counterpoint: Is Frontal Plane Correction Essential For Addressing Bunion Deformities?

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## Yes.

*These authors note that recent literature and surgeon experience have shown that frontal plane deformity has been grossly underestimated and inadequately addressed in the surgical correction of hallux valgus.*

**By Lawrence DiDomenico, DPM, FACFAS, and Zachary Flynn, DPM, AACFAS**



Addressing the frontal plane is essential to achieve complete correction and reduction of a hallux valgus deformity as recent studies have shown. It has been the senior author's approach to address the frontal plane as well as the sagittal and transverse plane when performing his surgical procedure of choice, the Lapidus bunionectomy, to provide long-term, predictable outcomes.

Mizuno first described frontal plane deformity in 1956.<sup>1</sup> The senior author has practiced frontal plane correction for the past 17-plus years. Performing a frontal plane rotation of the hallux, first metatarsal and sesamoid complex as an entire unit allows the surgeon to correct the great toe out of valgus, realign the sesamoid complex and correct the first metatarsal in all three planes without invading the distal soft tissues.

Additionally, it has been thought and taught that we need to resect the base of the lateral portion of the first metatarsal in order to reduce the intermetatarsal angle. In fact, the senior author's experiences have demonstrated this not to be true. On an AP radiograph that demonstrates a large lateral flare at the base of the first metatarsal, the lateral flare is actually rotated from a plantar position (the neutral position) into a pathologic valgus position, suggesting that there is a large flare. We have thought this is abnormal anatomy of the first metatarsal when in fact it is not. It is simply malalignment of the base of the first metatarsal.

The senior author suggests rotating the great toe, sesamoid and first metatarsal out of valgus (into a varus direction) to a neutral anatomic alignment while performing the Lapidus procedure. Once one has reduced the deformity and achieved anatomical alignment, the lateral flare will disappear on the AP radiograph as the lateral flare will be positioned in a more plantar, naturally occurring position. One of the advantages of frontal plane rotation as it relates to the base of the first metatarsal is that it allows for less dissection—minimizing risk to the patient and surgeon—while providing more bone-bone contact and bony surface area as well as a larger bony target for fixation and bone screw interface.

Yet widespread discussion on this topic has not occurred until the last few years, likely because of the variation in terminology clinicians have used to describe the deformity. Pronation, valgus and eversion are all in use throughout the literature to describe this frontal plane deformity.<sup>2,3</sup> Traditional decision-making processes regarding the correction of hallux abducto valgus (HAV) deformity have involved the utilization of standard three-view foot radiographs. Surgeons utilize ingrained radiographic parameters to select the ideal procedure based on the "severity" of the deformity.<sup>4</sup> Unfortunately, these surgeons have been basing their decisions on static radiographic projections that provide information in only two planes, primarily the transverse and sagittal planes.<sup>2,3</sup>

In the past, little attention has been given to the frontal plane while correcting HAV pathology. This is likely due to a lack of understanding and the thought that less technical procedures are adequate for correction. The distal, midshaft and basilar osteotomies that surgeons have traditionally used to correct hallux abducto valgus deformity provide mainly transverse plane correction. They do not address the primary level of deformity or the center of rotation angulation (CORA) as described by Paley and colleagues.<sup>5</sup> Instead, these procedures create a secondary deformity within the metatarsal primarily to address the transverse plane.

The lack of acknowledgement of the frontal plane could help explain why in an extensive review, Lehman reported the incidence of hallux valgus recurrence as high as 16 percent.<sup>6</sup> He also reported the incidence of hallux varus to be as high as 12 percent. These rates are of course variable but both are relatively high, considering the high amount of bunion procedures performed. Additionally, a recent survey of 105 foot and ankle surgeons displayed great disparity in decision-making on how to treat large bunion deformities.<sup>7</sup> It is unclear as to why there is such disparity although one can hypothesize that this could be due to a lack of understanding of the true deformity, or surgeon skill and comfort with certain procedures.

### What The Research Says About Hallux Valgus In Three Planes

Multiple recent publications have emphasized the true nature of hallux valgus deformity occurring in three planes.<sup>2,3,8-11</sup> More recently, in theory, frontal plane rotation is an under-evaluated aspect of the deformity. Researchers have demonstrated that without complete correction in all three planes, the sesamoid apparatus and the articular surface of the first metatarsal are not anatomic, therefore increasing the rate of radiographic recurrence.<sup>2,3</sup> It is recommended that preoperative and intraoperative evaluation of the deformity should include sesamoid axial radiographs to appreciate the sesamoid position underneath the crista of the first metatarsal.

In a hallux valgus deformity, the first metatarsal deviates from a stable sesamoid apparatus, owing to what appears to be transverse plane deformity. However, on the axial views, one can visualize the crista and appreciate the rotational aspect. DiDomenico and coworkers demonstrated that by destabilizing the tarsal metatarsal joint and then derotating the valgus great toe into a neutral position, the sesamoid complex and first metatarsal complex will reduce into an anatomic position and provide correction of frontal plane rotation of the sesamoid apparatus during a Lapidus procedure.<sup>11</sup>

Dayton and colleagues explained this in great detail in their cadaveric study.<sup>3</sup> The authors showed with manipulation of the metatarsal under AP radiography, the sesamoids laterally displaced with pronation and with supination, the sesamoids realigned underneath the metatarsal head. Scranton and Rutkowski first described the use of sesamoid axial radiographs to appreciate the frontal plane rotation of the metatarsal on the sesamoid apparatus in 1980.<sup>12</sup> They compared feet in a control group to those with hallux valgus deformity, showing that those with deformity had a mean pronation of 14.5 degrees. Mortier and colleagues followed up this work in 2012, performing a similar analysis with a mean of 12.7 degrees of pronation, which they attributed to first tarsometatarsal joint instability and not torsional change in the metatarsal.<sup>9</sup> Additionally, one can evaluate the frontal plane rotation on the AP radiograph by the tibial sesamoid position, proximal articular set angle, prominence of the medial eminence, lateral curvature of the metatarsal and lateral translocation of the proximal inferior first metatarsal tubercle.<sup>13</sup>

### What The Authors' Experience Reveals

In a prior study performed by DiDomenico and colleagues, intraoperative measurement of 19 patients with hallux valgus deformity revealed an average frontal plane deformity of 21 degrees.<sup>11</sup> This was equivalent to or exceeded the amount of transverse plane deformity in all the patients they evaluated. These findings corresponded with the work of Dayton and colleagues, who noted that frontal plane correction was undervalued and pivotal in the global correction of the deformity.<sup>3</sup> Addressing hallux valgus with a Lapidus arthrodesis allows for correction of the deformity in all three planes while avoiding the first MPJ and its inherent complications such as hallux varus, avascular necrosis, stiff joint, scar formation, etc.

DiDomenico and colleagues described the procedural approach using the hallux to derotate the metatarsal via ligamentotaxis.<sup>11</sup> By not exposing the first MPJ, all ligaments and capsular structures remain intact, allowing the surgeon to manipulate the frontal plane correction. By performing a lateral release and medial eminence resection, this destabilizes the joint and will not allow the surgeon to derotate in the frontal plane.

Many who disagree with this assessment will argue that more traditional methods have yielded successful and predictable results, and that it is unnecessary to alter their approach. However, as surgeons, our goal should be to provide the patient with the most successful and predictable procedure to correct their deformity.

Lagaay and colleagues performed a multicenter, retrospective chart review on the success rates of various procedures for hallux valgus.<sup>14</sup> They reviewed 646 patients who had a modified Chevron A-type osteotomy (20%), a modified Lapidus arthrodesis (34%), or a plain bone wedge osteotomy (24%) to correct hallux valgus deformity.

who had a modified chevron-austin osteotomy (27.0), a modified Lapidus arthrodesis (34.2) or a closing base wedge osteotomy (34) to correct hallux valgus deformity. Complications included recurrent hallux valgus, iatrogenic hallux varus, painful hardware, non-union and postoperative infection. The rates of revision surgery after Lapidus arthrodesis, closing base wedge osteotomy and chevron-austin osteotomy were similar with no statistical difference between them at 5 to 8 percent.<sup>14</sup> However, there was a notably higher incidence of hallux varus with distal osteotomies.

Okuda and colleagues in 2013 hypothesized that recurrence is likely due to inadequate reduction of the frontal plane deformity at the time of surgical correction.<sup>10</sup> The authors pointed to the lateral round sign of the metatarsal head and tibial sesamoid position as primary intraoperative indicators of complete correction. Frontal plane rotation, transverse plane deviation and sagittal plane instability all coincide to form a triplanar hallux valgus deformity, similar to the pes plano valgus deformity. Without addressing all three planes, correction would be inadequate as one sees in flatfoot corrections.

### In Conclusion

While some may remain skeptical of the recent trend of frontal plane deformity in hallux valgus, one should not ignore the data available on the subject. We would encourage all surgeons addressing hallux valgus deformity to reconsider their approach and how they preoperatively and intraoperatively assess their planned procedure and correction. While we understand true appreciation of the frontal plane aspect of the deformity can be difficult clinically, AP and sesamoid axial X-rays can yield valuable information as we referenced above. Additionally, multiple intraoperative techniques and devices are readily available to aid the surgeon. Adhering to tried and true surgical principles such as those established by Paley and colleagues regarding deformity correction has allowed the surgeon to produce consistent predictable results.

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For further reading, see "Addressing The Impact Of Frontal Plane Rotation On Bunion Repair" in the April 2015 issue of *Podiatry Today*, "How To Properly Align A Lapidus Bunionectomy In The Frontal Plane" in the June 2011 issue of the *DPM Blog* "Does Frontal Plane Rotation Really Matter In Bunions?" at <http://tinyurl.com/zccaldb>. To access the archives, visit [www.podiatrytoday.com](http://www.podiatrytoday.com).

## No.

Challenging the recent podiatric research, this author says an everted or pronated first metatarsal in patients with hallux valgus results from a foot deformity as opposed to a first metatarsal deformity, and emphasizes the importance of correcting the overall foot alignment rather than rotating the first metatarsal.

### By Doug Richie, Jr., DPM, FACFAS

A hot topic in the area of surgical procedures for treatment of hallux abducto valgus (HAV) is the possible need for correction of frontal plane deformity of the first metatarsal. This concept has been presented several times in past years at the Annual Scientific Conference of the American College of Foot and Ankle Surgeons, and was discussed again this year.<sup>1</sup>

The rationale for this new surgical approach is an assumption that the first metatarsal is "pronated" or everted with the HAV deformity. Thus, authors have proposed that a frontal plane correction, rotating the first metatarsal in the direction of inversion, is required to correct the deformity adequately.



For most of us who were well schooled in the pathomechanics of HAV deformity, this concept makes no sense at all. One has to ask: Who came up with this idea?

Scranton and Rutkowski in 1980 were among the first to describe a "pronated" position of the first metatarsal in HAV deformity.<sup>2</sup> Eustace and colleagues documented a similar observation in 1993.<sup>3</sup> Fourteen years later, Okuda took several radiographic measures of patients with HAV deformity and concluded that the first metatarsal was everted.<sup>4</sup> In 2013, Okuda described a "abduction-supination osteotomy" of the first metatarsal for correction of HAV.<sup>5</sup> Around the same time, DiDomenico and colleagues presented a frontal plane correction of the everted alignment of the first metatarsal when performing a Lapidus procedure for HAV deformity.<sup>6</sup>

A series of papers authored by Dayton and coworkers, all published in the *Journal of Foot and Ankle Surgery*, have driven home the concept that the first metatarsal is everted in most patients with HAV and that this frontal plane deformity requires correction that is best combined with a Lapidus procedure.<sup>7-11</sup> In these papers, the authors repeatedly challenge the original description of the axis of motion of the first ray of the human foot, first described by Hicks.<sup>12</sup> The justification for this challenge is the citation by Dayton and colleagues of two studies published almost 40 years ago by D'Amico and Schuster as well as Oldenbrook and Smith.<sup>13,14</sup>

The observation of isolated eversion of the first metatarsal with HAV deformity and the challenge of the Hicks description of the first ray axis of motion highlights the fallacy of the need to invert the first metatarsal in HAV surgery. I have a keen interest in this controversy as I participated in a study that clearly refuted the theory of motion of first ray motion as proposed by D'Amico and Shuster as well as Oldenbrook and Smith.<sup>15</sup> Our study was designed by Root and conducted by a group of students at the California College of Podiatric Medicine in 1980. In this study of 24 cadaver specimens, we showed that the first metatarsal always inverts with dorsiflexion and everts with plantarflexion relative to the remainder of the foot.

In our paper, we addressed the errors made by others who observe an everted position of the first metatarsal when the foot moves into maximum end-range pronation.<sup>15</sup> While the first ray dorsiflexes and inverts with foot pronation, movement of the entire foot into eversion/pronation carries the first ray into an overall position of eversion relative to the weightbearing surface. Herein is the major error in assuming that one must correct the first metatarsal into inversion in HAV surgery.

### Why An Everted First Metatarsal Results From A Foot Deformity

Radiographic measures of deformity and pathologies of the human foot measure angular relationships between segments of the foot itself. For example, the lateral talo-first metatarsal angle (Meary's angle) or the AP talocalcaneal angle (Kite angle) measure the relationships of segments within the foot. The intermetatarsal angle in HAV deformity measures the transverse plane relationship of the first and second metatarsals. Surgical procedures correct the alignment of the first metatarsal relative to the second metatarsal. The axis of the first ray, described by Hicks, measures the direction of the first metatarsal motion relative to the second metatarsal. This axis dictates that the first metatarsal inverts with dorsiflexion, a fact that more recent studies have verified using more modern and accurate techniques than those utilized by Hicks.<sup>16,17</sup>

In all of the radiographic studies of HAV patients that have demonstrated an everted position of the first metatarsal, the observation occurred with the foot on the ground

and the plane of reference was the ground itself, not the second metatarsal. In static stance, the first ray drives into dorsiflexion by ground reaction forces. According to the well-proven notion of the Hicks axis, the first metatarsal will invert with dorsiflexion. If the foot itself moves into pronation, the first ray will potentially end up pronated or everted to the ground even though it is actually inverted relative to the second metatarsal and the remainder of the foot. Therefore, this everted position of the first metatarsal in patients with HAV is the result of a foot deformity, not a first metatarsal deformity.

Understanding the influence of overall foot position, it is not surprising that weightbearing radiographs consistently show an everted position of the first metatarsal in patients with HAV deformity. Studies have verified that the only way the first ray could move into eversion is if the first ray is actually plantarflexed from its neutral position (rarely seen in patients with HAV) or if the entire foot has pronated and carried the first ray into eversion (much more common with HAV deformity).<sup>15</sup> In order to correct this everted position of the first metatarsal in patients with HAV deformity, a surgical procedure must correct pronation of the entire foot.

Consider a pediatric patient with femoral anteversion who has a resulting in-toed gait deformity. A compensation for femoral anteversion that occurs within the foot is subtalar joint pronation, which unlocks the midtarsal joint and results in forefoot abduction. With femoral anteversion, there will be an abduction deformity within the foot itself while the entire foot is actually adducted or in-toed from a more dominant deformity at the hip. No competent surgeon would correct the in-toed deformity in this child by operating on the foot itself when the cause of the transverse plane deformity lies more proximal. Furthermore, no surgeon would perform a procedure that would abduct the forefoot in this child with in-toed gait when this segment is already abducted.

The identical situation arises in patients with HAV deformity. Pronation of the entire foot causes the first metatarsal to be positioned in a pronated or everted position on the ground. The problem, therefore, is the position of the entire foot, not the first metatarsal. Why would a surgeon try to correct the frontal plane deformity of the foot by addressing the metatarsal itself? The first ray has compensated with dorsiflexion and inversion. Why would a surgeon rotate the first metatarsal further in the direction of inversion when the first metatarsal is already inverted relative to the rest of the foot?

#### What Structure Is Actually 'Pronated' In HAV Deformity?

A pivotal study quoted by advocates of correction of a "pronated" position of the first metatarsal is a semi-weightbearing computed tomography (CT) investigation by Kim and colleagues.<sup>18</sup> In this study, a coronal view of hallux valgus deformity revealed a "pronated position" of the head of the first metatarsal. However, the measurement of this pronated position of the first metatarsal followed the protocol of previously cited studies, which made the misleading measurement of the relationship of the head of the first metatarsal to the ground, not to the rest of the foot. This study, as others cited, did not control the position of the entire foot to the ground to ensure that pronation of the foot itself could lead to a distorted position of the first metatarsal. Furthermore, the authors of this study acknowledge the shortcoming of their semi-weightbearing CT study in stating "Ideally, the use of a weightbearing CT could have improved our study's outcome."<sup>18</sup>

Of more importance, the authors clarify that they did not measure a pronated position of the entire first metatarsal but limited their evaluation to the articular surface of the first metatarsal.<sup>18</sup> Instead of concluding that the entire first metatarsal was pronated, the authors clarify: "In conclusion, the present study confirmed the existence of pathologic pronation of the metatarsophalangeal apparatus in HV with the aid of several radiologic measurements."

What is critical is this clarification by the authors of this study that their findings were limited to the "metatarsophalangeal apparatus," which includes the articular cartilage and the sesamoid apparatus.<sup>18</sup> The pronated structures were not verified to include the entire first metatarsal and therefore, frontal plane surgical repositioning of the entire first metatarsal was not justified by this study.

It has been well recognized that adaptive changes occur in the head of the first metatarsal as the hallux moves into an abducted and valgus position.<sup>19</sup> The primary change occurs in the articular cartilage on the head of the first metatarsal with gradual lateral realignment. The lateral shifting of the proximal phalanx of the hallux not only deviates the proximal articular set angle (PASA) but also leads to the loss of cartilage medially and the creation of the medial eminence in the bunion deformity.<sup>20</sup>

Coronal imaging of the head of the first metatarsal in HAV patients has suggested a "pronated position," which most likely represents cartilaginous adaptation from retrograde forces of the valgus position hallux. Certainly, this does not represent or verify a "pronated" position of the entire first metatarsal in HAV patients. Verification of this concept comes from the only valid weightbearing CT study of HAV patients. Collan and coworkers looked at the frontal plane alignment of the first metatarsal to the ground in hallux valgus patients and concluded that first metatarsal bone rotation in either pronation or supination was not significant.<sup>21</sup> Instead, significant rotation in the direction of pronation occurred in the proximal phalanx of the hallux.

#### In Conclusion

Surgical procedures for HAV correct deformity of the first metatarsal relative to the second metatarsal and the rest of the foot, not relative to the ground. Therefore, surgeons should evaluate and correct the position of the first metatarsal relative to the second metatarsal, not to the ground. When one carries out accurate analysis of this relationship with weightbearing computed tomography studies of patients with HAV, it is clear that there is no frontal plane deformity of the first metatarsal.<sup>21</sup> The proper way to address the perceived everted position of the first metatarsal in patients with HAV deformity is to correct the overall foot alignment and not rotate the first metatarsal by itself in a direction contrary to its natural axis of motion. Further weightbearing CT studies are needed to determine whether frontal plane deviation of the cartilage in the head of the first metatarsal actually exists.

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