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Clarification of the Anatomic Definition of the Bunion Deformity

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ABSTRACT

Evolution of the terminology applied to the bunion deformity has progressed in parallel with our changing understanding of the deformity itself. Along this path of progression have been multiple terms, sometimes with multiple meanings. Hallux valgus and metatarsus primus varus are 2 of the most common terms for the deformity. Although commonly used, these descriptors can have multiple meanings, and inconsistencies in interpretation can lead to confusion. We propose a more detailed terminology to provide a more accurate description of the entire bunion deformity in 3 planes and for both the hallux and the metatarsal component of the deformity. The term we propose is *hallux abducto valgus with metatarsus primus adducto valgus*. An accurate understanding of the multiplanar position of the deformed foot is important for planning deformity correction. The descriptors in the terminology proposed will keep in the forefront the aspects of correction required for the first ray and hallux to be returned to an anatomically correct position.

During the past 150 years, many attempts have been made to accurately describe the etiology and progression of the bunion deformity. The terminologies used to describe the deformity have developed in parallel with the study of the pathologic progression of the deformity and observations of the anatomic position of the bones and joints involved. Multiple and, sometimes conflicting, terms have been used in describing the bunion deformity. The lack of standardization in the terminology has created confusion and inaccuracy when communicating. We propose a clarification of the terminology for the bunion deformity, which includes the position of the hallux and first metatarsal in 3 orthogonal planes and is based on the established anatomic definitions of the foot.

Early data from Durlacher (1) in 1845 purported a bunion to be an enlarged hallux metatarsophalangeal joint (MTPJ). Further development of the understanding of the deformity led Hueter (2) to recognize that it was not an enlargement of the first MTPJ, but rather a deviation of the hallux laterally. In the description by Hueter (2), hallux valgus indicated that the great toe (hallux) had deviated away from the midline of the body in the transverse plane (valgus). This deviation in the transverse plane can also be understood as abduction. The term *valgus* has also often been used to define an external rotation of the forefoot segments. Therefore, valgus can be interpreted as frontal plane rotation of the hallux, rather than the description by Hueter (2) of transverse plane deviation. One can see how this could create confusion when discussing the pathologic progression and abnormal positions of the hallux and metatarsal in a bunion deformity.

During the ensuing decades, additional observations led some to question whether the term *hallux valgus* accurately captured the true nature of the deformity. In 1924, Truslow (3) proposed a change in terminology from *hallux valgus* to *metatarsus primus varus*. The new term was intended to change the emphasis from the laterally deviated hallux to the medially deviated metatarsal, which he believed was the primary level of the deformity and the point at which deformity correction should be addressed. *Metatarsus primus varus* in the description of Truslow (3), and later as described by Lapidus (4), would indicate that the first metatarsal is angled toward the midline of the body in the transverse plane. This represents the first description of the primary level of the deformity located at the metatarsal cuneiform joint. Both *hallux valgus* and *metatarsus primus varus* are descriptors of the transverse plane position; however, both valgus and varus can be used to describe a frontal plane rotation, leading to confusion.

Although the origin is not clear, later terminology added a description of the frontal plane deformity of the great toe. This term, *hallux abductovalgus*, means that the great toe (hallux) has deviated away from the midline of the body in the transverse plane

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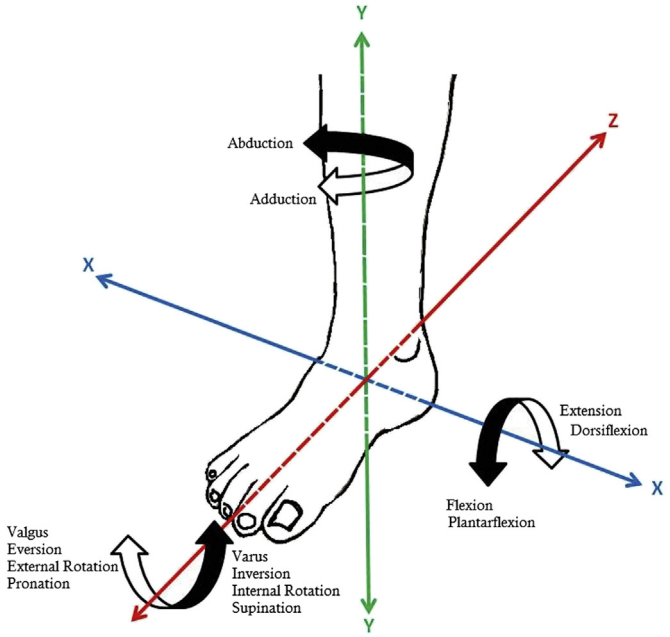

Fig. 1. The triaxial coordinate plane system labeled with equivalent terminology for motion of the foot about each axis. The y-axis shows the motions of abduction and adduction in the foot. The x-axis shows the motions of the foot known as flexion or plantar flexion in 1 direction and extension or dorsiflexion in the other. The z-axis shows the motions of the foot known as valgus, external rotation, eversion, or pronation in 1 direction and varus, inversion, internal rotation, or supination in the other. (From Kelikian AS. *Sarrafian's Anatomy of the Foot and Ankle: Descriptive, Topographic, and Functional*, pp. 507–508. Lippincott Williams & Wilkins, Philadelphia, 2011; http://lww.com.)

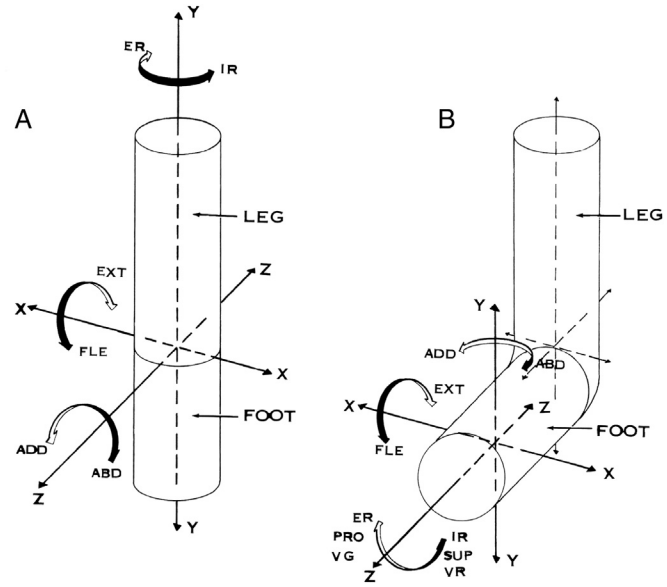

Fig. 2. (*A*) Axes of motion in the foot and leg of the embryo; the foot is aligned with the leg. (*B*) Axes of motion in the fetus with the foot at right angle to the leg. ER, external rotation; IR, internal rotation; EXT, extension; FLE, flexion; ABD, abduction; ADD, adduction; PRO, pronation; SUP, supination; VG, valgus; VR, varus. The vertical axis of ER, IR of the leg is now the longitudinal axis of the ER, IR of the foot. The longitudinal axis of ABD, ADD of the leg is now the vertical axis of ABD, ADD of the foot. The transverse axis of FLE, EXT remains unchanged. (From Kelikian AS. *Sarrafian's Anatomy of the Foot and Ankle: Descriptive, Topographic, and Functiona*l, pp. 507–508. Lippincott Williams & Wilkins, Philadelphia, 2011; http://lww.com.)

(abductus) and has rotated away from the midline of the body in the frontal plane (valgus) (Fig. 1). This descriptor used the definition of the word *valgus* that addresses frontal plane rotation. As discussed, valgus can mean deviation away from the midline of the body in the transverse plane, such as was used by Hueter (2). However, it can also refer to the frontal plane eversion about the longitudinal axis (Z-axis) of the foot, such as in hallux abductovalgus. If one uses the triaxial orthogonal coordinate system proposed by Huson (5) in 1987 and later explained by Sarrafian (6), valgus or external rotation about the Z-axis would more accurately describe the frontal plane rotational component of the deformity, rather than the transverse plane component (Fig. 2). This conceptual framework transposes the 3 cardinal planes used in the leg to the foot, with a change in the designation of the 3 planes owing to the foot position, which is 90° to the leg after normal embryologic rotation. We agree with Sarrafian (6) and Draves (7), who both noted that when specifically addressing the position of the foot, *varus* and *valgus* are better suited for describing frontal plane rotation around the z-axis and not medial and lateral angulations in the transverse plane (y-axis). We believe that the term *hallux abductovalgus* most accurately captures the multiplanar nature of the hallux component of the bunion deformity as it is currently understood. It also uses the conceptual framework best suited to observing and describing the position of the foot and its joint segments.

Just as the term *valgus* has multiple meanings, so also does *varus*. As stated, *varus* can indicate transverse plane deviation toward the midline of the body, such as in metatarsus primus varus. However, in the foot, varus can be defined as frontal plane inversion or internal rotation about the longitudinal axis of the foot (7). Thus, the term *varus* can lead to confusion if the investigator has not been careful to indicate the planar perspective being described. Again, if we use the triaxial orthogonal coordinate system as applied to the foot, *metatarsus primus adductus* would be the more accurate description of the transverse plane metatarsal deviation about the y-axis. However, unlike the hallux, an accepted term describing the multiplanar position of the metatarsal in a bunion deformity does not currently exist.

Part of the problem in assigning terminology to the metatarsal is that studies of the range of motion of the first ray add certain assumptions regarding the position of the metatarsal in a bunion deformity. As described by Hicks (8), the orientation of the axis of the first ray is from proximally and medially and plantarly to distally and laterally and dorsally. It produces a motion of dorsiflexion with inversion—or a varus frontal plane position. In contrast, the opposite direction of motion would combine plantar flexion with eversion—or a valgus frontal plane position. The inversion asserted to exist concurrently with dorsiflexion of the first ray gives the impression that in a bunion deformity the metatarsal itself is inverted (i.e., in a varus position in the frontal plane or z-axis).

The work by Hicks (8) was undertaken with the purpose of establishing normal axes of motion in the joints of the foot. Assumptions regarding the direction and magnitude of motion in a patient with a bunion have been based on this proposed axis orientation in a normal subject. This axis concept has been circumstantially applied to the bunion deformity and continually cited since the study by Hicks (8), with very little experimentation to confirm its accuracy when considering feet with bunion deformities. It has often been assumed that the direction and position of the first ray in feet with a bunion deformity follows the axis concept of Hicks (8) (i.e., dorsiflexion with inversion or varus). This is a tempting circumstantial association that has been made extensively during the past 60 years, but with little proof.

Multiple studies have supported the findings from Hicks (8) regarding the normal range of motion of the first ray (9–11). Despite these studies, and an institutional acceptance of axis of motion of Hicks (8), the findings regarding the first ray and its normal range of motion have been, in reality, conflicting. Other studies have asserted dorsiflexion with eversion of the first ray (12–14). We agree with Roukis and Landsman (15) that regardless of the study methods

used, no consensus has been reached regarding the normal range of motion of the first ray. Even if it were acceptable to apply the normal range of motion to the position of the metatarsal in a bunion deformity, that no agreement has been reached in published studies should be enough to prevent the practice.

It is important to note that in the original work by Hicks (8), he used the terms *extension supination* and *flexion pronation* to describe first ray motion. When referenced, his terminology has often been transposed to *plantar flexion eversion* and *dorsiflexion inversion*, respectively. The terms *supination* and *pronation* used when referring to uniplanar motion about a longitudinal axis can be synonymous with a variety of terms. According to Sarrafian (6) in his studies of lower extremity anatomy, the terms used to reference uniplanar motion about the longitudinal axis of the foot have included *pronation/supination*, *external rotation/internal rotation*, *valgus/varus*, and *eversion/inversion* (Fig. 1). Studies showing the metatarsal in a frontal plane valgus position have often used the term *pronation* to describe the position. Pronation when applied to the whole foot in an open kinetic chain describes a triplane motion (7); however, pronation when applied to the hallux or first metatarsal will be equivalent to frontal plane eversion or external rotation. This use of pronation and supination to describe uniplanar rotation has been conventionally used and understood with regard to the bunion deformity (Fig. 3).

In 1980, Scranton and Rutkowski (16) used axial radiographs to observe the pronated position of the metatarsal head in feet with and without a bunion. They found that in feet with bunion deformities the metatarsal head was in a pronated or valgus position averaging 14.5° (16). Feet lacking the deformity were only in a valgus position of 3.1° (16). A similar study undertaken by Mortier et al (17) in 2012 showed a significant pronation or valgus position of the first metatarsal in feet with bunion deformities. Although both studies used variations of axial radiographs to observe the frontal plane position of the metatarsal, a lack of standardization in both radiographic positioning and angular assessment prevented a comparison of the numeric values from giving meaningful quantitative information. However, a clear valgus position was present.

Additional studies have observed changes in the first metatarsal position on anteroposterior radiograph. Okuda et al (18) noted a valgus position created a distinct lateral rounding of the metatarsal head. This rounded appearance is the lateral plantar condyle of the metatarsal head becoming visible in the first inner space. D'Amico and Schuster (12) showed an increase in the observed lateral curvature of the metatarsal shaft as the plantar curvature becomes more laterally located with valgus positioning of the first metatarsal. Dayton et al (19) showed that as the metatarsal is rotated to a valgus position in vivo, after being freed from the ligamentous attachments at the first metatarsal cuneiform articulation, the sesamoids will appear to be laterally displaced. The sesamoids will appear to have moved from under the metatarsal head when, in reality, rotation has imparted the change in perspective (19).

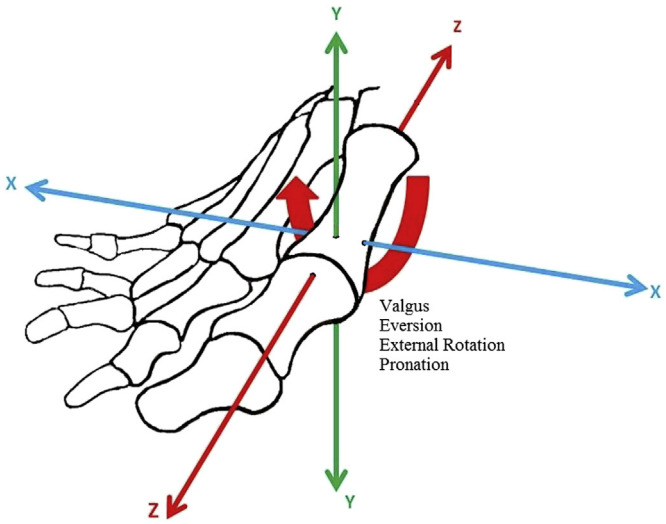

Fig. 3. Triaxial coordinate plane with z-axis motion about the first ray. The terms used to describe the direction of the motion indicated have included valgus, eversion, external rotation, and pronation.

Observation of the frontal plane component of a deviated metatarsal is not as easy as observing the frontal plane component of a deviated hallux. Because we now understand that the hallux, as well as the first metatarsal, component of a bunion is triplanar, the terms used to describe the deformity should include accurate anatomic positions. *Metatarsus primus varus* addresses only a single planar position and cannot fully describe the true nature of the deformity. Also, as stated, this can create confusion when varus has been used to describe the transverse plane position of the metatarsal, because the term *varus* can also be used to describe the frontal plane.

We propose a realignment of the commonly used anatomic descriptions of the bunion deformity to clarify the multiplanar components. The terminology must accurately capture the true nature of the deformity to prevent confusion when communicating. A term that captures the multiplanar nature of the metatarsal component is *metatarsus primus adducto valgus*, meaning that the first metatarsal (metatarsus primus) has deviated toward the midline of the body (adducted) and is in an everted position (valgus). We believe this terminology accurately follows the triaxial orthogonal coordinate system proposed by Huson (5) and clarified by Sarrafian (6) and provides a basis for clear communication regarding the deformity. If one uses the term *hallux abducto valgus* with the terminology we have proposed, we would have an anatomic definition of a bunion that would read *hallux abducto valgus with metatarsus primus adducto valgus*.

We believe this phrase accurately captures the multiplanar nature of the deformity along the entire segment of the first ray and great toe.

Recent studies have shown the power of rotational correction while addressing bunion deformities. In 2013, Dayton et al (20) and Okuda et al (21) showed that addressing the valgus rotational component of the bunion was integral to complete deformity correction, especially with respect to accurate first MTPJ and sesamoid alignment. Realignment of the sesamoid apparatus under an everted metatarsal head will leave the deforming force vectors intact and could be a source of deformity recurrence (17). We agree with others that in many cases, the residual abnormal sesamoid position combined with the lack of complete first MTPJ realignment has been a cause of recurrence of the bunion deformity. We believe this has resulted in part from the lack of correction of the valgus component of the metatarsal position.

An accurate understanding of the multiplanar position of the deformed foot is important for planning deformity correction. The descriptors in the proposed terminology will keep in the forefront the aspects of correction required for the first ray and hallux to be returned to an anatomically correct position. Additional research is required to understand the pathologic features leading to the valgus rotation of the metatarsal and the role of frontal plane rotation in the development of metatarsus primus adducto valgus.

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