The Journal of Foot & Ankle Surgery ■■ (2018) ■■–■■

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Review Article

Triplane Hallux Abducto Valgus Classification

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ARTICLE INFO

Level of Clinical Evidence: 5

Keywords:
bunion correction
CORA
first metatarsal
frontal plane rotation
hallux abducto valgus
hallux valgus
3-dimensional

ABSTRACT

One of the most common procedures performed in the foot and ankle is correction of hallux abducto valgus deformity or "bunion surgery." Most foot and ankle surgeons recognize the challenges associated with defining each patient's individual deformity and selecting the optimal procedure for the best long-term results. Using current 2-dimensional algorithms that focus on the severity of the transverse plane deformity, surgical outcomes have varied. In the past 10 years, high recurrence and complication rates for popular procedures have been reported. In the same period, the reported data have elucidated an evolving anatomic understanding of the bunion deformity, with an expansion to 3 dimensions, including the frontal/coronal plane. We present a new classification and approach for the evaluation and procedure selection for bunion surgery. We hope this conceptual treatise on hallux abducto valgus based on clinical consensus and current data will stimulate academic discussion and further research. This anatomic classification is based on the 3-dimensional anatomy of the first ray.

Medical classification systems are most useful if they provide an understanding of the deformity/pathology and then provide some useful insights into the predictable correction of the deformity. The optimal long-term results for bunion surgery have been elusive as demonstrated by the poorer than expected outcomes reported in recent studies (1–5). Bock et al (2) reported a 30% recurrence rate after the scarf procedure. Chong et al (4) discussed a 25.9% patient dissatisfaction rate after 5.2 years of follow-up for patients who had undergone bunion repair. Jeuken et al (5) performed a randomized controlled trial in 2016 and found a 75% recurrence rate in patients who had undergone a chevron or scarf procedure. These studies also reported radiographic recurrence rates ranging from 25% to as high as 78%. Although many bunion repair patients do well and have satisfactory results, the critical scrutiny of these results shows they could be improved. The evaluative parameters should include, not only patient satisfaction and other patient-reported outcome measures, but also anatomic realignment and recurrence of deformity, in particular, because patients are living longer and having more productive lives.

Currently, the most common classification used to determine procedure selection is a severity-based system that relies primarily on the first intermetatarsal angle (IMA) and other transverse plane angular measurements taken from an anteroposterior (AP) radiograph (6). Condon et al (7), in 2002, described the classic considerations in hallux abducto valgus (HAV), referencing the first IMA as normal (<9°), mild (9° to 11°), moderate (11° to 16°), and severe (>16°). Using classification, mild to moderate deformities would require a distal first metatarsal osteotomy, and more "severe" deformities would require more proximal osteotomies or first tarsometatarsal (TMT) fusions. Using this historic 2-dimensional framework, well over 100 procedures have been proposed to treat the HAV deformity with a primary focus on a transverse-plane metatarsal osteotomy at various levels combined with soft tissue balancing procedures at the first metatarsophalangeal (MTP) joint. Deenik et al (8) systematically reviewed the reported data to better understand the evidence basis for classifying HAV deformities according to angular measurements. They concluded that "treatment algorithms for HAV are primarily based on expert opinions and

Financial Disclosure: The authors are consultants for Treace Medical Concepts.
Conflict of Interest: None reported.
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https://doi.org/10.1053/j.jfas.2018.02.008

Table
Triplane hallux valgus classification and treatment algorithm

Class	Anatomic Findings	MTP Joint Status	Treatment Recommendation
1	Increased HVA and IMA No first metatarsal pronation evident on AP or sesamoid axial radiograph Sesamoids might be subluxed	No clinical or radiographic evidence of DJD	Metatarsal osteotomy or TMT correction; sesamoid release to help realign complex
2A	Increased HVA and IMA First metatarsal pronation evident on AP and sesamoid axial radiographs No sesamoid subluxation on Axial	No clinical or radiographic evidence of DJD	Triplane correction, including first metatarsal inversion, with or without lateral capsulotomy
2B	Increased HVA and IMA First metatarsal pronation evident on AP and sesamoid axial radiographs With sesamoid subluxation on Axial	No clinical or radiographic evidence of DJD	Triplane correction, including first metatarsal inversion plus conservative lateral capsular release before correction
3	Increased HVA and IMA; >20° MTA	No clinical or radiographic evidence of DJD	Metatarsal 2 and 3 transverse plane correction; metatarsal osteotomy or TMT correction per class 1 and 2 recommendations
4	Increased HVA and IMA with or without first metatarsal pronation	Clinical and or radiographic evidence of DJD	First MTP arthrodesis preferred; joint arthroplasty

Abbreviations: AP, anteroposterior; DJD, degenerative joint disease; HVA, hallux valgus angle; IMA, intermetatarsal angle; MTA, metatarsus adductus; MTP, metatarsophalangeal; TMT, tarsometatarsal.

are not supported by level 1 and 2 evidence." Of the parameters used to define the deformity in algorithms, the hallux valgus angle (HVA) was found to be the "single predictive parameter." Historically, the reported data support the HVA and metatarsal 1-2 angle as predictive radiographic indicators of the bunion deformity.

The search for consistent and effective methods for evaluation and management of the bunion deformity has continued for decades with elusive results, and attempts to classify the HAV deformity are numerous. This has resulted in part because the first metatarsal is not usually intrinsically deformed, despite a multitude of "corrective" osteotomies that have been used (9,10). Mizuno et al (11), in 1956, reported that a detorsional osteotomy should be performed for hallux valgus repair to address the valgus rotation of the first metatarsal. Scranton and Rutkowski (12), in 1980, studied 35 cadaveric specimens and found a significant valgus rotation in the bunion group (14.5°) versus the normal group (3.1°). The current data have demonstrated that the HAV deformity is a 3-dimensional condition of the first ray with the anatomic center of rotation angulation (CORA) at the first TMT joint (TMTJ) (13–20). Specifically, it has been consistently demonstrated that frontal/coronal plane rotation of the metatarsal is commonly associated with a HAV deformity, making it a 3-plane deformity. Three-dimensional imaging by Kim et al (18) demonstrated that ≤87% of HAV patients will have a frontal/coronal plane metatarsal rotational component to the deformity. Furthermore, the lack of consideration and treatment of all 3 planes of the deformity have been implicated as potential factors for deformity recurrence (21). With the new information highlighting the existence of frontal/coronal plane rotation of the first ray, it is necessary to consider a new classification system that will clarify both the deformity and a logical triplane anatomic algorithm for treatment. In creating this new classification, an attempt was made, not only to identify the key components of the HAV deformity in all 3 anatomic planes, but also to highlight the key deformities that can significantly affect the outcome of procedures on the first ray.

We present this classification specifically to initiate academic discussion and to generate scientific interest regarding the shortcomings of the common severity-based methods (Table). We hope the use of this system will spark interest in further research and higher levels of evidence. The individual classes are designated by identification and understanding of the key pathologic alignments in all 3 anatomic planes. Therefore, this classification is intended to make surgical interventions more comprehensive for all contributing pathologies. The assessments needed to implement this classification include both clinical assessment of MTP joint health and mobility and radiographic assessment of all 3 planes of metatarsal alignment (transverse, sagittal, frontal/coronal). At a minimum, this radiographic assessment of the foot will require AP, lateral, and axial sesamoid weightbearing radiographs.

Triplane HAV Classification

Class 1

In the class 1 deformity, HAV is present and the IMA is increased only in the transverse plane. No frontal/coronal plane rotational deformity of the first metatarsal will be present in class 1 deformities. Also, no clinical or radiographic indicators of MTP joint degenerative joint disease should be present. Sesamoid subluxation might or might not be present. From semi-weightbearing computed tomographic (CT) scan results, this less common type of deformity might occur in 12.7% of HAV cases (Fig. 1) (19).

Class 1 deformities can be treated using a number of transverse plane corrective procedures, including distal and midshaft first metatarsal osteotomies, because no frontal plane rotational component is present. Additional distal soft tissue procedures might or might not be necessary, depending on the presence of sesamoid subluxation.

Class 2

Class 2 HAV is subdivided into class 2A and class 2B and is defined by an increased HVA and increased IMA with the concurrent presence of frontal/coronal plane pronation/eversion of the first metatarsal. This can be best appreciated on sesamoid axial views. Kim et al (18) described the α-angle to measure pronation in their study. This is the angle formed by the line crossing the plantar condyles of the first metatarsal with respect to the horizontal surface (Fig. 2). They defined pronation as an angle >15.8° (18). Puccinelli et al (20) found in their CT study that the normal pronation observed was 0.8°. As such, when pronation is observed on axial views and correlates with the "apparent" sesamoid subluxation on the AP radiographic projection, rotational deformity correction in the frontal plane should be considered. Just as with class 1, no clinical or radiographic indicators of MTP joint degenerative joint disease should be present. Class 2 might represent