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Radiographic Relevance of the Distal Medial Cuneiform Angle in Hallux Valgus Assessment

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ABSTRACT

The angle formed by the distal articular facet of the medial cuneiform has been evaluated and discussed by various investigators. However, no consistent method has been available to radiograph and measure this entity. The wide variability of the angle is not conducive to comparative analysis. Additionally, investigators have noted that the angles observed (obliquity) vary greatly because of changes in radiographic angle, foot position, rotation of the first ray, and declination of the first metatarsal. Recognizing that these variables exist, we propose a reproducible assessment using digital radiography and application of deformity of correction principles. Our results have indicated a mean distal medial cuneiform angle of 20.69° in normal feet, 23.51° with moderate hallux valgus, and 20.41° with severe hallux valgus deformity. The radiograph beam was kept at 15° from the coronal plane. An inverse relationship was found between the distal medial cuneiform angle and bunion severity. This was in contrast to our expected hypothesis. The overall angle of the first metatarsal–medial cuneiform did, however, correlate with the severity of the bunion deformity ($p < .000$). The obliquity values and intermetatarsal angles changed in direct relationship to the radiographic projection angle. This illustrates the importance of using standardized radiographic projection angles. We conclude that the 1-dimensional standard anteroposterior radiograph with assessment of the distal medial cuneiform angle cannot adequately demonstrate the pathologic features of hallux valgus. A better indicator appears to be the first metatarsal–medial cuneiform angle. This pathologic entity is a 3-dimensional one that incorporates the joint morphology of the first ray, triplane osseous positioning, and soft tissue imbalances. Perhaps, 3-dimensional computed tomography imaging will provide better insight into this entity.

The obliquity of the distal medial cuneiform facet (distal joint orientation line) has been discussed often, with great variability reported since addressed by Morton (1) in 1927. Several investigators have suggested an atavistic etiology precluding to hallux valgus (1–3). Many investigators believe that the apex of the first ray deformity with hallux valgus lies within the first metatarsal cuneiform joint (4–10). Arthrodesis of the first metatarsal cuneiform joint for repair of hallux valgus was first addressed by Albrecht (9) in 1911 and later popularized by Lapidus (11) in 1934. With additional understanding of first ray mechanics and review of the success rates for various available bunion procedures, the arthrodesis technique at the first metatarsal cuneiform joint (Lapidus) has evolved to be a frequently used procedure for hallux valgus repair (7,12). Sanicola et al (13) reported that many variables are present in the angle assessment of the medial cuneiform. Triplane motion occurs about this joint, affecting the radiographic assessment from the actual anatomic angle. They found that the metatarsal declination and frontal plane motions affect this angle. Dayton et al (14) also proposed a frontal plane influence. In contrast, Sanicola et al (13) found the average obliquity angle to be approximately 15.1° both anatomically and radiographically. A review of the published data did provide us with a universal method to measure this joint. This pertains to both the actual osseous measurement and the radiographic technique. We found >5 different methods to radiographically measure the distal articular surface of the medial cuneiform. Although all methods used the distal joint orientation line, no consistency was found for the reference line. Brage et al (15) used the medial surface of the cuneiform, and Doty et al (16) used the angle formed by Chopart's joint. Additionally, the radiographic technique has varied greatly, from Doty et al (16) using 20° craniocaudally from the coronal plane to Brage et al (15) referencing the x-ray beam from the transverse plane. This variability has rendered comparison studies inaccurate and invalid.

Our goal in the present prospective radiographic study was to provide a consistent and universally accepted technique to evaluate

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this joint with standard anteroposterior (AP) radiographs. We also hoped to establish normal values for both bunion and normal feet to facilitate the surgeon in preoperative planning. Additionally, we wanted to evaluate the hypothesis that the observed obliquity of the cuneiform would correlate with an increased intermetatarsal angle (IMA) of the first and second metatarsals.

Patient and Methods

We prospectively selected (at random) 25 participants with normal feet (group A) and 25 participants with hallux valgus (group B). The selection occurred during a 4-month clinical experience (September 2014 to January 2015) from the senior author's (D.J.H.) practice. The selection criteria for both groups were that previous first ray surgery had not been performed and participant age ≥18 years. Group A included those without subjective or clinical evidence of hallux valgus deformity and an IMA of <10°. Group B included those with evidence of hallux valgus with an IMA >10°. A moderate deformity was defined as an IMA between 10° and 15° and a severe deformity as an IMA >15°. These criteria were similar to those used by Dayton et al (14). Standard weightbearing radiographs were taken with the participants standing in normal angle and base of gait. The radiographic projection was from cranially to caudally, 15° and 30° from the coronal plane (Fig. 1). The 15° angle was used in the present study, because we believe it to be the more common projection technique for foot and ankle surgery, similar to Coughlin and Freund (17). All measurements were taken by the same examiner (A.S.) using the digital software analysis associated with 20/20 Imaging® (Lake in the Hills, IL). The software included normal angle assessments such as the IMA and Cobb angle. Because the cuneiform bone is a short, irregularly shaped cancellous bone, the mechanical axis instead of the anatomic access was used (Fig. 2). The lateral angle formed by the distal joint orientation line and a line perpendicular to the mechanical axis could potentially be called the mechanical lateral distal medial cuneiform angle in accordance with the deformity of correction terminology (18). However, to simplify, we abbreviated this to the distal medial cuneiform angle (DMCA). Additional measurements were also taken for the IMA, first metatarsal–medial cuneiform angle, mechanical axis of the medial cuneiform to the Brage line, and the joint orientation line to the Brage line for comparative purposes.

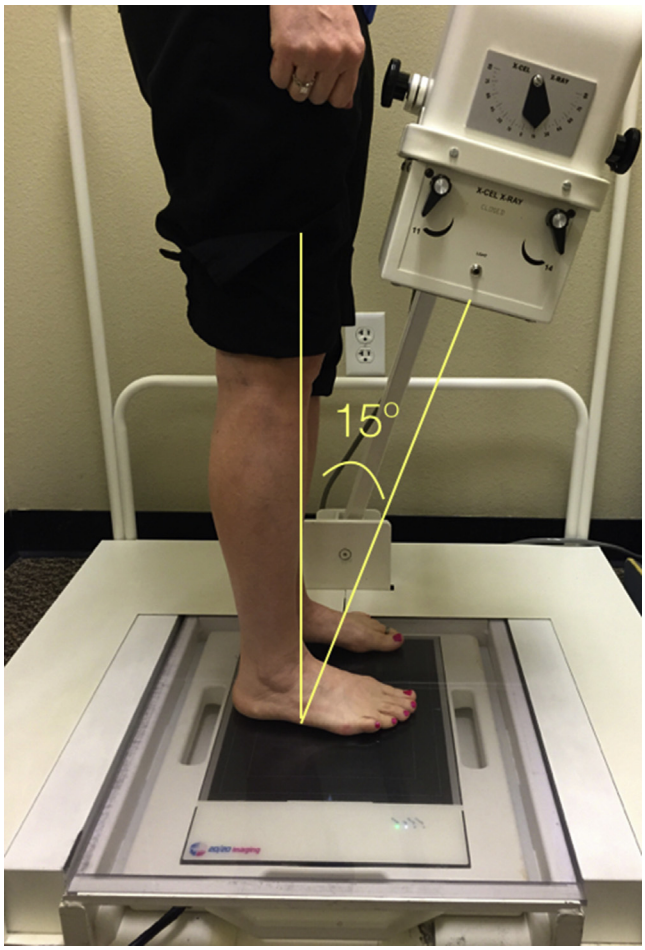

Fig. 1. View showing angle of radiograph projection beam.

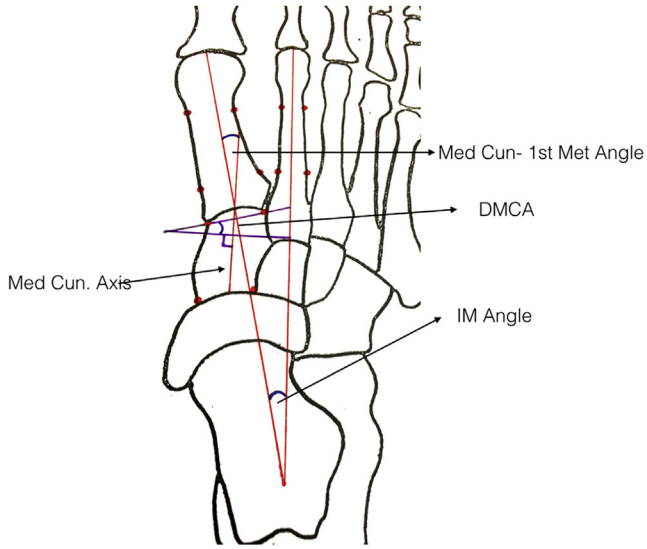

Fig. 2. Diagram showing the different angles. Cun, cuneiform; DMCA, distal medial cuneiform angle; IM, intermetatarsal; Med, medial; Met, metatarsal.

Statistical Analysis

Descriptive statistics were computed, and statistical analysis was performed using the Statistical Package for Social Sciences for Windows, version 20.0 (IBM SPSS Statistics, Chicago, IL). Descriptive statistics were computed for all radiographic measurements. Paired 2-sample *t* tests were used to compare the DMCA and IMA taken at both 15° and 30°. One-way analysis of variance was performed to compare the DMCA

Table 1
Patients in normal group

Patient No.	DMCA		IMA		First Metatarsal–Cuneiform Angle	
	At 15°*	At 30°*	At 15°*	At 30°*	At 15°*	At 30°*
1	17.9	14.3	5.9	6.1	16.4	17.6
2	19.7	12.7	6.7	8.8	22.5	20
3	19.4	5.3	4.4	6.4	18.3	16.8
4	18.2	1	9.5	9.8	18.4	16.2
5	11.8	9.3	6.9	5.8	19.8	15.3
6	17.0	6	6.1	5.0	19.7	14.5
7	5.5	19	9.1	8.9	8.9	9.1
8	29.1	9.3	7.6	6.8	16.5	17.5
9	18.2	3.1	8.0	8.3	14.7	14.8
10	26.4	18.1	5.5	5.2	25.9	23.3
11	27.1	9.3	8.5	5.6	21.4	18.4
12	21.1	0.9	4.1	4.7	6.0	4.1
13	14.2	−8.2	6.4	5.1	12.0	9.1
14	23.7	0	9.5	6.7	20.3	18.3
15	17.6	8.3	9.4	8.4	19.1	14.9
16	30.5	18.1	4.1	3.7	23.9	21.6
17	27.2	4.1	8.1	9.2	26.0	22.1
18	19.4	6.5	7.6	6.9	19.2	14.7
19	28.6	17.3	4.6	3.9	20.3	18.7
20	23.6	6.4	9.4	8.2	20.0	17.6
21	20.9	11.7	8.5	9.3	23.0	22.9
22	11.9	15.3	8.9	8.4	18.1	20.3
23	26.9	16.1	3.6	2.3	20.7	19.9
24	19.4	5.6	5.4	5.2	15.1	15.5
25	22.0	15.2	8.3	7.6	17.5	15.6
Mean	20.692	8.988	7.044	6.652	18.548	16.752

Abbreviations: DMCA, distal metatarsal–cuneiform angle; IMA, intermetatarsal angle.
* Radiographic projection x-ray beam at 15° or 30° from frontal plane.