

Sesamoid Position in Healthy Volunteers Without Deformity: A Computed Tomography Study



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ABSTRACT

We used coronal computed tomography to determine the normal sesamoid position in 20 healthy volunteers. The sample involved 40 feet (20 left [50%] and 20 right [50%]) in 20 volunteers, including 11 females (55%) and 9 males (45%). The relationship between the first metatarsal head and the sesamoid complex was categorized as Yildirim grade 0 in every case (100%). The mean width of the foot was 77.7 ± 5.8 mm, and the ratio of the foot width to the distance from the second metatarsal head to the tibial sesamoid was $39.6\% \pm 2.02\%$. Based on our findings, we consider Yildirim grade 0 to be the normal sesamoid alignment.

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Some investigators have emphasized the relevance of restoring the anatomic relationship between the sesamoid complex (SC) and the first metatarsal head when hallux valgus is surgically corrected (1–7) and that failure to restore the alignment of the sesamoids has been associated with recurrence of hallux valgus (1,8–12). In cases of hallux valgus, the SC takes a pathologic intermediate position between the first and second metatarsal heads, resulting in a predominantly lateral force on the first metatarsophalangeal joint (MTPJ) that increases the abduction vector of the first toe, leading to an increase in the metatarsophalangeal abduction (hallux abductus) angle (8,12–15). When radiographs are used as a guide to the degree of structural realignment of the first MTPJ, surgeons need to know the normal position of the SC, so that it can serve as a reference point to determine when adequate correction has been achieved. In 1984, Smith et al (16) described the normal position of the SC as grade 0 and 1 when viewed on standard weightbearing anteroposterior (AP) radiographs. Thus, many surgeons consider this reference to represent the normal alignment of the first MTPJ. Furthermore, it has become well known that the normal position of the SC relative to the second metatarsal is fixed (9,17,18), although its relation to the width of the foot has not been rigorously defined. The aim of our investigation was to further

assess the normal position of the SC relative to the first metatarsal head and to define its relationship with the width of the foot.

Materials and Methods

We undertook a cross-sectional study using descriptive statistics to describe the observed relationships among the SC, first metatarsal head, and the width of the foot in healthy volunteers without hallux valgus deformity. No comparisons were made with patients with hallux valgus deformity. To be eligible to participate, the volunteers were required to be ≥ 18 years old, have a body mass index < 35 kg/m², to be without complaints of foot symptoms or deformities of any sort, and to not have experienced previous foot injury or undergone foot surgery. To qualify as free of pedal deformity, for the purposes of our investigation, the volunteers were required to display “normal” values for the first intermetatarsal angle (IMA) and first MTPJ (hallux abductus [HA] angle; i.e., $< 10^\circ$ and $< 16^\circ$, respectively) (19). The measurement technique is detailed in the next paragraph. All the volunteers were evaluated by 2 orthopedic surgeons (M.A., C.V.) experienced in foot surgery (15 and 35 years of experience, respectively), and every participant provided written consent to participate in the present study.

Radiologic analysis of the feet was performed using AP weightbearing radiographs to determine inclusion eligibility. If the subject was included in the study, coronal and axial computed tomography (CT) scans were procured. Once included in the study, the standard radiographs and CT scans were assessed by a single musculoskeletal radiologist (J.D.A.) with > 25 years of experience. The AP radiographs were obtained with the participant in the standing position, and the first IMA and first MTPJ (HA) angles were measured as described by Karasick and Wapner (19). Specifically, the first IMA was measured as the angle formed by the intersection of the long axes of the first and second metatarsals, with an angle $< 10^\circ$ considered normal. The first MTPJ (HA) angle was measured as the angle formed by the intersection of the long axes of the first metatarsal and proximal phalanx of the hallux, with an angle $< 16^\circ$ considered normal.

Sesamoid coronal and foot axial CT scans were obtained using the Siemens Sensation 64 rows (Siemens Medical Solutions, Erlangen, Germany) set to the following

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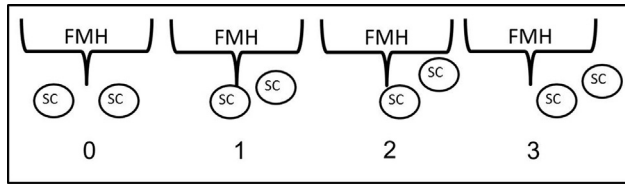


Fig. 1. The Yildirim computed tomography classification of the position of the first metatarsophalangeal sesamoids relative to the first metatarsal head (FMH). Numbers indicate Yildirim grade. SC, sesamoid complex.

parameters: 1-mm thickness, 1-mm pitch, an acquisition kernel of 30, and a 1-mm reconstruction width. The sesamoid position was measured on the CT scan using the method described by Yildirim et al. (20), which is an extension of the 4-grade Walter-Müller tangential radiographic view previously described by Smith et al (16) (Fig. 1). In this system, the position of the SC is defined as follows: grade 0, the medial sesamoid is entirely medial to the intersesamoid ridge; grade 1, less than half the width of the medial sesamoid is subluxed laterally; grade 2, more than one half the width of the medial sesamoid is subluxed laterally; and grade 3, the medial sesamoid is entirely lateral to the intersesamoid ridge. To date, grades 0 and 1 have been considered normal (16).

The second metatarsal-to-tibial sesamoid distance was determined in millimeters by measuring the distance from the medial cortex of the tibial sesamoid to the frontal plane bisector of the second metatarsal shaft (Fig. 2) (17). The width of the foot was determined in millimeters by measuring the distance from the medial cortex of the tibial sesamoid to the lateral cortex of the fifth metatarsal head (Fig. 3). Finally, the second metatarsal-to-tibial sesamoid distance was divided by the width of the foot to obtain the ratio of the 2 measurements. This ratio could be important for the determination of the displacement of the first metatarsal necessary in hallux valgus surgery to obtain the described ratio.

Results

A statistical description of the participants in our series and our results are listed in the Table. Our series included 20 volunteer participants, including 11 females (55%) and 9 males (45%). All 20 volunteer participants underwent bilateral foot evaluation. Therefore, a total of 40 feet, 20 left (50%) and 20 right (50%), were included in the analyses. The mean age of the participants was 33.4 (range 23 to 61) years, and all 20 were white and of Spanish nationality. Their mean height was 171 (range 150 to 190) cm, their mean weight was 68.3

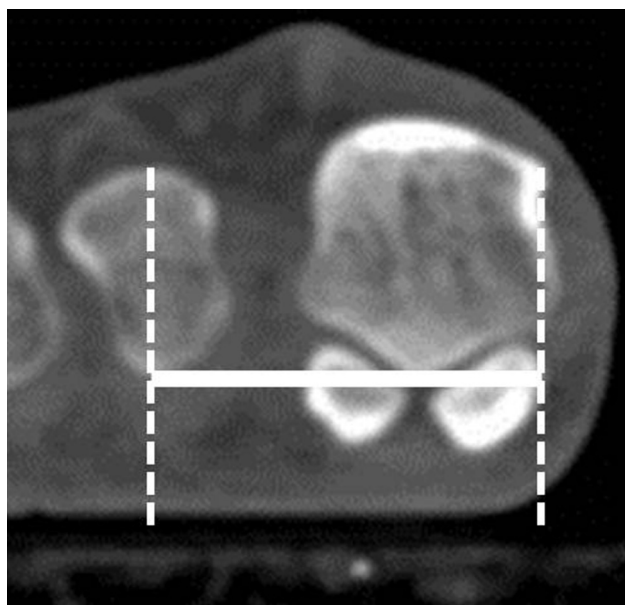


Fig. 2. The second metatarsal-to-tibial sesamoid distance was determined in millimeters by measuring the distance from the medial cortex of the tibial sesamoid to the frontal plane bisector of the second metatarsal shaft.

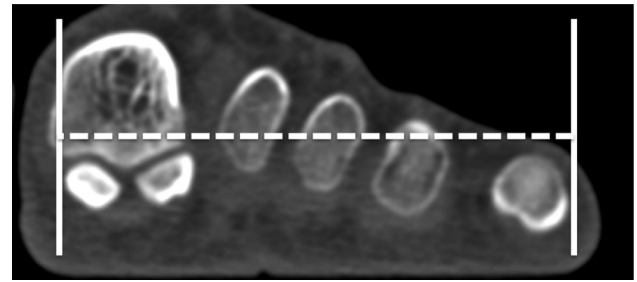


Fig. 3. The width of the foot was determined in millimeters by measuring the distance from the medial cortex of the tibial sesamoid to the lateral cortex of the fifth metatarsal head.

(range 51.2 to 97.8) kg, and their body mass index was 24.3 (range 19.2 to 32.8) kg/m². In each foot (100% of the participants), the relationship between the first metatarsal head and the SC was Yildirim grade 0 (Fig. 4). The mean first IMA was 3.7° ± 1.6° (range 2.1° to 5.2°), and the mean first MTPJ (HA) angle was 10.8° ± 3.03° (range 4° to 15°). The mean second metatarsal-to-tibial sesamoid distance was 30.7 ± 3.7 (range 21.4 to 39.4) mm, the mean width of the foot was 77.7 ± 5.8 (range 70.1 to 90.9) mm, and the mean ratio of the second metatarsal-to-tibial sesamoid distance to the width of the foot was 39.6% ± 2.02% (range 36.6% to 43%).

Discussion

In the present investigation, we observed a consistent Yildirim grade 0 sesamoid position in adult volunteers without evidence of pedal deformity. Hence, we concur with the general consensus among foot surgeons that Yildirim grade 0 represents the “normal” position of the SC. Whether Yildirim grade 1 can also be considered normal, we could not determine because none of our volunteer participants in the present investigation displayed a SC position of Yildirim grade 1. The generally accepted consensus of grades 0 and 1 as normal stems from the 1984 report by Smith et al (16), who based their guidelines on observations of standing AP radiographs of 8 feet. Their observations revealed 4 feet (50%) with a SC position of grade 0 and 4 (50%) with a SC position of grade 1. Later, in 2005, Yildirim

Table
Statistical description of series of volunteers and outcomes (N = 40 feet in 20 participants)

Characteristic	Value
Age (y)	
Mean ± standard deviation	33.4 ± 10.57
Range	23 to 61
Female sex (n)	22 (84.6%)
Bilateral foot involvement (n)	20
Sesamoid complex Yildirim grade 0 (n)	40 (100%)
First intermetatarsal angle (°)	
Mean ± standard deviation	3.7 ± 1.6
Range	2.1 to 5.2
First metatarsophalangeal (hallux abductus) angle (°)	
Mean ± standard deviation	10.8 ± 3.03
Range	4 to 15
Second metatarsal-to-tibial sesamoid distance (mm)	
Mean ± standard deviation	30.7 ± 3.7
Range	21.4 to 39.4
Width of the foot (mm)	
Mean ± standard deviation	77.7 ± 5.8
Range	70.1 to 90.9
Second metatarsal-to-tibial sesamoid distance to width of foot ratio (%)	
Mean ± standard deviation	39.6 ± 2.02
Range	36.6 to 43

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