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Lateral Sesamoid Position Relative to the Second Metatarsal in Feet With and Without Hallux Valgus: A Prospective Study

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ABSTRACT

We sought to determine whether hallux valgus displaces the sesamoid bones laterally away from a stationary first metatarsal or whether the first metatarsal head is displaced medially from the stationary sesamoids, which remain in position relative to the rest of the forefoot. We reviewed weightbearing radiographs in the dorsal plantar view of 128 consecutive patients (149 feet) seen over 2 months in 2014. Of these, 82 feet (55%) had a hallux valgus angle of $>15^\circ$ (hallux valgus group) and 67 feet (45%) had an angle of no more than 15° (control group). We measured the absolute distances from the center of the lateral sesamoid and the first metatarsal head to the long axis of the second metatarsal. Next, the relative distances, defined as the ratio of these 2 absolute distances to the length of the second metatarsal, were calculated to adjust for foot size. Both the absolute and the relative distances from the center of the first metatarsal head to the second metatarsal differed significantly between the 2 groups and correlated positively with the hallux valgus angle and first intermetatarsal angle. However, neither the absolute nor the relative distance to the lateral sesamoid bone differed significantly between the groups, nor did they correlate with either of the 2 angles. Thus, despite medial shifting of the first metatarsal in hallux valgus, the lateral sesamoid retains its relationship to the second metatarsal in transverse plane. Its apparent lateral movement is a radiographic misinterpretation. Awareness of this misinterpretation should improve the success of corrective surgery.

Two sesamoid bones are nearly always present at the first metatarsophalangeal joint. They lie on either side of the flexor halluces longus and are connected by an interosseous ligament, although congenital absence of the medial sesamoid has been infrequently reported (1).

Sesamoid subluxation away from the head of the first metatarsal is commonly found in feet with hallux valgus (HV) and is important in disease progression and the potential for recurrent deformity (2–4). Many studies have investigated the relative location and articulation between the sesamoids and the first metatarsal (4–10). However, not knowing the actual location of the sesamoids with respect to the rest of the forefoot can confuse corrective operations for HV. For example, the question remains whether the sesamoids should be pulled medially to restore their relationship with the first metatarsal head or the first metatarsal head should be pulled back to the sesamoids.

Many investigators have also proposed that, in reality, the subluxation is caused by the first metatarsal head drifting medially away from the sesamoids—that is, the sesamoids actually maintain their position (11–18). However, few to date have systematically investigated the actual relationship between the lateral sesamoid and the second metatarsal in feet with different hallux valgus angles (HVAs) or intermetatarsal angles (IMAs), but this relationship is also instructive for corrective operations. For example, should only the ligament between the sesamoids and the first metatarsal head be released, or should the soft tissue connecting with lateral metatarsals also be cut.

We sought to determine whether the lateral sesamoid actually moves laterally in HV or whether its apparent lateral movement is a radiographic misinterpretation. Thus, we compared, in a prospective cohort study, the position of the lateral sesamoid bone and the first metatarsal head relative to the second metatarsal on weightbearing dorsal plantar (DP) radiographs of feet with and without HV. We also

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correlated these distances with the HVA and first IMA to determine whether the position of the sesamoids was associated with HV.

Patients and Methods

Patients

The institutional review board of our hospital approved the study. All patients gave written informed consent to participate. All the patients who had attended our outpatient department for HV or other foot problems from August 1 to September 30, 2014 were eligible for the study to achieve the estimated sample size. Patients <20 years old and those with foot deformities, infection, or a history of trauma or surgery were excluded.

After the purpose of the research was explained and informed consent obtained, standard weightbearing DP radiographs were taken of the affected feet, with the central beam inclined at 15° from the coronal plane and targeted at the midtarsal joints. The tube-to-cassette distance was 1 m. Feet with an HVA of >15° were classified as having an HV deformity, and those with an angle of no more than 15° were classified as controls. Because we merely obtained conventional DP radiographs, HV in our study was defined only according to the transverse plane deformity.

Measurements

Measurements were mainly taken using the Centricity® Web, version 3.0, digital viewing system (GE Healthcare, Cleveland, OH) by the first author (X.G.). The HVA was measured between the long axes of the first metatarsal bone and the proximal phalanx, and the IMA was measured between the long axes of the first and second metatarsal (Fig) (19). All these lines should be the mechanical axes as defined by Paley and Tetsworth (20). In brief, the axis of the proximal phalanx was drawn through the center of the proximal articular surface and the center of the distal end of the diaphysis. The axis of the second metatarsal was drawn from the center of the distal articular surface to the center of the proximal end of the diaphysis. Finally, the first metatarsal axis was drawn to connect the center of the first metatarsal head and the center of the first metatarsal base, as described by Miller (21). We believe this method is the most precise and least-biased method of identifying the axis of the first metatarsal (22). The lateral sesamoid position (LSP) relative to the second metatarsal in the present study was defined as the shortest distance from the center of the lateral sesamoid to the axis of the second metatarsal (Fig.). The position of the first metatarsal (M_1P) was defined as the shortest distance from the center of the first metatarsal head to the axis of the second metatarsal. To adjust for differences in foot size, the deviation coefficient for the lateral sesamoid (LSDC) and the deviation coefficient for the first metatarsal (M_1DC), respectively, were defined as follows:

$$LSDC = LSP/LM_2 \text{ and } M_1DC = M_1P/LM_2$$

where LM_2 is the length of the longitudinal line of the second metatarsal.

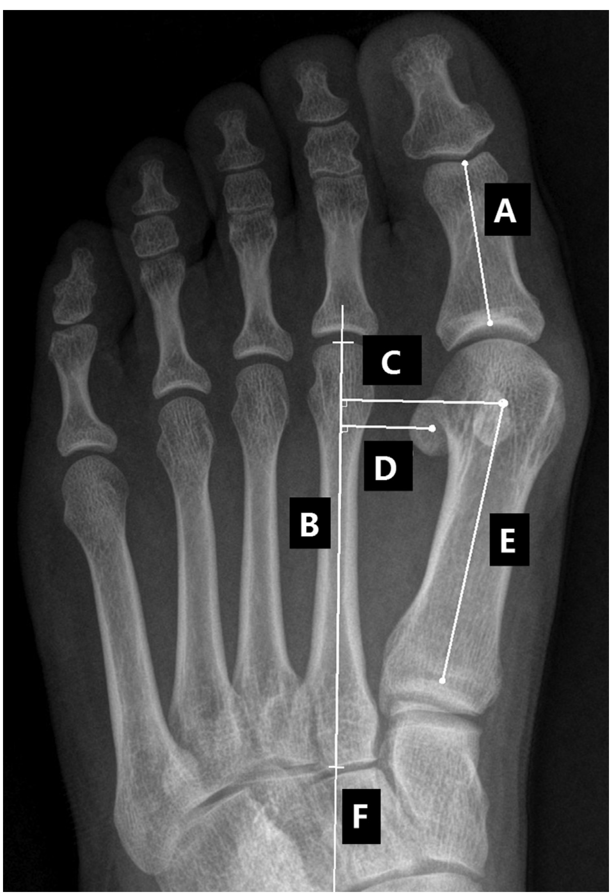

Fig. Measurements to locate the sesamoid bones in relationship to the other bones of the foot. Line A is the axis of the first phalanx; line B, the length of the second metatarsal; line C, the distance from the first metatarsal head to the long axis of the second metatarsal; line D, the distance between the center of the lateral sesamoid bone and the axis of the second metatarsal; line E, the axis of the first metatarsal; and line F, the axis of the second metatarsal. The hallux valgus angle is the arc between lines A and E, and the intermetatarsal angle is the arc between lines E and F.

Measurement Reliability

Ten feet were selected without known bias, and the HVA, IMA, LSP, M_1P, and LM_2 were measured twice, 1 week apart by the same author (X.G.) to determine the intrarater reliability. Next, 2 independent authors (C.Z., J.X.) measured the HVA, IMA, LSP, M_1P, and LM_2 to determine the interrater reliability. The intraclass correlation coefficients were calculated for both intrarater and interrater reliability (23).

Statistical Analysis

The measurements of the LSP, M_1P, LSDC, M_1DC, and LM_2 were compared between feet with and without HV using the Student *t* test. The linear relationships between the LSP, M_1P, LSDC, or M_1DC and the HVA or IMA were assessed using Pearson's correlation coefficients. All data conformed to the assumptions of the tests used to analyze them. Alpha was set at $\leq$0.05, and all tests were 2-tailed. The data were analyzed using the SPSS, version 21.0 statistical software package (IBM Corp., Armonk, NY) by 1 of us (C.W.).

Results

Demographic Information

Of the 128 enrolled patients (149 feet), 82 feet (55%) (from 63 females [77%] and 19 males [23%]) had HV. Their median age was 56.5 (range 20 to 81) years. The remaining 67 feet (45%) (from 43 females [64%] and 24 males [36%]) did not have HV and constituted the control group. Their median age was 53 (range 20 to 72) years. The groups did not differ in age or sex ($p = .56$ and $p = .09$, respectively).

Measurements and Reliability

The intrarater and interrater reliability was excellent (Table 1). Both the absolute deviation of the first metatarsal from the second metatarsal (i.e., M_1P) and the ratio calculated to control for foot size variation (i.e., M_1DC) exhibited significant differences between the HV and non-HV groups (Table 2). Both values were increased in feet with HV, indicating movement of the first metatarsal away from the second. In addition, both the larger absolute distance (i.e., M_1P) and the ratio (i.e., M_1DC) correlated with larger HVA and IMA measurements (M_1P to HVA, $r = 0.52$, $p < .001$; M_1P to IMA, $r = 0.68$, $p < .001$; M_1DC to HVA, $r = 0.60$, $p < .001$; and M_1DC to IMA, $r = 0.75$, $p < .001$).

More importantly, neither the absolute distance from the lateral sesamoid to the second metatarsal (i.e., LSP) nor the ratio calculated to normalize the foot size variation (i.e., LSDC) differed significantly between the 2 groups. Both values showed no increase in feet with HV, indicating the lateral sesamoid was stationary relative to the second metatarsal. Furthermore, neither the LSP nor the LSDC correlated with the HVA and IMA measurements (LSP to HVA, $r = 0.08$, $p = .33$; LSP to IMA, $r = 0.09$, $p = .25$; LSDC to HVA, $r = 0.18$, $p = .13$; and LSDC to IMA, $r = 0.18$, $p = .12$).