First Metatarsal Head and Medial Eminence Widths with and Without Hallux Valgus

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Background: Resection of the medial eminence in hallux valgus surgery is common. True hypertrophy of the medial eminence in hallux valgus is debated. No studies have compared metatarsal head width in patients with hallux valgus and control patients.

Methods: We reviewed 43 radiographs with hallux valgus and 27 without hallux valgus. We measured medial eminence width, first metatarsal head width, and first metatarsal shaft width in patients with and without radiographic hallux valgus.

Results: Medial eminence width was 1.12 mm larger in patients with hallux valgus ($P <$ .0001). Metatarsal head width was 2.81 mm larger in patients with hallux valgus ($P <$ .001). Metatarsal shaft width showed no significant difference ($P = .63$).

Conclusions: Metatarsal head width and medial eminence width are significantly larger on anteroposterior weightbearing radiographs in patients with hallux valgus. However, frontal plane rotation of the first metatarsal likely accounts for this difference. (J Am Podiatr Med Assoc 106(5): 323-327, 2016)

Resection of the medial eminence in bunion correction surgery is commonly performed and well described. In 1923, Silver[1] described using a chisel to remove a thin layer of cortex, along with periosteum and any exostoses, from the medial aspect of the first metatarsal head for treatment of hallux valgus. In 1928, McBride[2] described a conservative operation for bunions that focused on correcting muscle contracture and that included resection of the prominence on the medial aspect of the metatarsal head. In 1967, he reemphasized the importance of resection of the bunion prominence to ensure sufficient correction.[3] These articles laid the framework for the medial eminence resection that is commonly performed today.

Multiple authors have offered opinions on the medial eminence. Some authors state that the medial eminence hypertrophies, which leads to or exacerbates the bunion deformity.[4-7] Other authors state that no actual bone hypertrophy occurs.[1,8-10] In 2002, Thordarson and Krewer[11] attempted to end this debate. They investigated medial eminence thickness, comparing patients with hallux valgus with a control group. Their results showed that patients with hallux valgus had a medial eminence width of 4.37 mm, whereas the control group without hallux valgus had a medial eminence width of 4.14 mm. They concluded that the difference between groups of 0.2 mm was not significant and that bony proliferation is not a component of the bunion deformity. Thordarson and Krewer[11] showed no statistically significant difference, but they did not report their raw data or standard deviations or perform a power analysis. For these reasons, the present study was undertaken to re-create the results of Thordarson and Krewer[11] with further statistical analysis. If hypertrophy of the medial eminence exists, this may affect metatarsal head width. No studies have analyzed whether the metatarsal head width changes in hallux valgus. This study aims to elucidate whether the medial eminence and the first metatarsal head truly hypertrophy in patients with hallux valgus.

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Methods

Anteroposterior weightbearing radiographs from 200 patients were reviewed. All of the radiographs were taken with the patient weightbearing in the angle and base of gait, with the orthoposer at 10°. Two groups were identified: those with bunion pain and those without. Inclusion criteria for the bunion group included an intermetatarsal angle greater than 8° and a hallux abductus angle greater than 10°. Inclusion criteria for the control group included an intermetatarsal angle less than 8° and a hallux abductus angle less than 15°. No patient with a history of forefoot surgery or hallux limitus was included. Of the 100 patients with bunion pain, 43 met the inclusion criteria. Of the 100 patients without bunion pain, 27 met the inclusion criteria. These 70 radiographs were then viewed using iQ-VIEW (IMAGE Information Systems Ltd, Charlotte, North Carolina). Five digital measurements were manually obtained using distance and angular measurement tools within iQ-VIEW. Measurements included intermetatarsal angle, hallux valgus angle, medial eminence width, metatarsal head width, and metatarsal shaft width. The intermetatarsal angle was measured by the bisection of the first and second metatarsal shafts. The hallux valgus angle was measured by the bisection of the first metatarsal shaft with the proximal phalanx shaft.

Medial eminence width was measured by first drawing a line parallel to the bisection of the shaft of the first metatarsal that aligned with the medial shaft of the first metatarsal. A perpendicular line was then drawn and measured extending to the widest aspect of the medial eminence (Fig. 1). Metatarsal head width was defined as the measurement of the widest part of the metatarsal head and perpendicular to the metatarsal shaft bisection. Metatarsal shaft width was defined as the measurement of the narrowest part of the metatarsal shaft and perpendicular to the metatarsal shaft bisection.

An unpaired Student *t* test was used to statistically analyze all radiographic angles. A post hoc power analysis was performed to ensure adequate sample size.

Results

The mean age in the hallux valgus group was 55 years and of the control group was 47 years ($P = .0425$). The mean intermetatarsal and hallux valgus angles for the bunion group were 13.35° and 26.14°, respectively, and for the control group were 6.07° and 8.00°, respectively (Table 1). The mean ± SD medial eminence width, metatarsal head width, and metatarsal shaft width for the bunion group were 4.40 ± 1.15 mm, 24.00 ± 2.53 mm, and 13.31 ± 1.56 mm, respectively, and for the control group were 3.28 ± 0.85 mm, 21.19 ± 2.51 mm, and 13.51 ± 1.82 mm, respectively. The medial eminence width in the bunion group was 1.12 mm (95% confidence interval [CI], 0.60 to 1.64 mm) larger than that in the control group ($P < .0001$). The metatarsal head width was 2.81 mm (95% CI, 1.56 to 4.07 mm) larger in the bunion group ($P < .0001$). The metatarsal shaft width was 0.20 mm (95% CI, –1.03 to 0.63) smaller in the bunion group ($P = .63$). A post hoc power analysis showed a necessary sample size of ten patients per group.

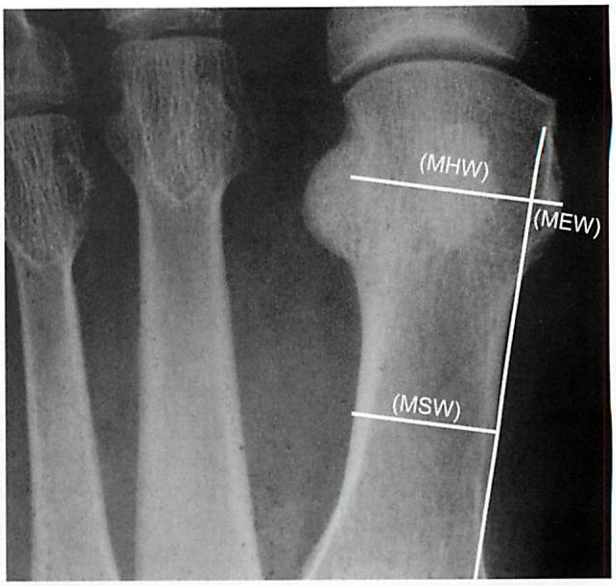

Figure 1. First metatarsal morphometrics. MEW, medial eminence width; MHW, metatarsal head width; MSH, metatarsal shaft width.

Discussion

The study by Thordarson and Krewer[11] showed no statistical difference in medial eminence width but did not include a power analysis. The present study shows that, with adequate power, the medial eminence width on an anteroposterior weightbearing radiograph is 1.12 mm larger in patients with radiographic hallux valgus. This study also shows that the metatarsal head width increases in size in patients with hallux valgus when analyzed on an anteroposterior weightbearing radiograph.

These findings should not be overstated and come with the limitation that this size change is visible on a single radiographic view. The anteroposterior

Table 1. Descriptive Statistics of Radiographic Measurements

Parameter	Hallux Valgus Group (n = 43)	Control Group (n = 27)	*P* Value
Intermetatarsal angle (°)	13.35 ± 3.18	6.07 ± 1.17	<.0001
Hallux valgus angle (°)	26.14 ± 7.6	8.00 ± 3.52	<.0001
Medial eminence width (mm)	4.40 ± 1.15	3.28 ± 0.85	<.0001
Metatarsal head width (mm)	24.00 ± 2.53	21.19 ± 2.51	<.0001
Metatarsal shaft width (mm)	13.31 ± 1.56	13.51 ± 1.82	.63

Note: Data are given as mean ± SD.

radiograph is two-dimensional and does not account for all aspects of the hallux valgus deformity. Although the terms *bunion* and *hallux valgus* are used loosely to describe the same clinical condition, Dayton et al[12] recently clarified these terms, suggesting more appropriate terminology: hallux abducto valgus with metatarsus primus adducto valgus. This terminology is triplanar and specifically describes the metatarsal as rotating into valgus, or eversion, in the frontal plane. The anteroposterior radiograph does not capture this rotation. Rotation in the frontal plane would not affect the width of a cylinder, such as the metatarsal shaft. However, the metatarsal head is not circular, but it tends more toward a square shape when viewed in the frontal plane. This square, as it rotates in the frontal plane, would show increased width on the anteroposterior radiograph, which would explain both the medial eminence and metatarsal head width increases found in this study.

Simple geometrical data support the idea of a square appearing to enlarge (Fig. 2). As the square rotates in the frontal plane, the orthoposer from above would capture an enlarging width of the square. Frontal plane rotation is a continuous variable, but if we assume that a patient without hallux valgus would have zero frontal plane rotation, then this study shows that the width would be 21.19 mm. If the frontal plane rotation accounts for the size increase, then a width of 24.00 mm (the average width in this study of a patient with hallux valgus) would be associated with a frontal plane rotation of 8.2°. Finally, the largest metatarsal head width in this study was 29.4 mm, which would be associated with a frontal plane rotation of 33.8°. Figure 3 shows the trigonometry used to deduce these numbers.

Kim et al[13] recently examined the frontal plane rotation of the first metatarsal using partially weightbearing computed tomograph, which they named the alpha angle. They determined the mean alpha angle without hallux valgus is 13.8 ± 4.1°, and with hallux valgus is 21.9 ± 6°. This is a mean increase in frontal plane rotation of 8.2°, similar to the 8.1° deduced in our study. However, our deduced increase in frontal plane rotation assumed a normal metatarsal would have 0° of frontal plane motion; Kim et al[13] showed that to be inaccurate. Combining Kim's results with our study, a normal metatarsal would have a frontal plane rotation of 13.8° and a head width on radiograph of 21.19 mm;

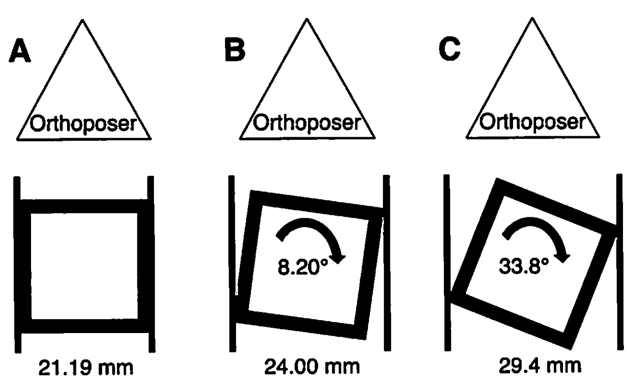

Figure 2. A, Width of a metatarsal head without frontal plane rotation. B, Width of the average metatarsal head in this study in patients with hallux valgus, correlating to 8.2° of frontal plane eversion. C, Width of the widest metatarsal head in this study, 29.4 mm, correlating to 33.8° of frontal plane rotation.

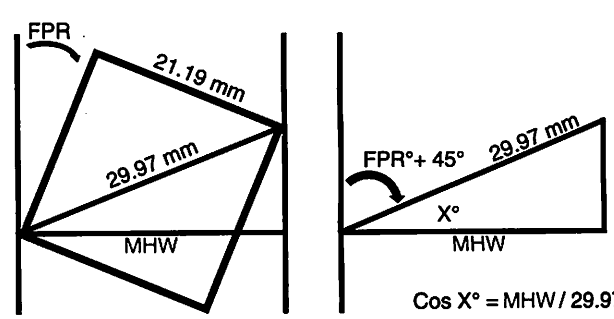

Figure 3. Trigonometric functions used to deduce estimated frontal plane rotation. FPR, frontal plane rotation; MHW, metatarsal head width as seen on an anteroposterior radiograph.

the metatarsal width of 24.00 mm would then be associated with a frontal plane rotation of 30.67°. Kim showed the frontal plane rotation to be 21.9° in hallux valgus. Dayton et al[14] recently described the quantity of frontal plane rotation necessary to anatomically realign the first metatarsophalangeal joint in hallux valgus surgery, showing an average of 22.1 ± 5.2° of rotation is needed. A head width of 24.00 mm, associated with a frontal plane rotation of 30.67°, would reduce to the normal range of frontal plane rotation with 22.1° of correction.

Enlargement of the head due to rotation suggests that the increase in medial eminence width and metatarsal head width is a radiographic artifact. Although this idea is based in geometry, it assumes a perfectly square metatarsal head. To our knowledge, no study has quantified the exact shape of the metatarsal head in a frontal plane section. In our experience, the metatarsal head shape tends more toward rectangular than round. This also explains why the shaft width does not change. The shaft, being tubular and thus more circular, would show less width change with rotation.[15]

The current study lays the groundwork to validate previous authors' observations. Silver[1] stated that the medial eminence "...is formed partly by the inner portion of the head which has been uncovered through the subluxation, partly by the projection of the prominent inner edge of the inferior portion of the head brought about through the rotation, and usually only to a lesser degree by any actual bone hypertrophy."[(p225)] This study agrees that the medial eminence is unlikely to be from bone hypertrophy but more likely from rotation of the metatarsal. Dayton et al[16] stated that "...medial eminence enlargement might be accentuated on anteroposterior radiographic examination owing to the abnormal profile caused by eversion, or valgus positioning, of the metatarsal."[(p352)] This study further explains their point that frontal plane malposition is likely responsible for the medial eminence enlargement.

One limitation of this study is the statistically significant difference in participant age between the hallux valgus and control groups. Although no study has shown age to relate to medial eminence or metatarsal head size, the study would be strengthened with an age-matched control group.

Future studies should explore new modalities to quantify the medial eminence and metatarsal head width because a single radiograph is likely flawed. Quantifying the medial eminence width and metatarsal head width before and after correction of frontal plane rotation without medial eminence resection would determine if the medial eminence and head width are radiographic artifacts. More important than radiographic studies, patient satisfaction data should be obtained as hallux valgus corrective surgery evolves and historic aspects of the procedure are retired.

Conclusions

The metatarsal head and medial eminence increase in width statistically significantly on an anteroposterior weightbearing radiograph in patients with radiographic hallux valgus. However, frontal plane rotation would explain these findings, and these enlargements are likely radiographic artifacts.

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Conflict of Interest: None reported.

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