

Relationships Between First Metatarsal, Sesamoid Positions and Other Clinically Relevant Parameters for Hallux Valgus Surgery

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Introduction

A successful correction of hallux valgus (HV) deformity is associated with good reduction of the sesamoids back under the 1st metatarsal head. Traditionally, the first metatarsal bone is relocated laterally to be placed over the sesamoids during HV corrective surgery, in the belief that HV leads to subluxation of the first metatarsal from the sesamoids. In recent years, many have advocated varus rotation of the 1st metatarsal to reduce the sesamoid position. The belief is that the first metatarsal bone is externally rotated concurrently with the sesamoid bones, rather than being subluxed from the sesamoid apparatus. Kim et al (1) showed that only 26% of HV deformities have simultaneous rotation of the first metatarsal and sesamoids, with these structures remaining congruous. They called this phenomenon "pseudo-subluxation". Shibuya et al (2) showed significant external rotation of the entire foot in patients with flatfoot deformity. The current study is designed to explore characteristics of the first metatarsal and sesamoid frontal plane rotations in relation to both underlying HV and other factors such as patient demographics and underlying flatfoot deformity.

Patients and methods

Weight-bearing plain radiographs of a foot DP, lateral and sesamoid axial views at the podiatry clinic at the Baylor Scott and White Health Care System, Central Texas Campus, Temple, TX from January 1, 2015 to December 31, 2017 were identified from the radiology log maintained in the clinic. To be included in the study, the patient had to be between the ages of 18-80. Previous osseous trauma or surgery were excluded. Most recent x-rays were used if patient had prior x-rays. If bilateral x-rays were taken, only the right foot was included. After collecting the radiographs, age, BMI and radiographic data were collected from their medical records. The radiographic data included tibial sesamoid position (TSP), hallux valgus angle (HVA), first and second intermetatarsal angle (IMA), metatarsus adductus angle (MAA), calcaneal cuboid angle (CCA), calcaneal inclination angle (CIA), and Meary's angle. Our outcome variables were the first metatarsal rotation angle (MRA) and the sesamoid rotation angle (SRA) (See **Figure 1**) as described by Kuwano et al (3). These variables were evaluated for association with the independent variables listed above.

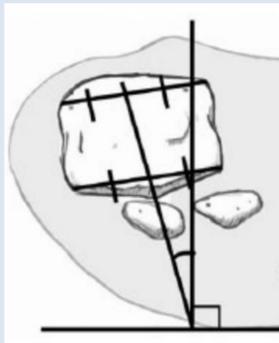


Figure 1: images showing sesamoid rotation angle (SRA) and metatarsal rotation angle (MRA) respectively.

Data Analysis

All statistical analyses were carried out using the R statistical package (R, Developmental, Core, Team, R: A Language and Environment for Statistical Computing 2015. <http://www.R-project.org>) by the primary author (NS). To identify average positions of the first metatarsal and the sesamoids in the frontal plane, the central tendency and dispersion of the sesamoid and the first metatarsal rotation angles were determined in terms of means and standard deviations. To identify factors associated with first metatarsal and sesamoid rotations, bivariate correlation tests (Pearson's correlation coefficients) were conducted to identify factors to be included in the final multiple linear models. If the bivariate correlation test gave a p-value of less than 0.2, the variable was included in the final linear model. The final model was then used to identify factors independently associated with each outcome variable (MRA or SRA) while adjusting for other covariates. Overall significance of each model was determined in terms of p-value (<0.05 considered significant) and R-squared. Estimated coefficients (slope) of each variable with p-value for significance and 95% confidence interval were also presented.

Results

A total of 114 sets of x-rays and patients were enrolled in the study. Of these, 76 were female and 38 were male. The average age of our cohort was 56 years (SD=14.0). The mean HVA and IMA were 20.9 (11.54) and 11.4 (3.21) degrees, respectively.

The mean MRA in the hallux valgus group was 7.25 (9.44) degrees, while that in the non-hallux valgus group was 2.5 (8.18) degrees (Student's t-test p=0.001). The mean SRA in the hallux valgus group was 19.2 (12.68) degrees while that in the non-hallux valgus group was 2.5 (8.18) degrees (Student's t-test p = 0.001). The MRA and SRA were normally distributed within both the hallux valgus and non-hallux valgus groups (Shapiro-Wilk P > 0.05).

After bivariate analyses for correlation with MRA, we identified TSP, HVA, IMA, MAA, CCA and MA to be included in the final model (Pearson's p < 0.2). After adjusting for all these covariates, only MAA remained significant in the final linear model (p=0.001).

After bivariate analyses for correlation with SRA, we identified BMI, TSP, HVA, IMA, CCA, CIA and MA to be included in the final model (Pearson's p < 0.2). After adjusting for the covariates, we identified TSP, HVA and MA to be independently correlated with SRA (p < 0.01)

Discussion

The current data showed that sesamoid position had a stronger association with other variables than the first metatarsal rotation. While MRA was higher in HV patients, the difference disappeared when considering other variables, such as flatfoot. Shibuya et al. showed significant association of flat foot with HV deformity. Generally, those who possess flatfoot also have valgus rotation of the entire foot. Therefore, the 1st metatarsal's valgus rotation, which manifests in the axial sesamoid view, may be part of the underlying flatfoot deformity.

The only factor that was independently associated with the first metatarsal rotation was metatarsus adductus. An increase in adductus was associated with internal rotation of the first metatarsal. Therefore, the first metatarsal should not be further internally rotated in those patients with metatarsus adductus. On the other hand, the sesamoids' valgus rotation was more predictable from other variables representing underlying flatfoot deformity to some degree in the bivariate analysis, it remained associated with hallux valgus after adjusting for the covariates. Therefore, the hallux valgus rotation of the sesamoids is seen to be associated with hallux valgus regardless of the presence of underlying flatfoot deformity. The strongest association of the sesamoid rotation was found to be with the tibial sesamoid position viewed in the DP view on the WB x-rays. Thus the model shows that the sesamoids rotate approximately 5 degrees for every 1 position of the 7 point-scale tibial sesamoid position (see **figure 2**)

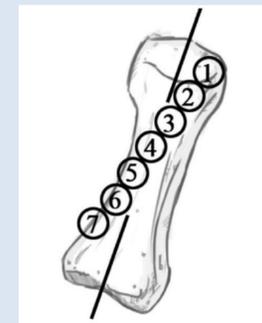


Figure 2: 7 point-scale for tibial sesamoid position

As underlying hallux valgus deformity was more strongly associated with sesamoid rotation than with first metatarsal rotation, we feel that our priority in surgery should be to improve the sesamoids rather than carrying out first metatarsal rotation. As the sesamoid rotation was strongly associated with sesamoid deviation relative to the first metatarsal on the DP view, reduction of the DP sesamoid deviation, as done traditionally, is still important in correcting HV deformity. It has been shown that sesamoid rotation reduces with lateral translation of the first metatarsal alone without any rotation of the first metatarsal. Lamo-Espinoza et al showed that average reduction of 11 degrees of the SRA with SCARF osteotomy with or without proximal phalanx osteotomy (4). Similarly, Ramdass and Meyr showed a reduction of the SRA by 7 degrees with distal chevron osteotomy was employed. (5)

Conclusion

The sesamoid rotation, rather than the first metatarsal rotation was independently associated with hallux valgus deformity after adjusting for other variables, such as underlying flatfoot deformity; therefore, reduction of the sesamoid position should be prioritized.

References

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