A Comparative Evaluation of First Ray Frontal Plane Position Based on the Metatarsal Head versus the Sesamoids.

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Statement of Purpose and Literature Review

Although hallux abductovalgus (HAV) is widely considered to be a triplanar deformity involving the transverse, sagittal and frontal planes, most of the historical published literature has focused on evaluation of the deformity in the transverse plane only [1]. However, our group has recently completed an investigation which quantitatively defined the relationship between the three planes [2], and others have recently added to the body of knowledge with respect to the frontal plane component of the deformity [3-4].

What has particularly interested our group of late has been the position of the sesamoids in the frontal plane and the effect of sesamoid position on evaluation of the deformity. Several authors have concluded that the sesamoids do not "move" substantially in the transverse plane, but these investigations have also demonstrated that there is frontal plane "motion" or at least pivoting/excursion [5]. We are also unaware of any investigation that has sought to evaluate for differences in frontal plane position between the metatarsal head and the sesamoids. It seems reasonable to assume that the two will move in a coordinated way based upon the structural anatomy, but this has yet to be established quantitatively.

The objective of this investigation was to advance the body of knowledge with respect to frontal plane aspects of the HAV deformity by quantifying its measurement based on an independent evaluation of the first metatarsal head and sesamoids.

Methodology

Following IRB approval, pre-operative weight-bearing sesamoid axial radiographs of 42 feet undergoing elective reconstruction of the first metatarsophalangeal joint were evaluated for three radiographic parameters in the frontal plane. These included the 4-point **medial sesamoid grade** (**MSG**; See Figure 2; describes the relationship between the sesamoids and the metatarsal head crista) [6], the **sesamoid rotation angle** (**SRA**; See Figure 1; describes the relationship between the plantar aspect of the sesamoids and the weight-bearing surface) [7], the **metatarsal rotation angle** (**MRA**; See Figure 1; describes the relationship between the plantar aspect of the first metatarsal head sesamoidal articular surface and the weight-bearing surface) [8].

Data points were graphically depicted against each other on frequency scatter plots and fit with linear correlation lines and calculation of a Pearson's correlation coefficient to establish quantitative and qualitative relationships. A paired student's t-test was additionally utilized to examine differences between the MRA and SRA at each MSG data point.

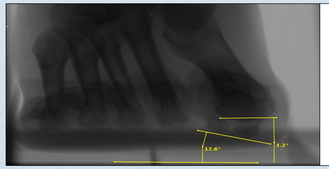


Figure 1: The angular relationship between the plantar aspect of the sesamoids and the weight-bearing surface has previously been established on a sesamoid axial view [7-8. This study sought to evaluate the first metatarsal head itself relative to the weight-bearing surface in an attempt to describe the relationship between the two and determine whether the sesamoid position is an effective surrogate for metatarsal position in the frontal plane.

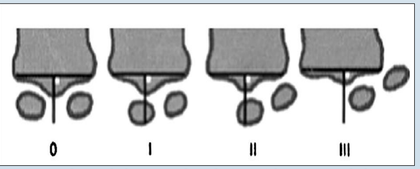
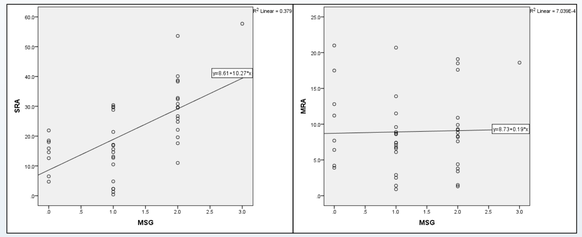


Figure 2: The medial sesamoid grade (MSG) has previously been established as a quantitative means to describe the relationship between the metatarsal head (specifically the crista) and the sesamoid position. However, as the two variables in the equation include both the sesamoids and the metatarsal, it is impossible to ascertain which is primarily driving the deformity and the specific relationship between the two [6].

Results

A selection of our results are displayed in the following graphs and tables.

Figure 3 and 4:
We first plotted the metatarsal rotation angle and the sesamoid rotation angle individually against the medial sesamoid grade. Interestingly, here we observed a potential dichotomy. As the medial sesamoid grade increased, so did the sesamoid rotation angle (Pearson correltation coefficient 0.615; p<0.001). But an increasing medial sesamoid grade appeared to have no such affect on the metatarsal rotation angle (Pearson correlation coefficient 0.027; p=0.868).



Figures 5 and 6:
A somewhat closer evaluation with a Loess best fit line appeared to demonstrate a difference in the relationship between the medial sesamoid grade and the sesamoid rotation angle at differing grades. The relationship appears to particularly diverge between sesamoid grades 1 and 2.

We also plotted the metatarsal rotation angle against the sesamoid rotation angle and observed a positive relationship (Pearson correlation coefficient of 0.510; p< 0.001). This would likely be described as an expected observation. In other words, as the sesamoids rotated in the frontal plane, the metatarsal head appeared to rotate as well.

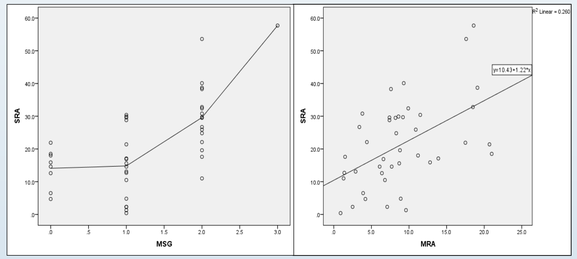


Table 1:
Finally we examined the difference between the sesamoid rotation angle and the metatarsal rotation angle at each medial sesamoid grade. Consistent with the frequency scatter plots, we observed the sesamoid rotation angle increased with increasing medial sesamoid grade, and that the metatarsal sesamoid angle stayed fairly consistent. At medial sesamoid Grade 0 there was a non-statistically significant difference between the two angles, and this reached significance with each subsequent grade.

MSG	SRA	MRA	Difference	P-Value
Grade 0 (n=8)	14.09 ± 5.94	10.59 ± 6.24	3.5	p=0.2700
Grade 1 (n=17)	14.81 ± 10.51	7.71 ± 4.81	7.1	p=0.0164
Grade 2 (n=16)	29.60 ± 10.18	8.86 ± 5.59	20.74	p<0.0001
Grade 3 (n=1)	57.7	18.6	39.1	N/A

Discussion

As with any scientific investigation, critical readers are encouraged to review the study design and results and reach their own conclusions, while the following represents our conclusions based on the specific results. As scientists, we also never consider data to be definitive, but do think that these results are worthy of attention and future investigation.

-These findings present unique data on the three-dimensional relationship between the first metatarsal head and the sesamoids in the HAV deformity. Taken together, these results might indicate that the frontal plane position of the sesamoids changes more substantially with deformity progression when compared to and independent of the first metatarsal head position. Previous investigations into the transverse plane have indicated that the first metatarsal changes position while the sesamoids remain relatively stationary through deformity progression and correction. These results in the frontal plane indicate the opposite: that the sesamoids change position while the first metatarsal head remains relatively stationary through deformity progression.

In conclusion, we hope that the results of this investigation add to the body of knowledge and lead to future investigations into the progression, evaluation and treatment of the hallux abductovalgus deformity.

References

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