An Objective Method for Evaluation of the Midfoot Sagittal Plane Position.

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Statement of Purpose and Literature Review

Radiographic evaluation of the sagittal plane position of the foot has traditionally only been described as being relative to either the weight-bearing surface, the talus, and/or the first metatarsal [1]. Customarily, Meary's angle has been used to determine the apex of sagittal plane deformity, which might occur anywhere within the medial longitudinal arch and/or midfoot [2]. In a pronated foot, the talar longitudinal axis is thought to deviate to the plantar aspect of the first metatarsal, whereas it bisects parallel to the first metatarsal in a rectus foot [3]. Another radiographic parameter which has been described specifically for sagittal plane motion of the first ray is Seiberg's index [4].

To our knowledge there has not been a radiographic measure described of the 1st metatarsal-cuneiform joint to measure the mobility and/or hypermobility of the first ray. Aiyer et al. attempted to investigate the change in midfoot angulation, however, they looked at the changes after performing a Cotton Osteotomy and did not isolate the motion to the first metatarsal cunieform joint [5].

The objective of this investigation was to quantitatively describe a method for the evaluation of the sagittal plane position of the midfoot, and to compare this measurement to the established method of the first metatarsal inclination angle. This was done by the creation of a novel radiographic measure in an attempt to quantify the motion in the sagittal plane of the first metatarsal-cuneiform joint.

Methodology

Following IRB approval, a consecutive series of 137 lateral weight-bearing radiographic projections from subjects without a history of foot trauma or surgery were evaluated. Radiographic parameters that were measured included: the first intermetatarsal angle (IMA), the hallux abductus angle (HAA), the tibial sesamoid position (TSP), the traditional first metatarsal inclination angle (1MIA; defined as the resultant angulation between the weight-bearing surface and a longitudinal bisection of the first metatarsal shaft).

Additionally two new radiographic measurements were created: the **distal medial cuneiform articulation angle** (**DMCA**; the resultant angulation between the weight-bearing surface and the anterior facet of the medial cuneiform; See Figure 1 *Angle A*) and the **Calculated 1MIA** (the resultant angulation between the weight-bearing surface and a perpendicular to *Angle A*). Given that the first metatarsal-medial cuneiform joint is described as a plane joint, one might assume that a bisection of the longitudinal axis of the first metatarsal shaft should be perpendicular to the anterior facet of the medial cuneiform [6]. Hence, using Euclid's elements of geometry, and indirect measure of the 1MIA could be calculated [7]. This is essentially what the 1MIA "should" be based on the position of the midfoot.

This investigation essentially compares the actual measurement of the 1MIA (**Measured 1IMA**) to this indirect measurement of the 1IMA (**Calculated 1MIA**), with the assumption that any differences observed between the two speaks to sagittal plane motion of the first metatarsal-medial cuneiform articulation.

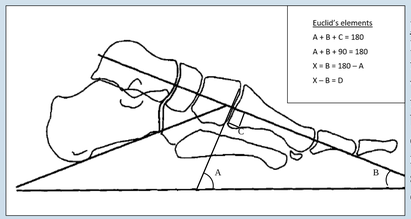

Fig 1: This figure depicts measurement of the DMCA (Angle A), a perpendicular to Angle A, and the Calculated 1MIA (*Angle B*). This investigation works from the assuming that Angle B should be the sagittal plane position of the first metatarsal based on the position of the midfoot. If this is different than an actual measurement of the first metatarsal inclination angle, then the difference speaks to motion at the first metatarsal-medial cuneiform joint.

Results

Results are displayed in the following figures:

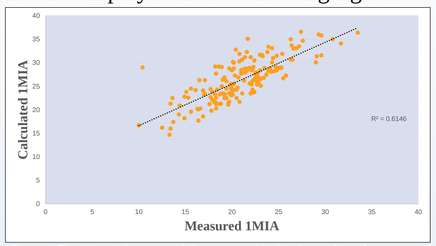

Figure 1: The effect of the measured first metatarsal inclination angle on the calculated first metatarsal inclination angle.

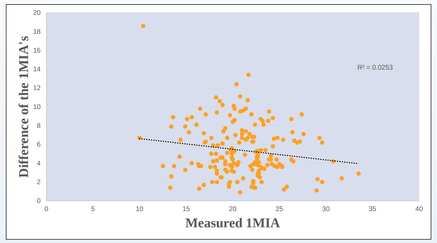

Figure 2: The effect of the measured first metatarsal inclination angle on the difference between the two first metatarsal inclination angle measurements.

First, the ***measured first metatarsal inclination angle*** was a mean ± standard deviation (range) of 20.96 ± 3.66 degrees (10.4-33.5), while the ***calculated first metatarsal inclination angle*** was 26.25 ± 4.20 degrees (14.7-36.6). This was a difference of 5.29 ± 2.87 degrees (0.9-18.6) and was found to be a statistically significant difference with a paired sample T-test ($p<0.0001$). As one might expect, a positive correlation was observed between these two variables (Figure 1). Interestingly however, no substantial correlation was observed between the measured first metatarsal inclination angle and difference between the two first metatarsal inclination angle differences (Figure 2).

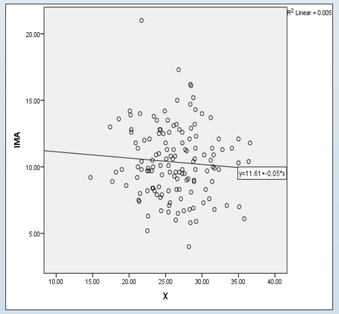

Figure 3: The effect of the calculated first metatarsal inclination angle on the first intermetatarsal angle (IMA).

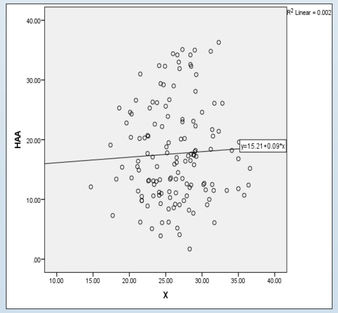

Figure 4: The effect of the calculated first metatarsal inclination angle on the hallux abductus angle (HAA).

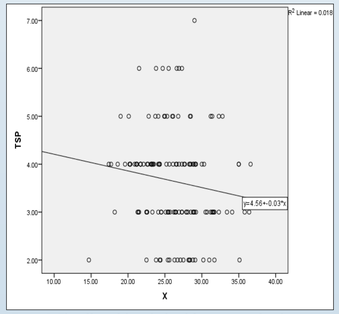

Figure 5: The effect of the calculated first metatarsal inclination angle on the tibial sesamoid position (TSP).

Second, no substantial correlation (by means of the Pearson correlation coefficients) was observed between the calculated first metatarsal inclination angle and 3 common measurements of transverse plane first metatarsal-phalangeal joint position (Intermetatarsal angle; Figure 3 [-0.074; p=0.391], Hallux abductus angle; Figure 4 [0.048; p=0.579]. Tibial sesamoid position; Figure 5 [-0.135; p=0.116]).

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.

- First, the results of this investigation might provide original objective data with respect to the sagittal plane position of the midfoot, specifically at the first metatarsal-medial cuneiform joint. It is interesting to consider that the calculated first metatarsal inclination angle was always higher than the measured first metatarsal inclination angle. This indicates that the structural anatomy of the midfoot tends to put the first metatarsal in a relatively dorsal position whereas the functional anatomy tends to put the first metatarsal in a relatively plantar position.
- Second, it might also be interesting to consider that the difference between the two measurements (calculated and measured first metatarsal inclination angle) demonstrated no substantial correlation to the measured first metatarsal inclination angle. This might indicate first ray position independent of the orientation of the anterior aspect of the medial cuneiform. This observation might be supported by the relative lack of correlation observed between the calculated first metatarsal inclination angle and three common measures of 1st MPJ position.

In conclusion, we hope that the results of this investigation add to the body of knowledge and lead to future investigations into the evaluation and treatment of the medial column structure and function.

References

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