**Statement of Purpose and Literature Review**

Our group has previously performed an investigation into the transverse plane radiographic parameters utilized in the assessment of the hallux abductovalgus (HAv) deformity and established a quantitative and qualitative objective basis for defining normal versus abnormal measurements [1]. However, analysis only described the transverse plane whereas HAv is generally considered to be a deformity involving the transverse, sagittal and frontal planes. Yet despite this widely held belief, very few investigations have specifically attempted to describe the quantitative relationship between these three planes during the development of the HAv deformity [2-6].

Therefore the objectives of this original investigation were to 1) quantitatively evaluate measurement of the frontal plane in the HAv deformity, and 2) examine the relationship between the transverse, sagittal and frontal planes in the HAv deformity.

**Methodology**

Following IRB approval, pre-operative weight-bearing DP lateral, sesamoid and axial radiographs of 89 feet undergoing elective reconstruction of the first metatarsophalangeal joint were evaluated for radiographic parameters in the transverse (1st intermetatarsal angle [IMA], hallux abductus angle [HAA], tibial sesamoid position [TSP]), sagittal (first metatarsal inclination angle [Inclin_1], and frontal (tibial sesamoid grade [SG], sesamoid rotation angle [SRA]) planes. Data points were then graphically depicted against each other on frequency scatter plots and fit with linear and Loess best fit lines (which is commonly referred to as fitting a line to a cloud of data points) as well as correlation coefficients.

As scientists, we also never consider data to be definitive, but we do think that results are worthy of attention and future investigation.

**Results**

A selection of our results are displayed in the following graphs with provided data interpretations:

- **Part 1: Relationship of the frontal and transverse planes**
  - We first plotted radiographic measures of the transverse plane (1st intermetatarsal angle [IMA], hallux abductus angle [HAA], and tibial sesamoid position [TSP]) against radiographic measures of the frontal plane (first metatarsal inclination angle [Inclin_1, Inclin_frontal], and tibial sesamoid grade [SG], analyzed the data with both linear and Logistic best fit lines, and calculated a correlation coefficient (Pearson's correlation coefficient). Moderate positive and negative relationships were observed between the IMA and SG indicating that as frontal plane HAv deformity increased, the first metatarsal would be expected to become less inclinated.

- **Part 2: Relationship of the sagittal and transverse planes**
  - We then plotted radiographic measures of the transverse plane (IMA, HAA, and TSP) against a radiographic measure of the sagittal plane (first metatarsal inclination angle [Inclin_1]), analyzed the data with linear and Logistic best fit lines, and calculated a correlation coefficient (Pearson's correlation coefficient). Significant "moderate" negative relationships were observed between the IMA and SG indicating that as frontal plane HAv deformity increased, the first metatarsal would be expected to become less inclinated.

**Discussion**

As with any scientific investigation, critical readers are encouraged to re-examine 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 we do think that results are worthy of attention and future investigation.

- **First**, these results provide objective and quantitative evidence in support of a triplanar component to the development of the hallux abductovalgus deformity. We observed consistent and statistically significant correlations between the transverse, sagittal and frontal planes utilizing commonly performed radiographic parameters. As transverse plane deformity increased, frontal plane deformity increased and the 1st metatarsal inclination angle decreased. As and frontal plane deformity increased, the 1st metatarsal inclination angle decreased. We believe that these results reinforce evaluation and treatment of this deformity in all three biomechanical planes.

- **Second**, these results do not support an evaluation of the lateral "curvature" of the first metatarsal and hallux proximal phalanx as a surrogate for frontal plane deformity. We do not have substantial correlation between this finding and the progression of radiographic deformity in the frontal, transverse or sagittal planes. We believe that these results indicate that the frontal plane deformity warrants specific radiographic evaluation.

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.