A Case-control Study of 3D versus 2D Weight Bearing CT Measurements of the M1-M2 Intermetatarsal Angle in Hallux Valgus

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Category: Midfoot/Forefoot

Keywords: hallux valgus intermetatarsal angle weight bearing ct 3D 2D measurements

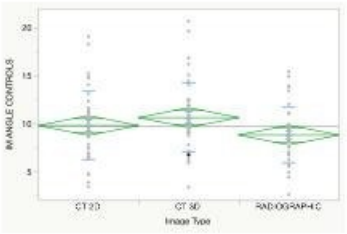
Introduction/Purpose: Surgical planning based on angular measurements obtained on conventional radiographs is challenging due to perspective distortion and operator bias. Novel weightbearing CT (WBCT) three-dimensional (3D) measurements using coordinate systems may represent a more reliable and accurate evaluation of this 3D deformity. The objective of this study was to compare the M1-M2 intermetatarsal angle (IMA) obtained manually on WBCT digitally reconstructed 2D radiographs versus a set of coordinates from the full 3D dataset, in patients with hallux valgus (HV) deformity and in healthy controls.
We hypothesised that the 3D measurements would be more reliably obtained, demonstrating different values when compared to 2D radiographic measurements.

Methods: In this multicenter retrospective comparative study, 83 feet that underwent WBCT of the foot were included (41 HV: mean age 59, 81% female, 42 controls: mean age 52, 80% female). Datasets were analysed by three independent trained foot and ankle surgeons using the same protocol. Coordinates in three planes (x,y,z) of four different landmark points were harvested: center of the heads and midpoint of the proximal metaphysis of the 1st and 2nd metatarsal. The IMA measurements were then performed in reconstructed radiographic images (DRR-IMA). The data collected was then analyzed by a single 4th independent and blinded investigator who calculated the 3D angle (3D-IMA) and its projection on the weightbearing plane (2D-IMA). Intra-observer realiability was assessed by Pearson/Spearman's correlation. Intermethod correlation was evaluated by intraclass correlation coefficient (ICC). Mean values for measures were comparared by One-way ANOVA. P-values of less than 0.05 were considered significant.

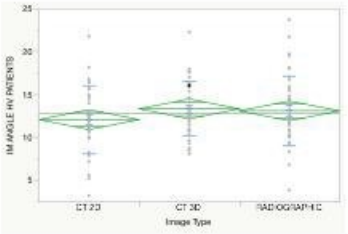
Results: Intraobserver reliability was excellent for radiographic DRR-IMA (0.95) and 3D coordinates assessment (0.99). Intermethod correlation between the three different imaging modalities (DDR, 2D and 3D), considering bias and interactions, were respectively 0.71 and 0.51 in control and HV patients.
IMA measurements were found to be similar when measured in DRR, 2D and 3D WBCT images, for both controls and HV patients. Mean values and confidence intervals (CI) for controls were 8.8 degrees (CI, 7.9-9.7) in DDR images, 9.8 degrees (CI, 8.7-10.9) in 2D images and 10.6 degrees (CI, 9.5-11.8) in 3D images. When compared to controls, HV patients demonstraded significantly increased IMA ($p<0.05$): 13.06 degrees (CI, 11.8-14.3) in DDR images, 12.1 degrees (CI, 10.8-13.3) in 2D images and 13.3 degrees (CI, 12.3-14.3) in 3D images.

Conclusion: We found that similar values for IMA were measured in 2D reconstructed radiographs, WBCT 3D and 2D projected images. When compared to controls, HV patients were found to have increased IMA in all three different imaging types used (DDR, 2D and 3D). Intermethod correlation was higher for IMA performed in controls. Intraobserver reliability was excellent for both radiographic IMA measurements and WBCT 3D coordinates. Our study is the first study to evaluate measurements of the 3D-IMA in HV and control patients. Further investigations are required before guidelines for its clinical use can be formulated.

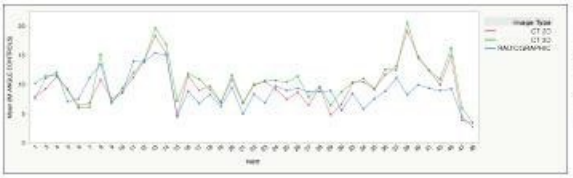
Intermetatarsal Angle 1-2
Control Patients



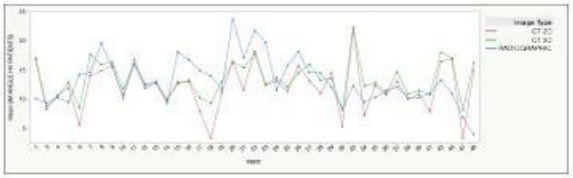
Intermetatarsal Angle 1-2
Hallux Valgus Patients



IMA Measurements in Control Patients
Parallelism Plots for Intermethod Correlation
(Radiographic and WBCT 2D and 3D images)



IMA Measurements in Hallux Valgus Patients
Parallelism Plots for Intermethod Correlation
(Radiographic and WBCT 2D and 3D images)



Foot & Ankle Orthopaedics, 3(3)
DOI: 10.1177/2473011418S00321