Evaluation of metatarsal torsion by using 3D analysis and computed tomography. Hallux valgus vs Hallux rigidus vs. Normal feet.

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INTRODUCTION: Reduction of the medial longitudinal arch and rotation of the first ray are observed in hallux valgus. One factor that contributes to the rotational deformity of the first metatarsal in hallux valgus is torsion of the metatarsal itself. Hallux rigidus is also thought to involve a reduction in the longitudinal arch in their pathogenesis, but the torsion of that has not been discussed. We hypothesized that metatarsal torsion may be a morphological bone change unique to hallux valgus. In this study, we compared torsion of the metatarsals (M1-M5) in three dimensions between feet with hallux valgus, feet with hallux rigidus, and healthy control feet with no history of foot disorders in order to investigate differences in the effects on pathological conditions.

METHODS: All participants were female. There were 16 feet in the control group, 16 in the hallux valgus group, and 14 in the hallux rigidus group. Mean age in each group was 56, 57, and 64 years. The average hallux valgus angle in the hallux valgus group was 42°, the average intermetatasal angle in the hallux valgus group was 21°, and the Hattrup and Johnson classification in the hallux rigidus group was Grade I for 9 feet and Grade II for 5 feet. One randomly selected foot from the control group was designated as the reference foot. For comparison between groups, CT images of the metatarsals were reconstructed in 3D (Fig 1), and 35% of the proximal and distal areas were taken and superimposed on the reference foot using the iterative closest point algorithm (Fig 2), which allows superimposition of 3D objects without specifying sites of anatomical features. The torsion angle was defined as the angle of rotation of the distal part of the articular axis with respect to the proximal area (Fig 3). In the hallux valgus group, correlations of the torsion angle with the hallux valgus angle and intermetatarsal angle were also calculated.

RESULTS: The hallux valgus group had significantly greater torsion toward pronation in the first metatarsal, by 11° versus the control group and 13° versus the hallux rigidus group ($p < 0.01$). The hallux valgus group also had significantly greater torsion toward pronation in the fifth metatarsal, by 15° versus the control group and 14° versus the hallux rigidus group ($p < 0.01$) (Fig 4). No significant difference was observed in the second, third, or fourth metatarsals ($p > 0.05$). There was no significant correlation with the hallux valgus angle or intermetatarsal angle of first metatarsal and fifth metatarsal in the hallux valgus group ($p > 0.05$).

DISCUSSION AND CONCLUSION: It is considered that hallux rigidus and hallux valgus may have shared pathological origins, such as failure of the windlass mechanism and hypermobility of the first ray, the changes that ultimately occur in these two conditions are different. Feet with hallux valgus had pronation deformities in the first and fifth metatarsals that were not observed in control feet or feet with hallux rigidus, meaning that torsion toward pronation in the first metatarsal itself was a deformity unique to hallux valgus. Our results indicated that the degree of rotation does not correlate with severity, it is likely that this rotation exists prior to onset of hallux valgus. This may partly explain why the presentation of hallux valgus is ultimately different from that of hallux rigidus despite the shared pathological origins of these conditions. In other words, the sesamoid complex and the plantar fascia might create a tendency toward relatively lateral displacement, which would increase the rotation and internal rotation of the first metatarsal.

Fig 1. 3D model of the foot

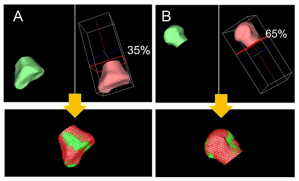
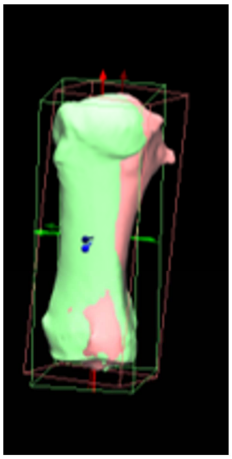


Fig 2 The first metatarsal in each participant was superimposed over the reference foot.
A) The areas 35% proximal,
B) The areas 35% distal to the 1st MT.



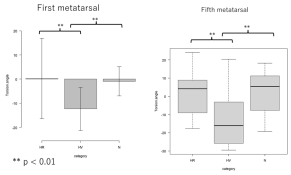


Fig 4