3-Dimensional Analysis of First Tarsometatarsal Joint After First Metatarsal Osteotomy with Weightbearing CT (WBCT)

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Introduction

- The pathology of the bunion deformity consists of deformities in the axial, coronal, and sagittal planes of the first metatarsal and its articular surface with the medial cuneiform
- While weightbearing radiographs have been utilized for assessment of these deformities, such methods have limitations with regard to image magnification, patient position, and superimposition of bone alignments
- With advances with weightbearing computed tomography (WBCT), evaluation of the 3-dimensional components of the first metatarsal along with its proximal articular surface can be assessed with greater precision

Figure 1: Bunion Deformity

Objective

- This study aims to observe the effect of the midshaft osteotomy on the alignment of the tarsometatarsal joint in three dimensions

Figure 2: Scarf Midshaft Osteotomy

Methods

- Ten feet from 10 cadaveric specimens underwent common midshaft first metatarsal osteotomies
- Pre- and post-operative weight-bearing CT scans with .3mm cubic voxel size were collected from each of the subjects in neutral standing position

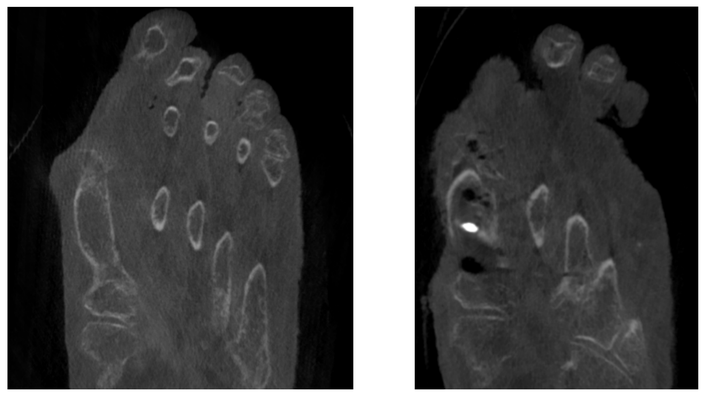

Figure 3: Foot Before and After Midshaft Osteotomy

- 3D renderings of the medial cuneiform, first metatarsal, and the first phalanx were generated from the scans, followed by definition of reference frames for each bone to evaluate changes in the metatarsal in relationship to the medial cuneiform.

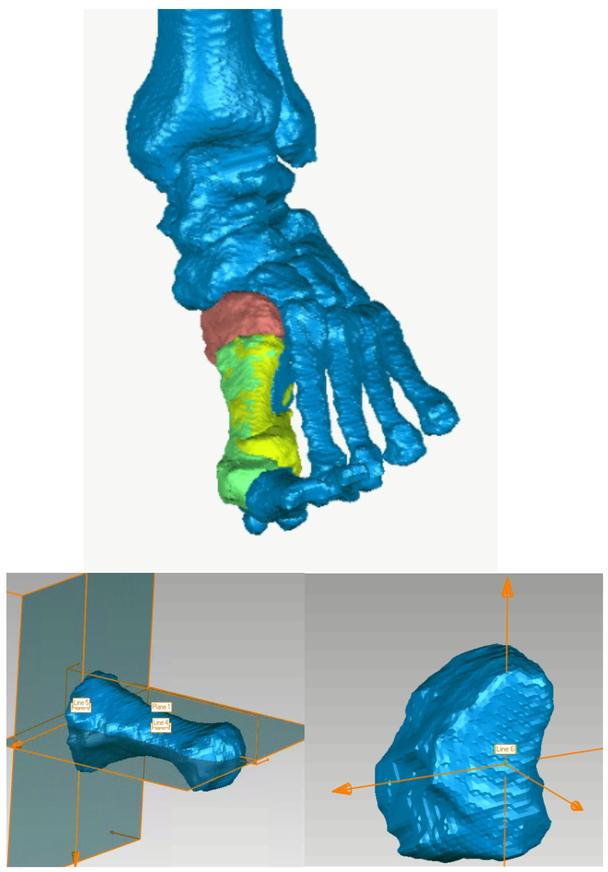

Figure 4: a) Foot with Metatarsal Motion, b) Metatarsal Reference Frame c) Cuneiform Reference Frame

Results

- The measurements of the rotational parameters showed greater changes in the coronal plane postoperatively with eversion of the first metatarsal relative to the medial cuneiform at the first tarsometatarsal joint

	Pre-Surgery			Postsurgery (without Geometry Change)		
	Dor/Pla (α)	Inv/Ev (β)	Int/Ext (γ)	Dor/Pla (α)	Inv/Ev (β)	Int/Ext (γ)
Average	19.43	0.30	-8.62	23.42	-4.17	-11.20
Std. Dev.	3.67	9.00	6.97	8.67	9.00	8.19

- Post-operative changes in the sagittal plane and axial plane with relationship of the first metatarsal to the medial cuneiform were not statistically significant.

	Postsurgery to Foot Reference Frame (No Geometry Change)		
Significance	0.09	0.04	0.51

- Distance mapping showed a significant increase in surface-to-surface distance at the dorsal tarsometatarsal joint post-operatively with a reduced distance at the inferior portion of the tarsometatarsal joint.

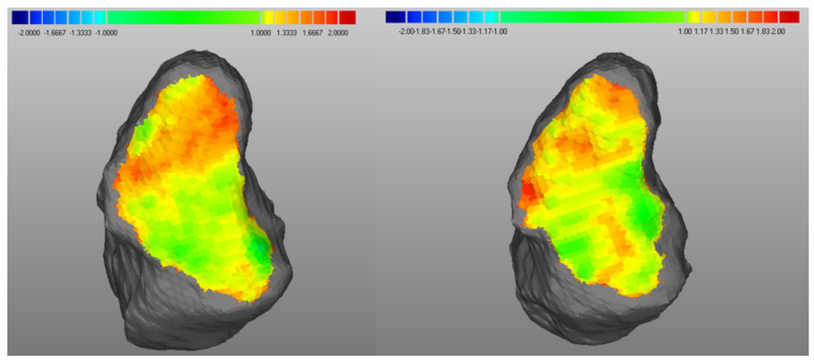

Figure 5: Cuneiform Distance Maps a) Pre-Osteotomy and b) Post-Osteotomy

Conclusions

- Based on the results of the study, midshaft osteotomies of first metatarsal can cause increased dorsiflexion in the sagittal plane, significant eversion in the coronal plane, and external rotation in the axial plane at the tarsometatarsal joint. Distance mapping analysis on WBCT images identified differences in surface-to-surface interaction of the first metatarsal and the medial cuneiform.