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Paper Session 2: Ankle and Hindfoot

The Use of 3D Prints to Compare the Efficacy of Three Different Calcaneal Osteotomies for the Correction of Heel Varus

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Category: Hindfoot

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Introduction/Purpose: There are multiple surgical osteotomies described for the correction of heel varus. An adequately powered clinical comparison of these osteotomies has not been published. In this study we used 18 identical 3D prints of a patient with heel varus to compare the surgical correction obtained with a Dwyer, oblique or Z osteotomy. The adequately powered statistical results of this study quantify the unique advantages and limitations of these osteotomies.

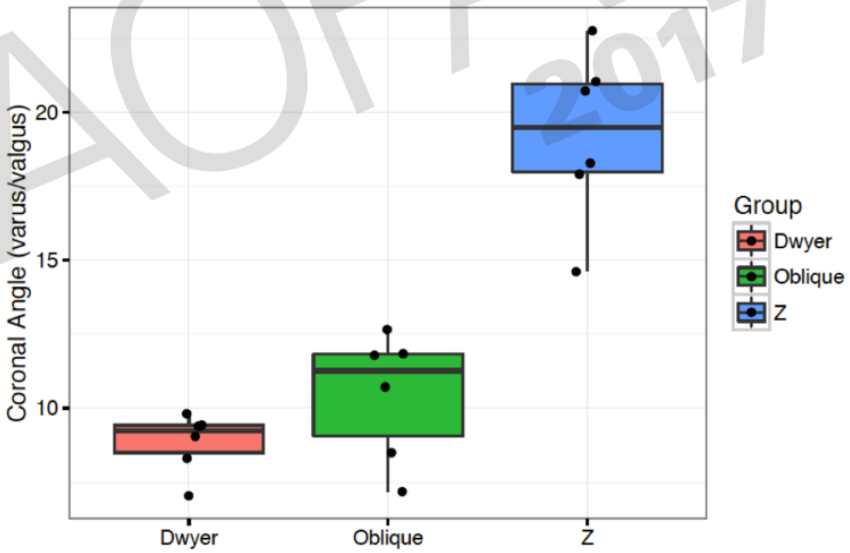
Methods: A CT scan of a patient with heel varus (16 degrees) from Charcot-Marie-Tooth disease was selected for 3D modeling. Eighteen identical 3D prints were created of an anatomical construct of the talus, calcaneus and cuboid. Coordinate frames were added to the talus and calcaneus to evaluate rotation. Six of the prints were CT scanned to establish baseline data measurements (Uncut Control Group). All 18 prints were then divided into 3 groups of 6 models each. A custom jig was used to precisely and accurately replicate a different osteotomy in each group(Dwyer, oblique or Z). A 1 cm wedge was removed from each osteotomy. Following the simulated surgeries, all 18 models were CT scanned using the same parameters as had been used for the uncut models. Anatomic and coordinate measurements were calculated using multiplanar reconstruction image processing. Coordinate measurements were established as the rotation of the calcaneal coordinate frame with respect to the talar coordinate frame.

Results: A standard 1-way analysis (ANOVA) was performed on the initial data. Additionally, a Tukey Studentized Range test was run using the raw data to compare the uncut model, Dwyer, oblique and Z osteotomies for all variables that showed statistically significant differences using the ANOVA. Coronal angle correction (Figure 1): The overall ANOVA test is significant ($p < 0.001$). Tukey post-hoc comparisons demonstrate that Z is significantly different from Oblique (mean difference = 8.8; 95pct CI [5.5,12.0]; $p < 0.001$) and Dwyer (mean difference = 10.4; 95pct CI [7.1, 13.6]; $p < 0.001$), but Oblique and Dwyer are not significantly different from each other (mean difference = 1.6; 95 pct CI [-1.6, 4.9]; $p=0.422$). Calcaneal shortening (Figure 2): The overall ANOVA test is significant ($p < 0.001$). All group comparisons are significant except for the Z vs Uncut ($p=0.919$). Lateral translation (Figure 3): The overall ANOVA test is significant ($p < 0.001$). All group comparisons are statistically significant from one another.

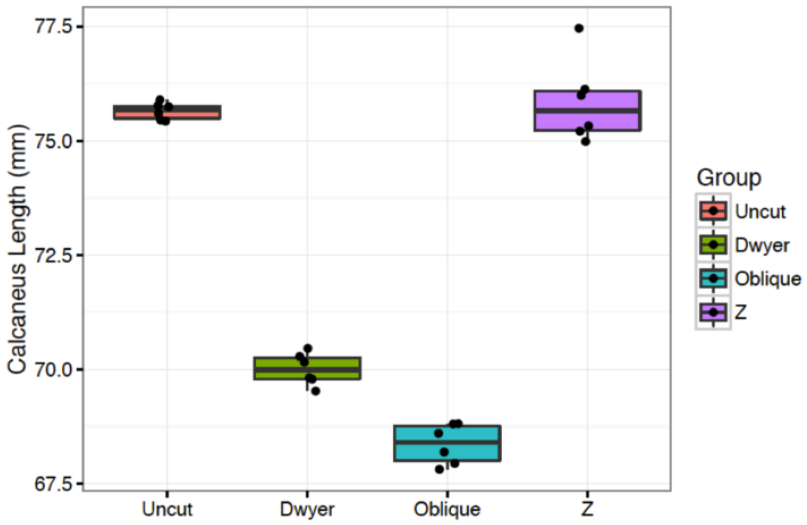
Conclusion: The Z osteotomy provided significantly more correction in the coronal plane (varus/valgus), with no significant shortening of the calcaneus, compared to the Dwyer and oblique osteotomies. The Z osteotomy, however, produced much less correction than anticipated, with only 3 degrees of final heel valgus. The Dwyer and Oblique osteotomies remained in varus. None of the osteotomies provided more than 6mm lateral translation of the tuberosity. These results have significant application to the appropriate choice of a calcaneal osteotomy for heel varus.

Calcaneal Osteotomy Coordinate and Anatomic Measurements				
	Uncut Mean (std)	Dwyer Mean (std)	Oblique Mean (std)	Z Mean (std)
Coordinate Measurements				
Sagittal Angle (°) *(Flexion/Extension)*	0.28 (0.30)[a]	0.24 (0.39)[a]	0.94 (1.03)[a]	0.91 (0.39)[a]
Coronal Angle (°) *(Varus/Valgus)*	0.54 (0.73)[a]	9.38 (1.01)[b]	10.99 (2.15)[b]	19.75 (2.89)[c]
Axial Angle (°) *(Abduction/Adduction)*	0.39 (0.37)[a]	14.08 (1.92)[b]	12.20 (1.52)[b]	0.70 (0.66)[a]
Lateral Displacement (mm)	4.24 (0.40)[a]	10.22 (1.37)[b]	8.51 (0.72)[c]	4.44 (0.65)[a]
Anatomic Measurements				
Axial Calcaneocuboid Angle (°)	52.91 (1.52)[a]	56.21 (0.97)[b]	56.56 (1.63)[b]	48.68 (1.01)[c]
Axial Talocalcaneal Angle (°)	15.53 (0.24)[a]	19.04 (0.35)[b]	19.43 (0.75)[b]	13.76 (0.73)[c]
Calcaneal Length (mm)	75.65 (0.18)[a]	70.01 (0.35)[b]	68.36 (0.44)[c]	75.85 (0.91)[a]
Coronal Varus Angle (°)	16.47 (1.37)	-	-	-

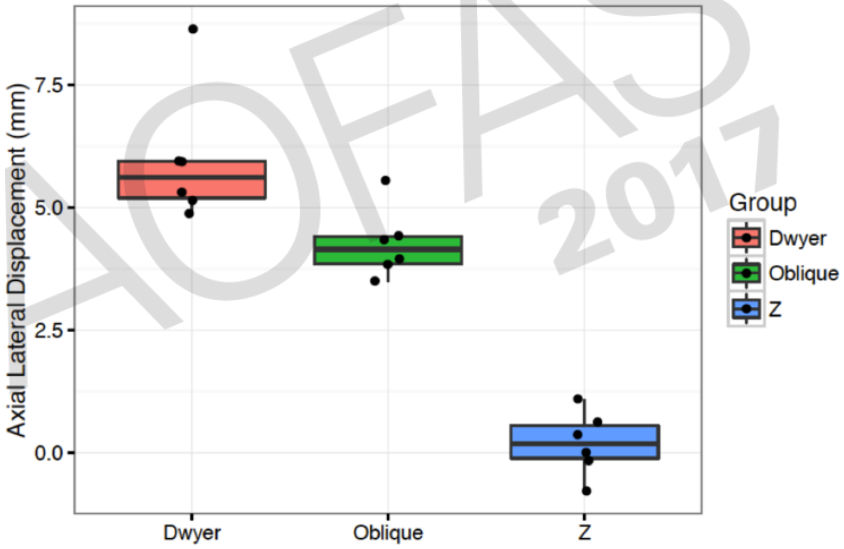
Within each row, means with the same superscript letter are not significantly different whereas those with different superscript letters are significantly different ($p < 0.05$)
Std: Standard deviation



Coronal Angle
Figure #1



Calcaneal Length
Figure #2



Lateral Displacement
Figure #3