DEVELOPMENT OF 3D PRINTED PATIENT-SPECIFIC SCAPHOID IMPLANT TO ACHIEVE CUSTOMISED SCAPHOID REPLACEMENT

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Introduction

Treatment of scaphoid bone fractures is always complex due to limited vascularization, difficult anatomic position for surgical access and unpredictable healing course due to patient movement. [1] Replacement of the scaphoid with an implant could be an alternative if the cartilage of the scaphoid fossa is still intact. In this study, a 3D printed patient-specific scaphoid was developed.

Methods

3D model of scaphoid was generated using CT scan of two cadaveric wrists. Special channels, 2mm in diameter, were created using Autodesk Meshmixer. Implant was 3D printed using titanium (Ti64ELI Grade 23) powders. 2mm suture anchors were used to suspend implant on trapezium and lunate separately.

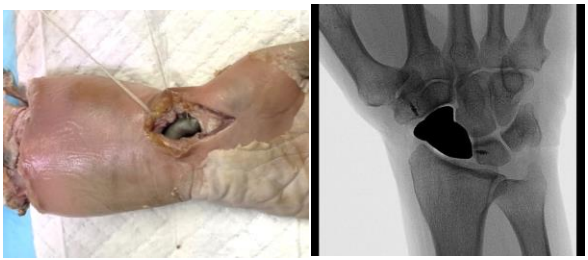

Figure 1: Implantation of 3D-printed scaphoid in cadaveric wrist

Post-implant 3D CT scans were performed and bones segmented using Materialise Mimics. MATLAB software was used to calculate the translational and angular displacements of the scaphoid to evaluate its static stability during wrist flexion-extension and radioulnar deviation.

Results

Two 3D printed scaphoid implants based on the CT scan of the respective cadaveric wrist used in the study:

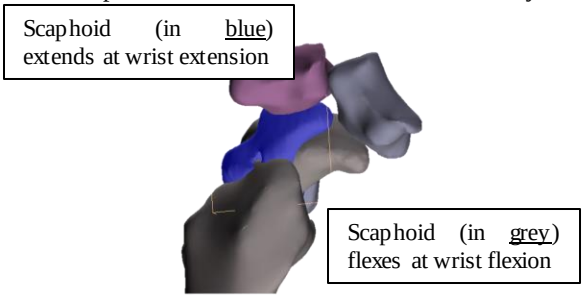

Figure 2: 3D model of implanted wrist in wrist flexion-extension

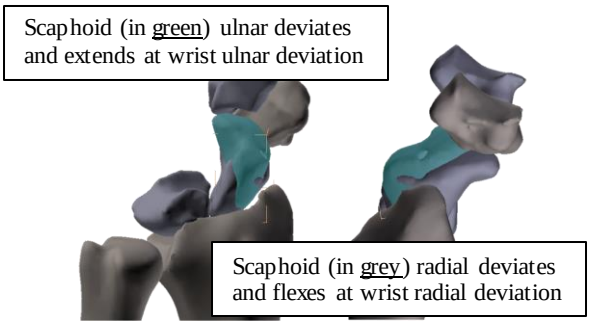

Figure 3: 3D model of implanted wrist in wrist radioulnar deviation (Left) Frontal (Right) Sagittal view

Scaphoid static stability was evaluated by computing scapholunate (SL) angle and distance:

SL angle/°	Wrist positions				
	Neutral	RD	UD	Flex	Extend
Wrist 1	57.2	46.1	46.3	49.3	49.3
Wrist 2	66.0	62.7	55.9	60.6	56.9

Table 1: SL angles for the two implanted wrists

SL distance/mm	Wrist positions				
	Neutral	RD	UD	Flex	Extend
Wrist 1	1.36	1.55	1.65	1.40	2.09
Wrist 2	2.25	1.98	2.27	1.36	2.61

Table 2: SL gaps for the two implanted wrists

Discussion

Static instability was observed for Wrist 2 as SL gap was more than 2mm and SL angle was more than 60°. Based on the CT scan images of Wrist 2, the screw position on the lunate bone was off-centered and slanted towards the dorsal end of the lunate. This could have caused the instability observed, where the scaphoid dissociates away from the lunate. In future work, computational simulation can be performed to determine the optimal suture anchor positions for stability of the scaphoid. Subsequently, a surgical guide can be developed for use by the surgeon during the surgical implantation.

References

1. Eathorne SW. The wrist: clinical anatomy and physical examination--an update. Prim Care. 2005;32(1):17-33.

Acknowledgements

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