Optimizing Proximal Pole Scaphoid Reconstruction: Integration of 3D Imaging and Custom Cutting Guides for Precision Grafting

Daniel Bowles, Brian Li, Sruthi Katakam, Todd A Goldstein, John Nolan, Kate Wilkins Nellans

INTRODUCTION:

Proximal pole scaphoid reconstruction presents significant challenges due to the anatomical complexity and variability of the hamate and scaphoid bones, often resulting in extended operative times and excessive bone graft use. Our study explores the incorporation of high-resolution three-dimensional (3D) imaging and custom cutting guides to support proximal pole hamate graft precision, reduce bone waste, and maintain operative times on par with traditional methods.

METHODS:

We utilized 3D design software to transform high-resolution 2D CT scans into interactive 3D models, offering detailed anatomical insight and accuracy for surgical planning. Two custom 3D cutting guides were developed: one for the necrosed scaphoid and one for the donor proximal pole of the ipsilateral hamate. These guides were aligned and installed using K-wire mapping based on identifiable landmarks, such as Lister's tubercle, ensuring precise graft excision and fixation.

RESULTS:

The integrated 3D modeling technology facilitated an accurate hamate graft fit, demonstrated by a near 1:1 match in the coronal plane and minimal bone waste. Remarkably, no additional autograft or allograft was required. Recovery was marked by complete radiographic union, full range of motion, minimal to no pain, and a return to work at the three-month follow-up. Despite the additional steps, operative time remained consistent with traditional procedures.

DISCUSSION AND CONCLUSION:

Our findings highlight the potential of high-resolution 3D imaging and custom cutting guides to aid graft match precision and reduce bone waste in proximal pole scaphoid reconstruction. Operative times comparable to traditional techniques underscore the efficiency of using 3D modeling. Moreover, the custom guides facilitated accurate and efficient surgical execution, with no complications reported to date. Future research will focus on optimizing the placement and security of cutting guides and developing similar techniques for other hand surgeries. This ongoing refinement aims to further guide the precision and efficiency of surgical procedures involving complex anatomical structures.

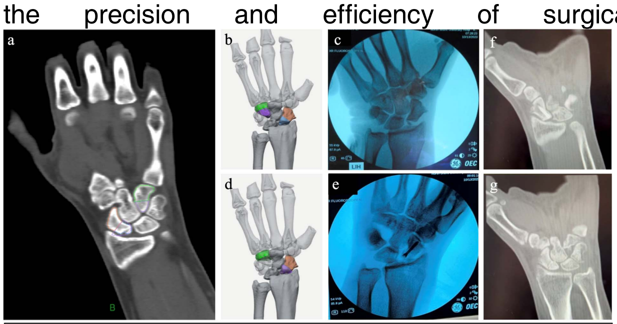

Fig. 1: (a) Preoperative CT of patient's wrist used to create the 3D model in Materialise Mimics. (b) 3D render of preoperative wrist showing scaphoid (orange), templated scaphoid to be excised (blue), hamate (green), and templated hemi-hamate autograft (purple). (c) Preoperative X-ray showing the fractured scaphoid proximal pole. (d) Postoperative 3D render showing preserved scaphoid distal pole (orange), hemi-hamate autograft proximal pole (purple), and remaining hamate distal pole (green). (e) Postoperative X-ray showing hemi-hamate autograft fixation with a cannulated 18 mm x 2.2 mm headless compression screw. (f) 2-month follow-up CT showing accuracy of autograft alignment and fixation. (g) 2-month follow-up CT view in plane dorsal to (f), showing autograft alignment and healing around nail.

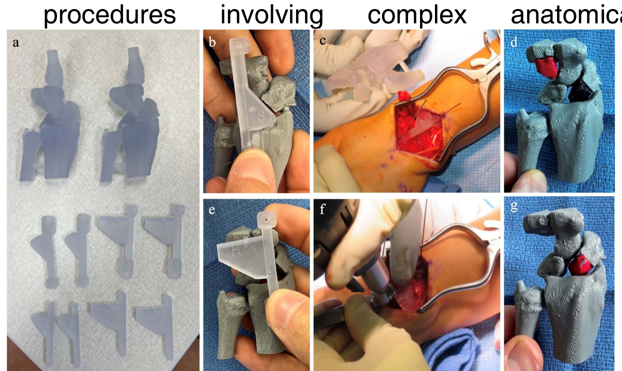

Fig. 2: (a) Preoperative 3D printed models of the patient's wrist with personalized scaphoid and hamate cutting jigs. (b) Scaphoid cutting jig positioned on the preoperative model. (c) Scaphoid cutting jig used to excise the fractured proximal pole. (d) Preoperative 3D printed reference model of the patient's wrist with the fractured portion of the scaphoid (black) and the hamate graft (red) labeled. (e) Hamate cutting jig positioned on the model. (f) Hamate graft cutting jig used to prepare the donor proximal pole. (g) Postoperative 3D model of the patient's wrist with the hemi-hamate autograft.