

A Virtual Reality Workflow for Facial Trauma: Virtual Reduction, Rapid 3D Printing and Plate Bending

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INTRODUCTION

Immersive virtual reality (VR) has advanced multiple surgical fields, including neurosurgery, orthopedics, oral/maxillofacial surgery, and surgical education.¹⁻⁴ The ability of VR to visualize complex three-dimensional (3D) relationships is particularly relevant to craniofacial surgery. While VR has been studied in orthognathic surgery and head and neck reconstruction, its application to craniofacial trauma remains underexplored. This study examines the implementation and evolution of VR in craniofacial trauma at a single institution, outlining the development of a dedicated trauma workflow.

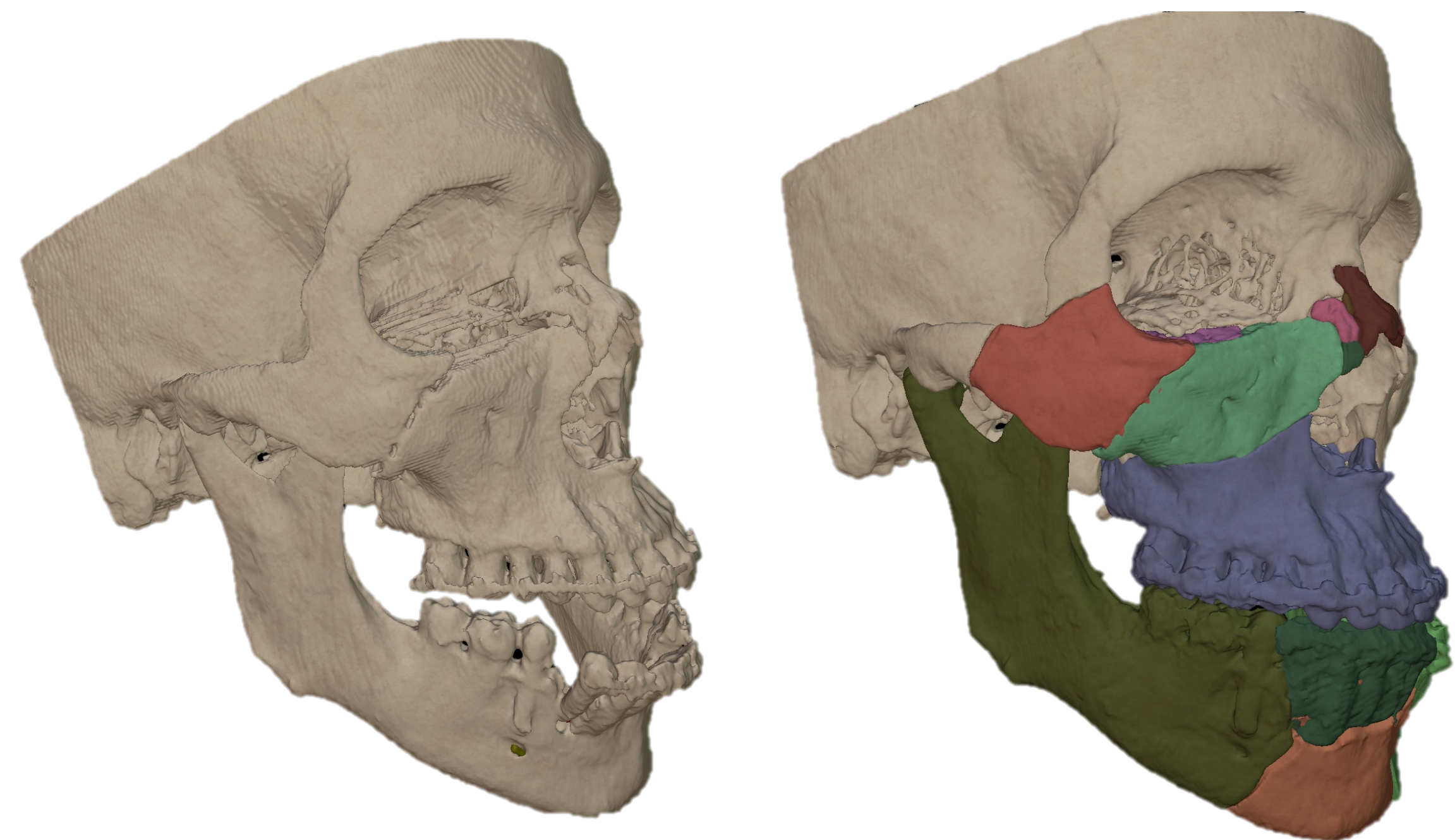


Fig 1 ImmersiveTouch pre- and post reduction VR planning of pan-facial fractures

METHODS/RESULTS

A retrospective review was conducted of patients treated with VR-assisted planning for facial fractures between 2020 and 2025. VR was utilized by four plastic surgeons across two hospitals. Over this period, 155 craniofacial trauma cases incorporated VR. In total, VR has been applied in 1,472 surgical procedures spanning more than eight distinct indications.

Sinai Chicago Craniofacial Trauma Workflow

Step 1: Fracture segmentation in virtual reality

Preoperative CT scan is examined in the VR planning platform and fractures are segmented by the plastic surgeon. Reduction is simulated to create a reduced 3D model to be printed. The entire process takes **10-20 minutes**. (Fig 2)

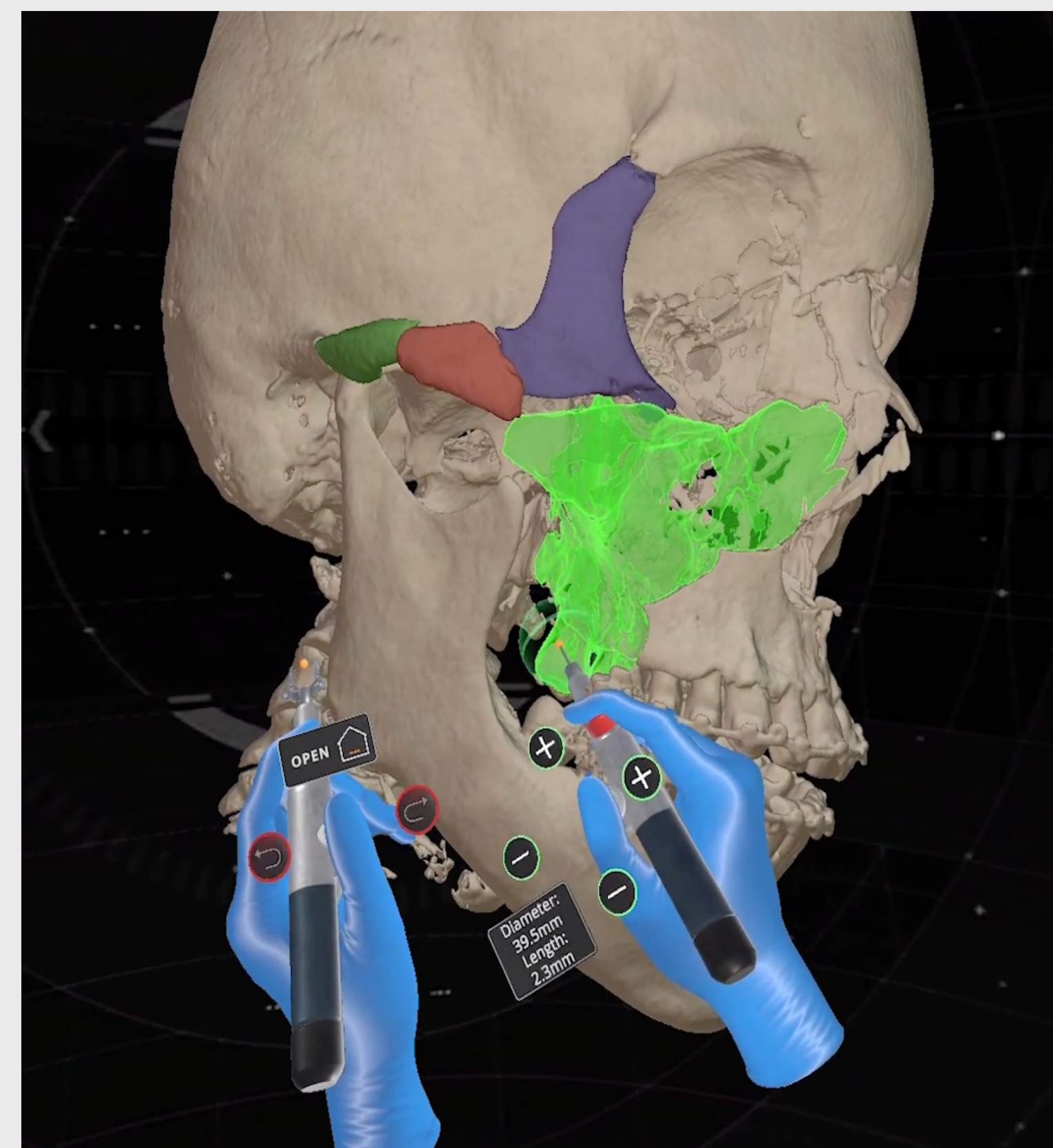


Fig 2 shows the interactive, immersive VR platform with real-time manipulation, segmentation and reduction of facial fractures.⁵



Fig 3 3D printed model and printer

Step 2: Rapid 3D printing

Reduced models are 3D printed onsite, a process that **takes 12 hours** and is often performed overnight for surgery the following day. (Fig 3)



Step 3: Plate bending

The surgeon then uses the reduced 3D-printed model to pre-bend plates. Plates can then be sterilized and used intraoperatively. This workflow now makes custom surgical planning possible with an **overnight turnaround**. (Fig 4)

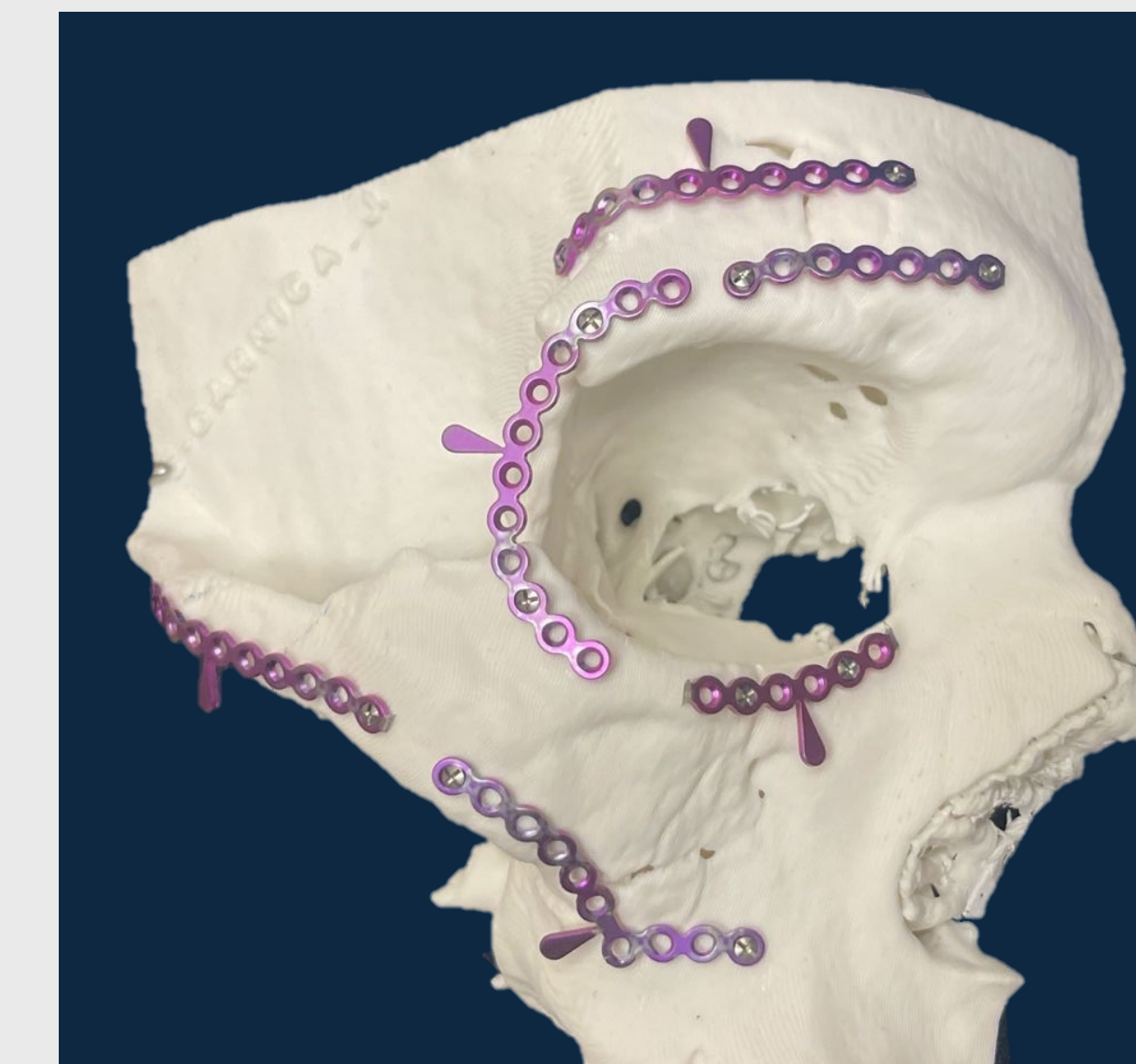


Fig 4 3D models pre-operative plate bending

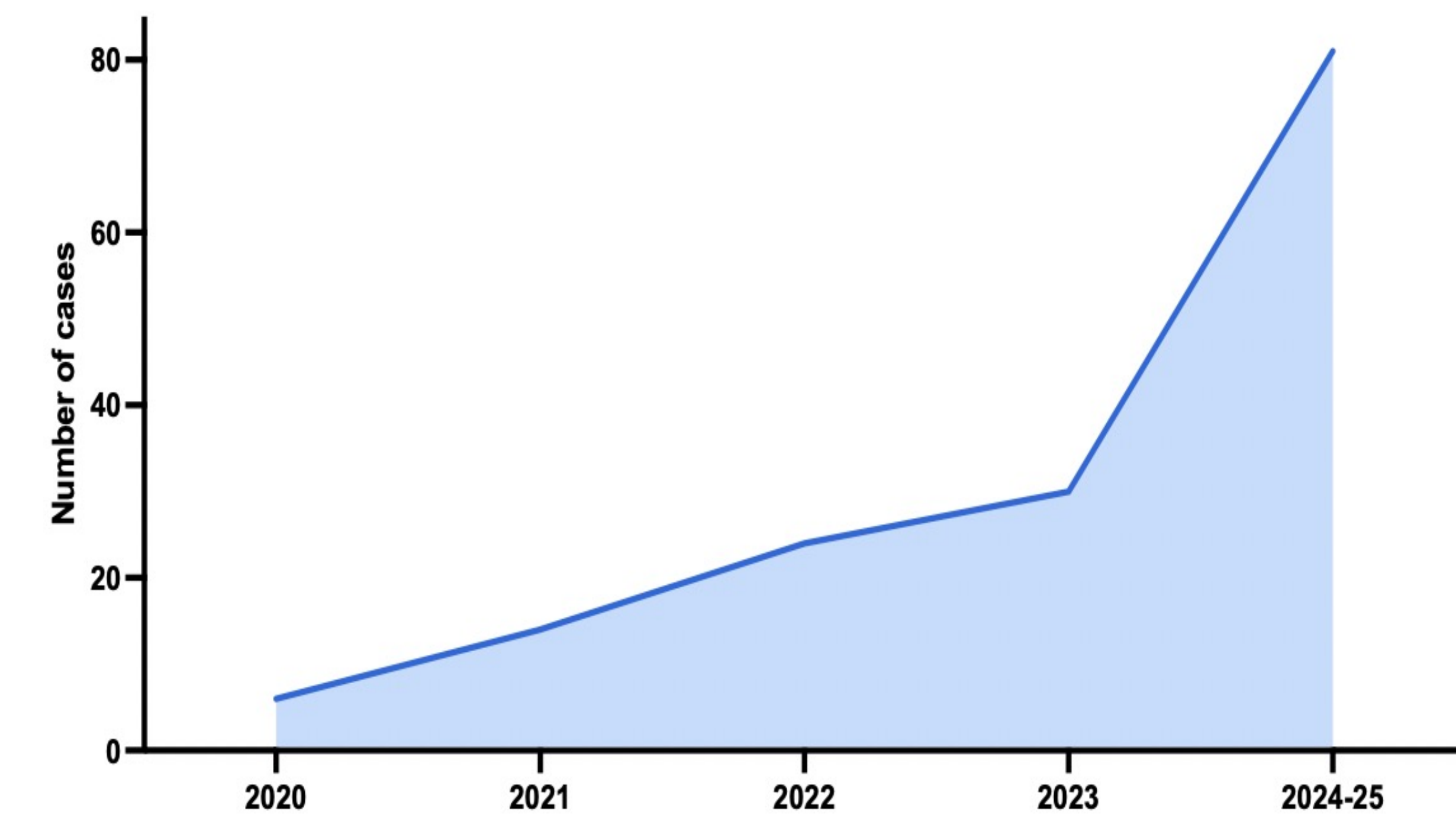


Figure 5 shows the significant increase in use of VR for craniofacial trauma over this short 4.5-year period.

CONCLUSION

The use of VR for surgical planning allows for the manipulation of bone in 3D which can significantly improve intraoperative navigation for fracture reduction and fixation. This technology allows for the segmentation of individual fracture fragments and reduction creating a model for surgeons to use in real-time. This study demonstrates an evolution of the use of VR for craniofacial trauma, introducing a three-step workflow that allows for a 24-hour turnover from fracture presentation to custom planned surgical intervention.

FUTURE DIRECTIONS

Building on this established VR-assisted trauma workflow, future efforts will be focused on expanding implementation and evaluating surgical outcomes such as operative time, blood loss, and long-term patient outcomes.

¹Ayoub A, Puljajala Y. The application of virtual reality and augmented reality in Oral & Maxillofacial Surgery. *BMC Oral Health*. 2019;19(1):238. doi:10.1186/s12903-019-0937-8

²Lan L, Mao RQ, Qiu RY, Kay J, de Sa D. Immersive Virtual Reality for Patient-Specific Preoperative Planning: A Systematic Review. *Surg Innov*. 2023;30(1):109-122. doi:10.1177/15533506221143235

³Arias-Amezquita E, Alkureishi L, Purnell C, et al. Virtual Reality Planning in Reconstructive Surgery for Orbital Prosthetic Rehabilitation Using ImmersiveTouch Platform: Preliminary Report. *J Craniofac Surg*. 2024;35(2):392-397. doi:10.1097/SCS.00000000000009794

⁴Kaplan N, Marques M, Scharf I, et al. Virtual Reality and Augmented Reality in Plastic and Craniomaxillofacial Surgery: A Scoping Review. *Bioengineering (Basel)*. 2023;10(4):480. doi:10.3390/bioengineering10040480

⁵Immersive VR/AR Custom Simulations. ImmersiveTouch. Accessed April 11, 2025. <https://www.immersivetouch.com/custom-projects>