Intraoperative Immersive Three-Dimensional Neuronavigation for Skull Base Surgery and Frontal Sinus Dissection

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Introduction

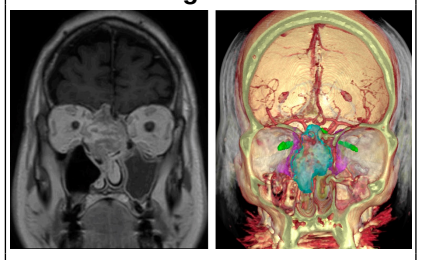
- Identification of anatomic landmarks during endonasal skull base surgery preseents an operative challenge.
- Neuronavigation systems assist with spatial orientation, but they often require the surgeon to mentally correlate three-dimensional (3D) views with two-dimensional (2D) radiology studies.
- This study outlines the initial clinical experience with a novel technology that connects endosocpic visualization with intraoperative navigation.
- Manually segmented, 3D reconstructions of patient anatomy for varied tumor resections were created and used during endoscopic skull base surgery.

Methods

Prospective study involving endoscopic anterior skull base and complex paranasal sinus cases. Data from pre-operative CT and MRI scans were fused to create 3D digital models of patient anatomy. Using technology developed by Surgical Theater (Mayfield Village, OH), these reconstructions were designed to highlight particular anatomic regions of interest with unique color segmentation and text labels. The models were studied during the pre-operative period to guide surgical approach and anticipate critical structures.

The reconstructions were linked with navigational technology created by Brainlab (Munich, Germany) during endoscopic surgery; linking was accomplished using Surgical Theater's EndoSNAP. The endoscope was used as the navigational probe, generating a dynamic image of the tumor anatomy that was displayed alongside a matching camera view produced by the endoscope. These two views could be overlaid to provide a mixed reality visualization throughout the surgery.

Figure 1



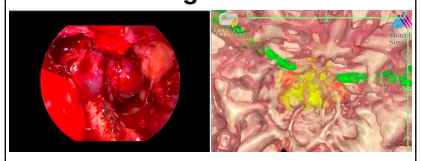
Preoperative MRI and 3D digital reconstruction for a patient diagnosed with olfactory neuroblastoma.

Results

40 cases were performed. The pathologies included tumors of the anterior skull base or sinonasal cavity, inflammatory sinus disease, and CSF leaks. The most common lesions were pituitary tumors (15). It took approximately 30 minutes to create each reconstruction before surgery

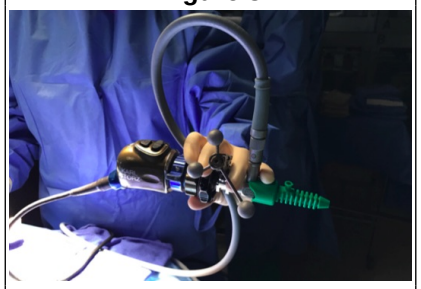
Specific anatomic structures were chosen for enhancement based on patient anatomy and pathology. The most commonly isolated structures for visualization were tumors, the internal carotid arteries, and the optic nerves. Subjective feedback was recorded based upon survey questionnaires performed by the operating surgeons . These reviews detailed how the mixed reality visualization benefited surgical decision-making.

Figure 2



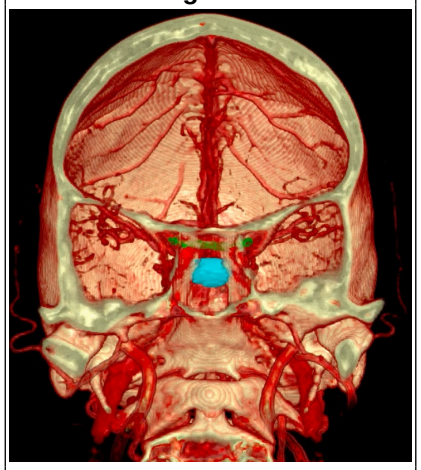
Intropeartive endoscopic and reconstruction views captured during pituiatry adenoma resection.

Figure 3



Endoscope with Brainlab Navigational Fiducials attached.

Figure 4



Digital 3D reconstruction for a patient diagnosed with pituitary adenoma.

Conclusions

We describe the first clinical series of complex skull base pathologies treated using a mixed reality platform. The EndoSNAP is a promising mixed reality system for guidance during endoscopic surgery. Direct application can be accomplished reliably during a variety of complex skull base surgery. Future detailed clinical studies involving outcome analysis will evaluate the accuracy of the reconstructions and elaborate their effects on complication rates and operative time.

Learning Objectives

1) Describe a novel, mixed reality navigational tool for endoscopy surgery.
2)Describe the initial experience with this tool with 40 patients