

3D Navigation-Guided Volumetric and Angular Quantitative Analysis of Nasofrontal Trephination, Sublabial Contralateral Transmaxillary, and Subtarsal Contralateral Transmaxillary Approaches to the Skull Base and Upper Cervical Spine



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Background

Recent advances in endoscopic skull base surgery have enabled access to previously challenging regions. While the sublabial contralateral transmaxillary (SL-CTM) approach is well established, the nasofrontal trephination (NFT) and subtarsal contralateral transmaxillary (ST-CTM) approaches offer novel corridors whose spatial reach and angular capacities remain underexplored.

Objective

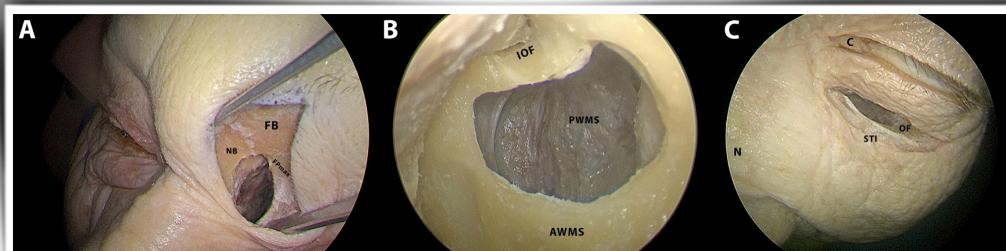
To perform a 3D navigation-guided volumetric and angular analysis of NFT, SL-CTM, and ST-CTM approaches to quantify and compare their anatomical reach and assist surgical decision-making.

Methods

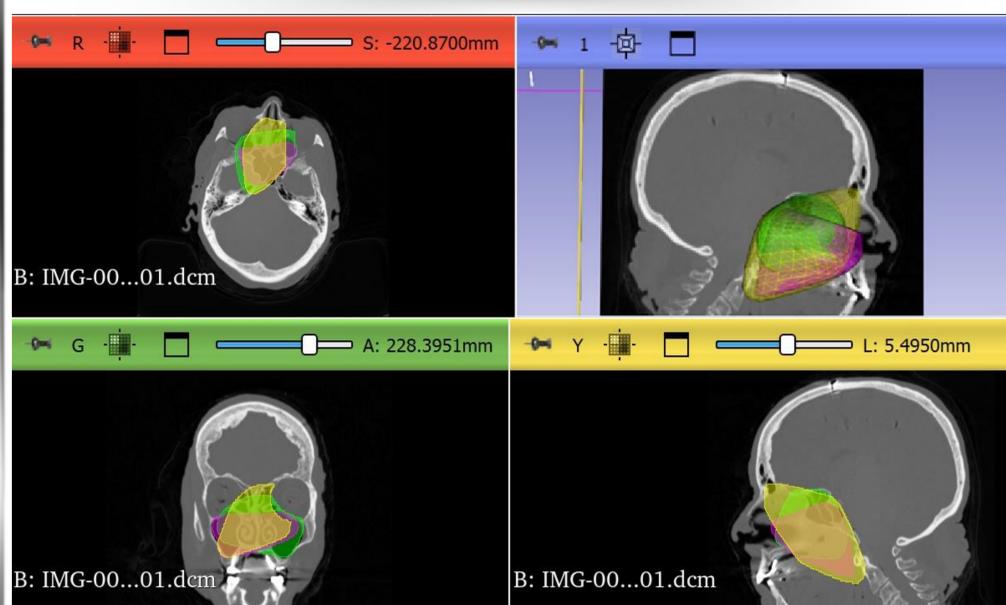
Five latex-injected cadaveric heads were dissected using each approach. Pre-dissection CT imaging and a stereotactic navigation system facilitated precise annotation of reachable anatomical landmarks. Using 3D Slicer software, fiducial points were reconstructed into three-dimensional models to measure accessible volumes and instrument angulation in coronal and sagittal planes.

Results

NFT approach achieved the highest mean accessible volume (156,643 mm³), followed by SL-CTM (134,982 mm³) and ST-CTM (111,458.5 mm³). NFT also demonstrated the greatest vertical angular reach (113.64° ± 29.45°), while SL-CTM achieved the broadest horizontal angulation (109.4° ± 13.36°). SL-CTM provided superior lateral access to the paramedian skull base, whereas NFT extended further caudally toward the odontoid and craniovertebral junction. ST-CTM offered intermediate performance in both dimensions.



A, nasofrontal incision; **B**, sublabial contralateral transmaxillary; **C**, subtarsal contralateral transmaxillary; AWMS, anterior wall of maxillary sinus; C, medial canthus; FB, frontal bone; IOF, infraorbital foramen; NB, nasal bone; N, nose; OF, orbital floor; PWMS, posterior wall of maxillary sinus; STI, subtarsal incision.



Each segment (yellow, green and blue) represents the maximum spatial reach of an approach. Yellow segment: Nasofrontal approach, green segment: Contralateral sublabial transmaxillary approach, purple segment: Contralateral subtarsal transmaxillary approach.

Conclusion

The NFT approach offers significant vertical maneuverability and volume for accessing midline caudal skull base lesions, making it a strong adjunct to endonasal routes. SL-CTM approach provides enhanced lateral reach, ideal for petrous apex and paramedian targets. This study introduces a reproducible navigation-based volumetric modelling methodology to guide approach selection and optimize operative planning.

References

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