Endoscopic Endonasal Transcavernous Surgery for Pituitary Adenoma Resection: Artificial Intelligence Analysis of Surgical Technique

Jonathan B. Lamano, MD/PhD[1], A. Sofia Alvarez, MD[1], Dhiraj J. Pangal, MD[1], Michael T. Chang, MD[2], Juan C. Fernandez-Miranda, MD[1]

[1]Department of Neurosurgery, Stanford University, Palo Alto, California

[2]Department of Otolaryngology, Stanford University, Palo Alto, California

Introduction

Pituitary adenomas with cavernous sinus invasion represent a distinct surgical challenge as incomplete resection of cavernous sinus disease is associated with increased risk of recurrence or lack of remission. However, misguided cavernous sinus exploration can also be associated with significant vascular and cranial nerve injury. Safe, anatomically based approaches to transcavernous resection have been described involving an extensive bony exposure, inspection of the medial wall of the cavernous sinus, opening of the anterior wall, release of parasellar ligaments and inferior hypophyseal artery, and ultimately removal of the medial wall and/or exploration of cavernous sinus compartments.[1-3] Artificial intelligence driven analysis of operative videos provides a mechanism to further define the transcavernous surgical technique.

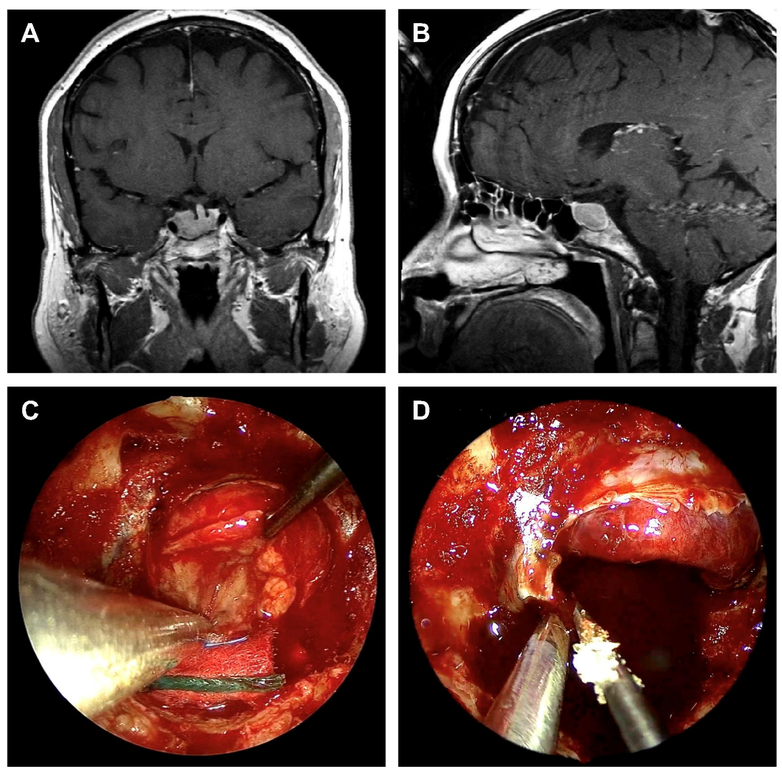

Figure 1. Endoscopic endonasal transcavernous surgery for resection of a pituitary adenoma with cavernous sinus invasion. (A) Coronal and **(B)** sagittal MRI studies demonstrate a hypoenhancing pituitary lesion with involvement of the right cavernous sinus. **(C)** The sellar component of surgical resection was performed involving central debulking and dissection of the tumor from the normal pituitary gland and the right-sided medial cavernous sinus wall. **(D)** Evidence of tumor invasion was identified along the medial wall of the right cavernous sinus, prompting transcavernous exploration and resection of the medial wall of the cavernous sinus, without evidence of frank cavernous sinus invasion.

Methods and Materials

Operative videos of patients undergoing an endoscopic endonasal approach for pituitary adenoma resection from 2022-2023 were reviewed. Cavernous sinus invasion was identified in 9 patients, who subsequently underwent transcavernous surgery for resection of cavernous sinus disease. Operative videos were uploaded to the Surgical Data Science Collective and instrument detection was performed via built-in machine learning and computer vision algorithms.[4] Separate analyses were performed during the sellar and transcavernous components of tumor resection to facilitate comparison of instrument use statistics, instrument timelines, and heatmaps across phases of surgical resection.

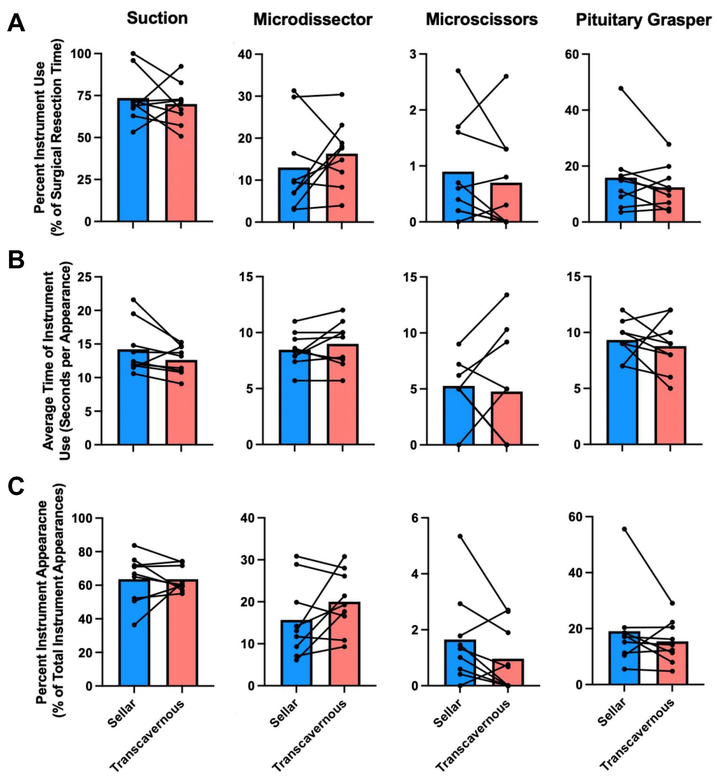

Figure 2. Instrument Use Across Sellar and Transcavernous Phases of Pituitary Adenoma Resection. (A) Percent instrument use across the duration of surgical resection, **(B)** average duration of instrument use per instrument appearance, and **(C)** percent instrument appearance across all instrument appearances was not significantly different across the sellar and transcavernous phases of surgery for the suction, microdissector, microscissors, or pituitary grasper.

Results

Transcavernous resection encompasses a shorter duration of time compared to sellar resection (23 minutes versus 57 minutes, p=0.01). The tear-drop suction, microdissector, microscissors, and pituitary grasper were the instruments identified by the detection algorithm with 70-99% confidence in detection. Injectable hemostatic agents, cottonoids, and the right-angle knife were not detected in this analysis. On pairwise analysis, there was no significant difference in suction, microdissector, microsscissors, or grasper use across the sellar and transcavernous portions of the operation, as measured by percentage instrument use, average duration of instrument use, and percentage of instrument appearances (p>0.05). During transcavernous resection, the suction was in use for 70.0% of the operative duration, comprising 63.6% of all instrument appearances, with an average duration of use of 12.6 seconds. The microdissector was in use for 16.3% of the transcavernous phase, comprising 20.0% of instrument appearances, with an average duration of use of 9.0 seconds. The grasper was used for 12.5% of the transcavernous resection, accounting for 15.4% of instrument appearances, with an average duration of use of 9.0 seconds. The microscissors were in use for 0.7% of the transcavernous resection, encompassing 1.0% of instrument appearances, with an average duration of use of 4.8 seconds. Instrument timelines demonstrated trends towards more consistent microdissector use during the transcavernous phase and less grasper use. Compared to heatmaps of instrument use during the sellar resection phase, instrument use during the transcavernous phase remained restricted to the affected cavernous sinus.

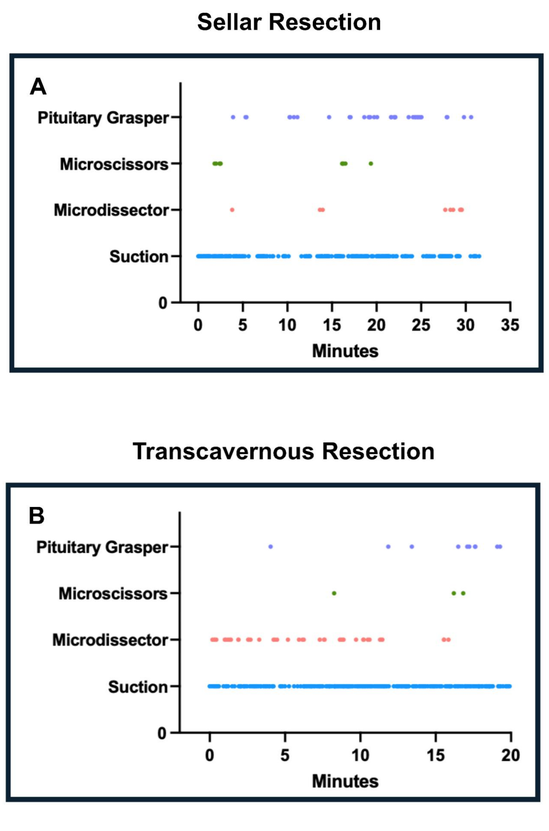

Figure 3. Instrument Timelines Across Sellar and Transcavernous Phases of Pituitary Adenoma Resection. Comparison of instrument timelines during the **(A)** sellar phase and **(B)** transcavernous phase of resection demonstrate trends towards increased microdissector use and decreased pituitary grasper use during the transcavernous phase of tumor resection.

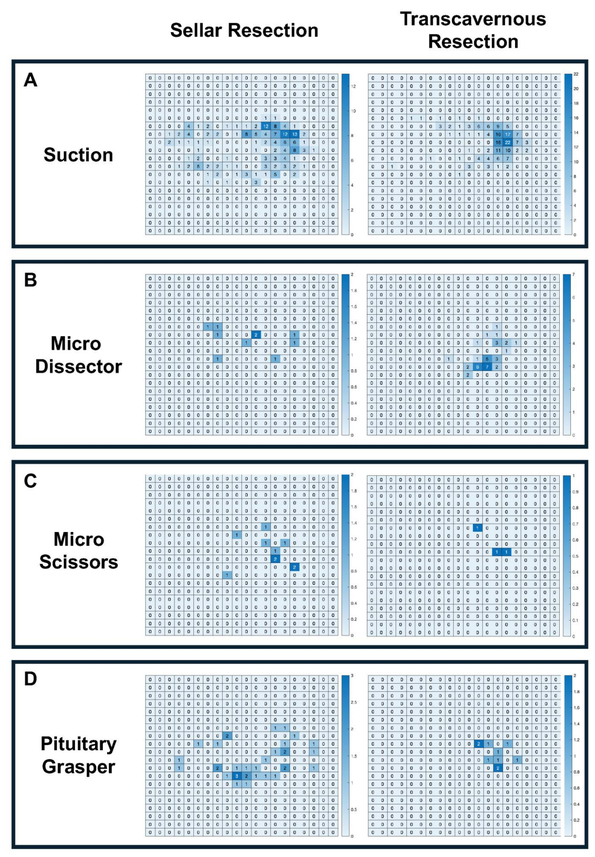

Figure 4. Instrument Heatmaps Across Sellar and Transcavernous Phases of Pituitary Adenoma Resection. Instrument heatmaps across the sellar and transcavernous phases of tumor resection demonstrate increased **(A)** suction, **(B)** microdissector, **(C)** microscissors, and **(D)** pituitary grasper use targeted towards the affected cavernous sinus.

Conclusions

Transcavernous exploration and resection requires proficiency in cavernous sinus anatomy, proper surgical technique, and the ability to control venous sinus bleeding. Artificial intelligence analysis identified a hierarchy of instrument use, with the suction and microdissector comprising the most predominantly used instruments during transcavernous resection. Overall, this serves as a preliminary attempt to characterize proper transcavernous resection technique.

Contact

Jonathan B. Lamano, MD/PhD
Stanford University
Department of Neurosurgery
Jonathan.Lamano@Stanford.edu

References

1. Truong HQ, Lieber S, Najera E, et al. The medial wall of the cavernous sinus. Part 1: Surgical anatomy, ligaments, and surgical technique for its mobilization and/or resection. *J Neurosurg* . 2018: 131(1): 122-130.
2. Cohen-Cohen S, Gardner PA, Alves-Belo JT, et al. The medial wall of the cavernous sinus. Part 2: Selective medial wall resection in 50 pituitary adenoma patients. *J Neurosurg*. 2018: 131(1): 131-140.
3. Fernandez-Miranda JC, Zwagerman NT, Abhinav K, et al. Cavernous sinus compartments from the endoscopic endonasal approach: Anatomical considerations and surgical relevance to adenoma surgery. J Neurosurg. 2017: 129(2): 430-441.
4. Surgical Data Science Collective. <https://www. surgicalvideo.io>