Expanding Access to the Petrous Apex and Petroclival Region using the Contralateral Transmaxillary Approach with the Addition of Transpterygoid Drilling

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INTRODUCTION

When approaching the petrous apex and petroclival region, endoscopic transnasal surgery serves as an alternative to transcranial approaches for the midline skull base lesions. However, lateral access is limited due to the steep angle through the nasal access, especially in the area behind the petrous internal carotid artery (ICA) and, ultimately, in the cerebellopontine angle. Recently, the contralateral transaxillary (CTM) approach has been reported as a more direct trajectory providing a more parallel angle to the petrous ICA. Nevertheless, lateral access to petrous bone drilling using this approach can become limited by the pterygoid process and the lateral buttress of the maxillary sinus. Therefore, we aimed to explore the contralateral transmaxillary transpterygoid (CTMP) approach with and without removal of the lateral buttress of the maxillary sinus to further expand access to the petroclival area.

MATERIALS & METHODS

Ten sides of five formalin-fixed, latex-injected anatomical specimens were dissected to compare the CTM, CTMP, and CTMP with lateral buttress removal (CTMP-LBR). In addition, **30 sides** of non-pathological computed topography angiography (CTA) scans were used to obtain digital measurements for the three approaches. During the anatomical dissection of the CTMP-LBR, the periosteum encasing the infratemporal fossa musculature was left intact and the musculature was retracted posteriorly. The instrumentation to the petrous apex is not performed through the musculature.

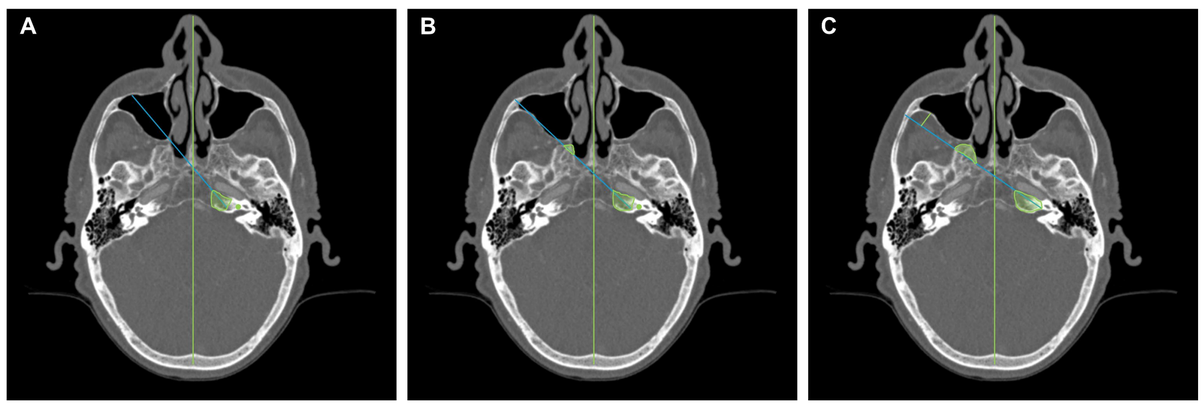

Figure 1. Radiographic measurements of computed tomography angiography (CTA) scans. (A) CTM approach highlighted in blue, with the target of the medial cochlea (green circle) taking care not to involve the pterygoid and ensuring no violation of the petrous carotid. Measurements include area of drilled retrocarotid petrous bone. (B) CTMP approached highlighted in blue, with the target of the medial cochlea (green circle), ensuring no violation of the petrous carotid. Measurements include area of drilled retrocarotid petrous bone and pterygoid. (C) CTMP-LB, with trajectory of the approach highlighted in blue, with the goal of the trajectory reaching the medial cochlea while minimizing distance within the infratemporal fossa and ensuring that the petrous carotid is not violated. Measurements include area of drilled retrocarotid petrous bone, area of drilled pterygoid, and minimal distance of soft tissue compression within the infratemporal fossa.

RESULTS

Table 1. Summary of cadaveric measurements

Parameter (median, range)	CTM (n = 10)	CTMP (n = 8)	CTMP, lateral buttress removal (n = 8)	p value
Angle (°)	36° (25-43°)	45° (34-50°)	55° (45-62°)	< 0.001
Increase in distance of access from ICA anterior wall	Ref.	47.2% (20-128.6%)	122.9% (27.8-214.4%)	0.017

Table 2. Summary of radiographic measurements

Parameter (median, range)	CTM (n = 30)	CTMP (n = 16)	CTMP, lateral buttress removal (n = 29)	p value
Length (mm)	101.9 (90.3-114.6)	102.8 (90.8-115.7)	107.9 (92.3-120.7)	0.050
Angle (°)	41.9° (33.0-46.5°)	47.6° (45.1-50.3°)	54.1° (48.3-60.1°)	< 0.001
Proportion of drilled retropetrous carotid bone (medial to the cochlea)	69.6% (41.7-100%)	83.1% (71.4-100%)	100%*	< 0.001

Table 3. Radiographic details of CTMP and CTMP-LBR

Parameter	Median (Range)
CTMP (n = 16)	
Length of pterygoid drilling (mm)	3.8 (2.7-8.2)
CTMP-LBR (n = 29)	
Length of pterygoid drilling (mm)	9.1 (4.0-15.4)
Displacement of soft tissue of the infratemporal fossa (mm)	11.1 (4.0-17.2)

Table 4. Comparison of radiographic measurements between patients that could benefit from CTMP (without LBR) vs CTM alone

Parameter (median, range)	No (n = 14)	Yes (n = 16)	p value
Angle of petrous ICA (°)	33.5° (23.7-42.8°)	27.9° (21.2-33.2°)	**0.005**
Distance from petrous ICA to IAC (mm)	25.4 (21.4-29.8)	22.9 (18.4-28.2)	0.096
Distance of IAC from midline (mm)	31.0 (28.3-35.7)	30.7 (28.3-35.1)	0.865
Width of clivus (mm)	23.3 (18.7-27.5)	22.0 (17.7-26.1)	0.177

RESULTS CONT.

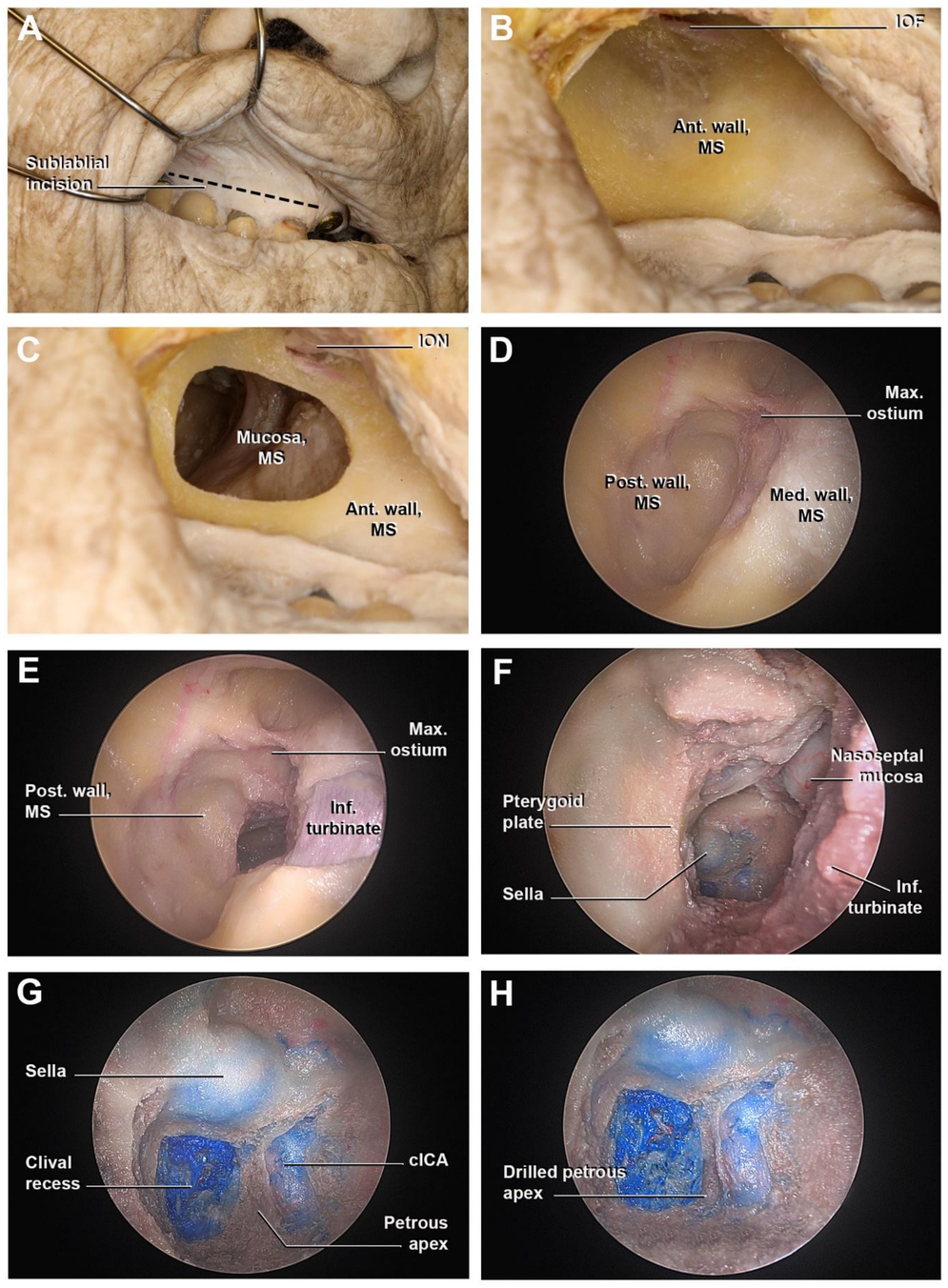

Figure 2. Steps of the CTM approach. A sublabial incision is made (A) and the mucosa elevated to access the anterior wall of the maxillary sinus (B), after which a Cadwell-Luc window is created below the infraorbital nerve (C) to acces the maxillary sinus (D). Using the natural maxillary ostium within the medial wall of the maxillary sinus, a window is drilled in the posterior portion of the medial maxillary sinus wall (E, F) in order to access the sphenoid sinus (G). Compared to endoscopic endonasal approach to the sphenoid sinus, the petrous apex is centered in the field of view with CTM, allowing for more direct drilling of the petrous apex (H). Abbreviations: *Ant*. anterior; *cICA*. cavernous internal carotid artery. *Inf*. inferior; *IOF*. infraorbital foramen. *Max*. maxillary; *Med*. medial; *MS*. maxillary sinus; *Post*. posterior.

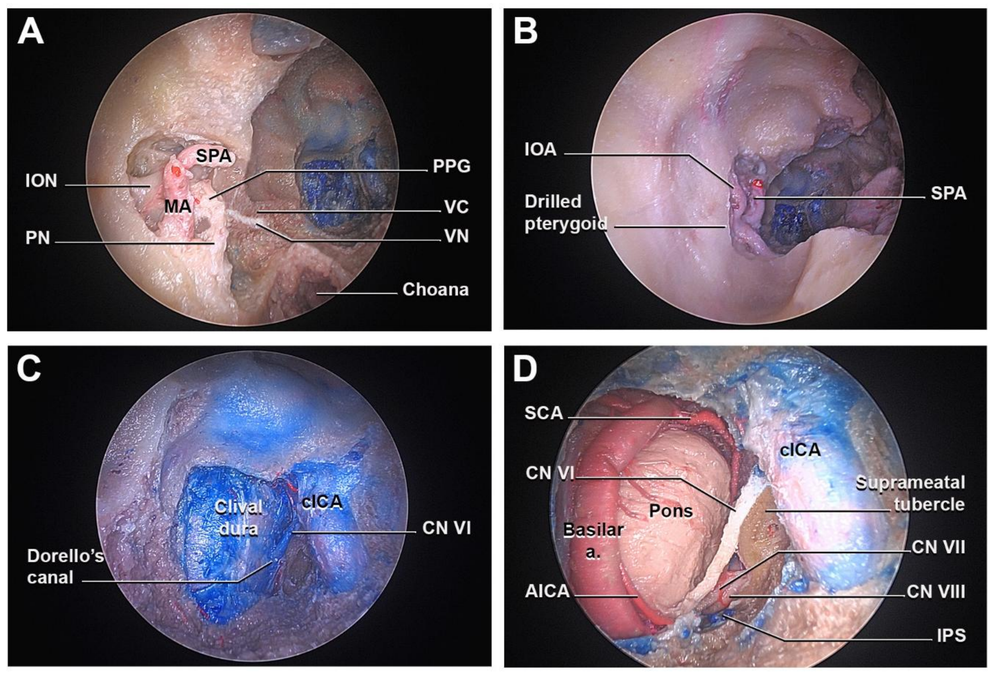

Figure 3. Steps of the CTMP approach with additional pterygoid drilling to the CTM and expanded access to the petroclival area. (A) View of the transpterygoid approach from endoscopic endonasally with transection of the sphenopalatine artery, taking care to expose and protect the vidian nerve within the vidian canal. (B) View from the contralateral transmaxillary trajectory following transpterygoid drilling, demonstrating lateralization of the contents of the pterygopalatine fossa, in order to provide expanded access to the sphenoid sinus. (C) Within the sphenoid sinus, the bone of the clival recess can be drilled to provide access to the clival dura and content within the posterior fossa. (D) With the addition of the transpterygoid drilling, a more favorable angle is achieved to allow for additional drilling of the retrocarotid petrous bone, until cranial nerves VII and VIII are reached, serving as the posterior limit of this approach. Abbreviations: *a*. artery; *AICA*. anterior inferior cerebellar artery; *cICA*. cavernous internal carotid artery; *CN*. cranial nerve; *IOA*. infraorbital artery; *ION*. infraorbital nerve; *IPS*. inferior petrosal sinus; *MA*. maxillary artery; *PN*. palatine nerve; *PPG*. pterygopalatine ganglion; *SCA*. superior cerebellar artery; *SPA*. sphenopalatine artery; *VC*. vidian canal; *VN*. vidian nerve.

CONCLUSIONS

CTMP, the modification of the CTM with the additional pterygoid drilling, with or without removal of the lateral buttress can increase access to the petroclival area, especially the inferior petrous apex. Following removal of the lateral buttress, minimal soft tissue compression within the infratemporal fossa is required to achieve a surgical angle parallel to that of the petrous ICA. Preoperative assessment of the petrous ICA angle may be useful in selecting whether CTM versus CTMP should be employed to maximize access to the petroclival area and intraoperative safe maneuvers surrounding this area.