Petrous Apex 360°: A Comprehensive Anatomical Study of Microsurgical and Endoscopic Approaches Using 2D and 3D Photogrammetry Models for Optimized Surgical Corridor Selection.

Cezar K Prigenzi, MD [2]; Elena Rosellini, MD[2] ; Gean F Gerbino, MD [2]; Sergio Farias, MD[2] ; Gabriel V Rosales, MD[2]; Aysu I Kabakci, MD[2]; Dan Oberman, MD[3]; Djalma de Campos G Jr 4 ; Joao P Almeida, MD, PhD[1] [2]

[1]Department of Neurosurgery, Indiana University, Indianapolis, IN, US
[2]Almeida's Skull Base Lab, Wile Hall, IU Health; Department of Neurosurgery, Hospital Força Aérea do Galeão, Rio de Janeiro, RJ[3];, BR; Nove de Julho University, Bauru, SP, Br4

Background : The petrous apex is a highly complex anatomical region located at the confluence of the middle fossa, posterior fossa, and sphenoid sinus, related to critical neurovascular structures. Its depth and delicate adjacent anatomy demand precise anatomical understanding for effective tumor resection and minimal morbidity. Optimal surgical approach selection is necessary, guided by lesion characteristics, extension, and patient anatomy.

Objective : This study aims to provide a comprehensive anatomical and surgical correlation of microsurgical and endoscopic approaches to the petrous apex. By comparing various surgical corridors through a 2D and a 3D photogrammetry model visualization, we seek to precisely delineate their respective advantages, limitations, and specific exposed anatomical segments. This informs optimal surgical planning, enhancing understanding of tumor addressing based on extensions and locations.

Figure 1: Photographic record by Cezar Kabbach, copywriting by João Paulo Almeida, a panoramic view of the final dissection used to build the photogrammetry 3D model, with the petrous apex being the center of rotation.

METHODS : Anatomic dissections were performed on 10 sides of alcohol-fixed, formilin/silicone-injected cadaveric heads. Four primary surgical approach categories were investigated: 1) pre-temporal middle fossa approach , 2) retrosigmoid approach, 3) endoscopic endonasal (EEA), and 4) endoscopic transorbital. Endoscopic dissections used HD video systems (Storz and Striker Towers); microsurgical dissections used microscopes (Zeiss NC4 and Leica M320) and high-speed drills (MedTronic Midas and Striker). Extensive 2D high-resolution photographic documentation captured for each approach and processed into Agisoft Metashape software to generate 3D photogrammetric models. These models enabled analysis and comprehensive comparison of surgical fields, critical structures, and tumor corridors.

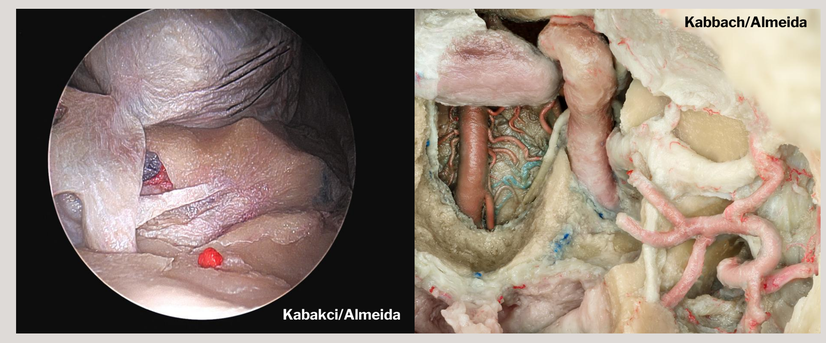

Figure 4: Photographic record by Aysu Kabakci (Left), demonstrating the view of the petrous apex through an endoscopic transorbital approach, and Cezar Kabbach (Right) demonstrating the real petrous apex and the structures surrounding it, the VI nervo medial and posterior to it and the petrous carotid laterally , copywriting by João Paulo Almeida.

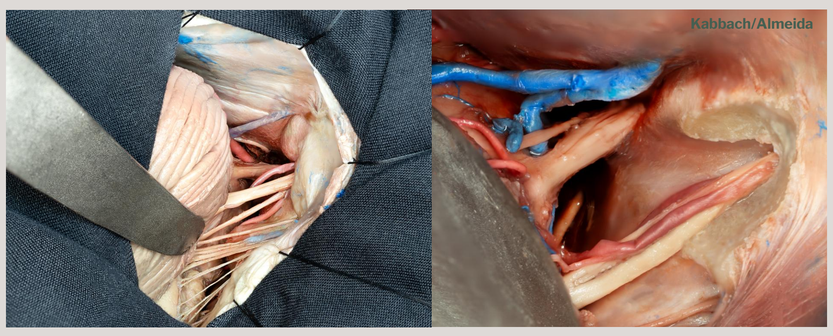

Figure 2: : Photographic record by Cezar Kabbach, copywriting by João Paulo Almeida, showing the retrossigmoid approach exposing the cerebellopontine angle (left), and a zoom in shot of the petrous apex, exposed above the VII and VIII complex, and underneath the trigeminal nerve after the drilling of the internal acoustic meatus.

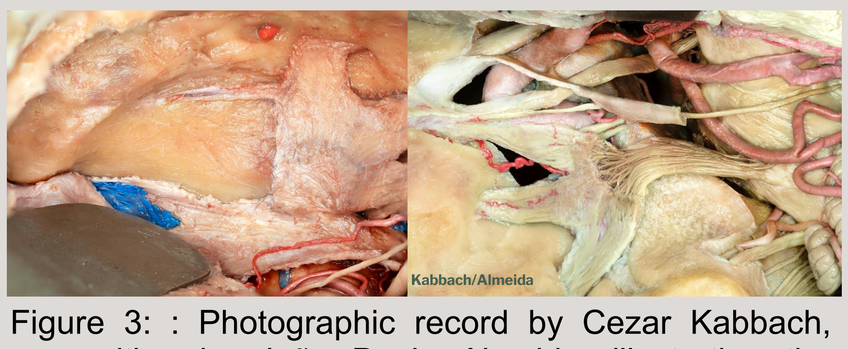

Figure 3: : Photographic record by Cezar Kabbach, copywriting by João Paulo Almeida, illustrating the limits of the petrous apex from a pre temporal middle fossa approach, on the left, the gasserian glangion (anterior), superior petrosal sinus (medial), arcuate eminence (posterior) and the GSPN (lateral). After drilling part of the petrous apex, we expose from a different angle on the right the real petrous apex, hidden underneath the trigeminal nerve.

Results : Distinct anatomical access and working corridors were analyzed through a photogammetry 3D model for each approach. The retrosigmoid approach provided excellent exposure of the preganglionic trigeminal nerve, ideal for posterior fossa extending lesions. The middle fossa approach offered broad trigeminal nerve exposure (ganglionic and post-ganglionic segments), effective for anterior and lateral extending lesions into the middle fossa. Endoscopic endonasal access established a direct ventral corridor, with lateral expansion capabilities well-suited for medial and inferior extending lesions. The endoscopic transorbital route enabled access to the petrous apex, effectively exposing pathologies lateral to the incisura and cerebellopontine angle (ganglionic segment) with minimal brain retraction. A comprehensive 360° analysis revealed differences in surgical fields, working angles, and critical neurovascular exposure relative to tumor locations and its extensions.

Discussion : Our comprehensive cadaveric study, utilizing advanced 2D and 3D photogrammetry modeling, offers an anatomical comparison of key surgical approaches to the petrous apex. These findings enhance neurosurgical trainees' anatomical understanding and spatial reasoning, optimize pre-operative planning via superior visualization of tumor corridors and extensions, and ultimately improve patient outcomes by guiding neurosurgeons to select the most effective and safest pathway for complex petrous apex pathologies based on specific location, extensions and characteristics.

REFERENCE: Rhoton AL Jr, Congress of Neurological Surgeons. Cranial Anatomy and Surgical Approaches. 1st ed. Philadelphia: Wolters Kluwer; 2023. ISBN 9781975226879.

Scan to see the 3D model.

Email: cezarkcprigenzi@gmail.com
Phone: +55 13 99751-1075