

# Application of 3-dimensional Modeling to Plan Totally Endoscopic Per-Meatal Drainage of Petrous Apex Cholesterol Granuloma

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## Keywords

petrous apex, cholesterol granuloma, 3-dimensional, endoscopic ear surgery, infracochlear

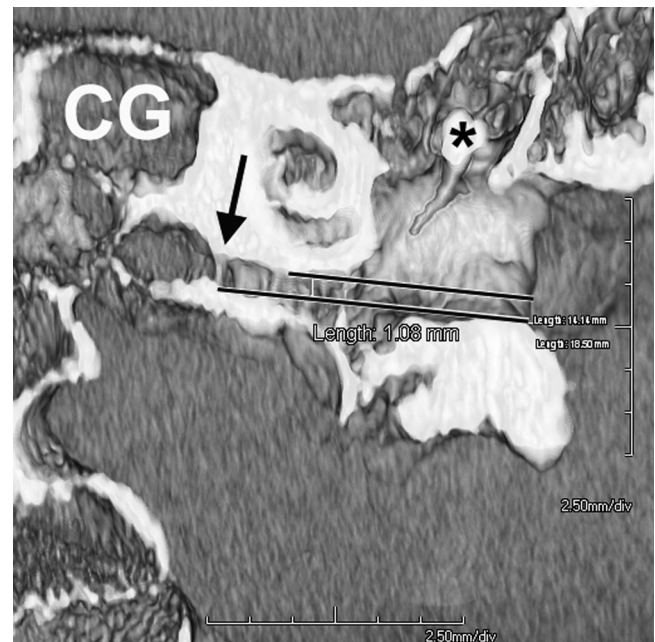
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Cholesterol granuloma (CG) of the petrous apex (PA) may be asymptomatic or enlarge to cause symptoms from compression of neural and vascular structures within the temporal bone. Surgical decompression may then be indicated. We present a case of PA-CG where the feasibility of decompression with a minimally invasive per-meatal infracochlear approach was first assessed through 3-dimensional imaging and printing technology. Exemption was granted by the hospital's Research Ethics Board.

## Case Report

PA-CG was identified as an incidental finding on magnetic resonance imaging (MRI) of a 4.5-year-old boy during investigation for a febrile seizure. Although he remained asymptomatic, serial MRI obtained 19 months later revealed enlargement of the CG. Further evaluation with computed tomography (CT) demonstrated erosion of the internal auditory meatus and the bony wall of the intrapetrous carotid artery. Given this expansile growth and neurovascular encroachment, surgical drainage was considered.

The decision to proceed with surgery was predicated on an ability to minimize morbidity. Multiple corridors were considered, but transmastoid access was impeded by a large, anteriorly placed sigmoid sinus and transsphenoidal access, by the small size of the immature sinus and adjoining marrow and growth plates. Middle fossa and retrosigmoid approaches were considered too invasive for this asymptomatic child. A pneumatized infracochlear tunnel offered the prospect of an endoscopic per-meatal infracochlear approach, but it was uncertain whether the narrow pediatric external meatus would provide sufficient access. Three-dimensional modeling was employed



**Figure 1.** Paracoronal computed tomography reconstruction of the right temporal bone (facing anteriorly) predicting a 1-mm-wide per-meatal trajectory (parallel lines) toward the bony septation (arrow) between the infracochlear tunnel and the cholesterol granuloma (CG). Asterisk: malleus head.

to verify the feasibility and safety of this approach. First, multiplanar CT imaging was analyzed to confirm that the infracochlear tunnel could indeed be accessed along a per-meatal trajectory (**Figure 1**). Next, a 3-dimensional printer (Spectrum

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**Figure 2.** View of right temporal bone model with 0° 4-mm endoscope of Rosen needle passing into the infracochlear tunnel. The needle was introduced toward the petrous apex, so confirming surgical feasibility. Asterisk: long process of incus.

Z510; 3D Systems, Rock Hill, South Carolina) was used to create a synthetic model of the patient's temporal bone (material: ZP-131; binder: ZB-60) after the CT scan was segmented (Mimics and Magics software; Materialise, Plymouth, Michigan). The approach was then successfully trialed on a printed model (**Figure 2**).

Parental consent to proceed with this approach was taken after careful explanation. A superiorly based tympanomeatal flap was elevated with a 0° 4-mm endoscope. Bony septations among the jugular bulb, promontory, and Jacobson's nerve were removed with a curette. A 45° 3-mm endoscope was then used for better infracochlear visualization. Delicate dissection toward the PA with a Rosen needle resulted in egress of the CG content. This opening was then enlarged with a rasp. Finally, the remaining contents were aspirated with suction. A stent was not placed, being considered at risk of infective contamination if acute otitis media were to occur.

The patient made a rapid recovery without complication. He remained asymptomatic, but subsequent MRI revealed reaccumulation of the CG and further expansion. At age 9 years, the procedure was repeated, again endoscopically with uncomplicated recovery, to widen the infracochlear tunnel with a Skeeter drill and insert a T-tube stent.

## Discussion

Developments in endoscopic ear surgery allow the prospect of an even less invasive per-meatal approach to the PA than that provided by transsphenoidal surgery.<sup>1-3</sup> Similarly, though, access may be restricted in children by smaller morphology, making the feasibility of this approach uncertain. Surface rendering of skull base imaging provides accurate representation<sup>4</sup> for preoperative evaluation (as **Figure 1**) but is not sufficient to predict the complex 4-dimensional interaction between movement of endoscope and instruments within the complex

curvature of the ear canal. Three-dimensional printing provides an increasingly and widely available method of modeling temporal bone anatomy.<sup>5</sup> Our case demonstrates that this technology can be used to model surgery preoperatively with sufficient accuracy to confirm the feasibility of totally endoscopic pediatric ear surgery. Further study—for example, comparing measurements and interventions in cadaveric temporal bones with models—could be used to determine the limits of accuracy. This, with faster techniques for CT scan segmentation in preparation for printing and with wider clinical availability of printers, may allow 3-dimensional printing to become a valuable tool for routine preoperative planning and patient-specific preoperative training.

## Conclusion

Totally endoscopic drainage through the infracochlear tunnel provides a truly minimally invasive option for PA-CG that is feasible even in childhood. As with other approaches, reaccumulation of PA-CG is a common challenge. Multiplanar image reconstruction and 3-dimensional printing can help determine feasibility of the approach in accordance with an individual's ear canal morphology.

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## Author Contributions

**Charnelle Carlos**, acquisition of data, drafting manuscript, approval; **William Parkes**, interpretation, revisions, approval; **Adrian L. James**, design and interpretation, revisions, approval.

## Disclosures

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