Published in final edited form as:

Otolaryngol Head Neck Surg. 2016 May ; 154(5): 920–923. doi:10.1177/0194599816630979.

Endoscopic Transcanal Retrocochlear Approach to the Internal Auditory Canal with Cochlear Preservation: Pilot Cadaveric Study

Judith Kempfle, MD^{#1,2}, Elliott D. Kozin, MD^{#1,2,3}, Aaron K. Remenschneider, MD, MPH^{#1,2,3}, Andreas Eckhard, MD^{1,2}, Albert Edge, PhD^{1,2}, and Daniel J. Lee, MD^{1,2,3}

¹Eaton-Peabody Laboratories, Massachusetts Eye and Ear Infirmary, Boston, Massachusetts, USA

²Department of Otolaryngology, Massachusetts Eye and Ear Infirmary, Boston, Massachusetts, USA

³Department of Otology and Laryngology, Harvard Medical School, Boston, Massachusetts, USA

[#] These authors contributed equally to this work.

Abstract

Contemporary operative approaches to the internal auditory canal (IAC) require the creation of large surgical portals for visualization with associated morbidity, including hearing loss, vestibular dysfunction, facial nerve injury, and skull base defects that increase the risk of cerebrospinal fluid leak. Transcanal approaches to the IAC have been possible only via a transcochlear technique. To preserve cochlear function, we describe a novel endoscopic transcanal infracochlear approach to the IAC in cadaveric temporal bones. Navigation fiducials were secured on fresh cadaveric heads, and real-time computed tomography imaging was used for surgical guidance. With a combination of curved instruments and rigid angled endoscopy, a transcanal hypotympanotomy and subcochlear tunnel were created with superior extension to access the IAC. Postprocedure imaging and temporal bone dissection confirmed access to the IAC without injury to the cochlea or neighboring neurovascular structures.

Reprints and permission: sagepub.com/journalsPermissions.nav

Corresponding Author: Elliott D. Kozin, MD, Department of Otology and Laryngology, Harvard Medical School, 243 Charles Street, Massachusetts Eye and Ear Infirmary, Boston, MA 02114, USA. Elliott_Kozin@meei.harvard.edu.

Author Contributions

Judith Kempfle, conception, data collection, analysis, writing of manuscript, final approval; **Elliott D. Kozin**, conception, data collection, analysis, writing of manuscript, final approval; **Aaron K. Remenschneider**, conception, data collection, analysis, writing of manuscript, final approval; **Andreas Eckhard**, data collection, analysis, writing of manuscript, final approval; **Albert Edge**, data collection, analysis, writing of manuscript, final approval; **Daniel J. Lee**, conception, data collection, analysis, writing of manuscript, final approval.

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

Disclosures

Competing interests: None.

Sponsorships: None.

Supplemental Material

Additional supporting information may be found at <http://otojournal.org/supplemental>.

Keywords

internal auditory canal; vestibular schwannoma; temporal bone; endoscopic ear surgery; lateral skull base surgical navigation; neurotology

Surgical navigation and high-definition endoscopy offer the opportunity to rethink contemporary approaches to the lateral skull base. Otologic navigation has been applied for a host of indications when used with the microscope,^{1,2} but a postauricular incision and significant bone removal are needed to access structures of the lateral skull base. In contrast to the microscope, the rigid endoscope can provide wide-field views of the middle ear and skull base through the external auditory canal.³⁻⁵ Combining lateral skull base navigation and endoscopic ear surgery techniques, we aim to demonstrate a minimally invasive, transcanal, infracochlear approach to the internal auditory canal (IAC) with cochlear preservation in cadaveric specimens.

Methods

Study Materials

The study was approved by the Massachusetts Eye and Ear Infirmary Institutional Review Board. A total of 7 bone-anchored fiducials were placed on operative and contralateral sides in fresh cadaveric heads (n = 3). High-resolution computed tomography (CT) scan was obtained for electromagnetic-based image guidance (Fusion; Medtronic, Dublin, Ireland). Rigid endoscopes (3 mm, 0° and 30°, 14-cm length; Karl Storz) connected to a high-definition video camera (Karl Storz, Tuttlingen, Germany) and tower were used for transcanal visualization. Instruments included commercially available straight and curved burs (Medtronic) and a stapes curette (Miltex, York, Pennsylvania). Drill speeds were set at 50,000 revolutions per minute. Gross dissection and CT imaging of each specimen were performed postoperatively.

Surgical Technique

The overall aim of the dissection is to access the IAC through a transcanal technique, avoiding the jugular bulb, facial nerve, carotid artery, and cochlea. The approach may theoretically allow for hearing preservation via a minimally invasive surgical portal. With a 0° endoscope, the tympanic membrane was visualized. A Rosen knife was used to incise the canal skin anteriorly, inferiorly, and posteriorly to create a tympanomeatal flap based superiorly between the notch of Rivinus and the anterior-superior canal wall. This was elevated and left attached to the malleus. The flap was tucked superiorly and protected throughout the case. The ossicular chain was left intact. Under endoscopic visualization, a 4-mm cutting bur, followed by a 4-mm diamond bur, was used to perform a transcanal hypotympanotomy, similar to an infracochlear approach to the petrous apex. Bone was removed posteriorly, avoiding the mastoid air cells and protecting the vertical segment of the facial nerve. Bone was removed inferiorly to define the jugular bulb.

Within the tympanic cavity, a 3-mm diamond bur was used to define the superior aspect of the jugular bulb and to define the petrous carotid anteriorly. The round window niche was

exposed by removing the funiculus and entering the subcochlear tunnel (**Figure 1**). With use of a 2-mm diamond angled drill through the ear canal, the bone of the cochlear basal turn was thinned under image guidance to widen the infracochlear tunnel (**Figure 2**). Four landmarks now define the transcanal infracochlear approach: carotid anteriorly, jugular bulb inferiorly, facial nerve posteriorly, and cochlea superiorly (**Figure 2**).

Navigation defines the trajectory necessary to access the IAC, and the large hypotympanotomy allows the drill and endoscope to be utilized simultaneously. A superiorly oriented infracochlear canal through the petrous bone is possible through the 2-mm and then 1-mm diamond curved burs. Care was taken not to drill directly medially, to avoid inadvertent access into the posterior fossa. Navigation was used to confirm the location, distance, and trajectory of the IAC. All 3 views are utilized, with the sagittal view providing key surgical windows. Final bony removal inferior to the IAC (described as an internal auditory canalotomy) is performed with angled bone curettes (**Figure 2**).

Results

Bone-anchored fiducials achieved an error margin of 0.2 to 0.6 mm. The combination of rigid endoscopes and high-accuracy surgical navigation provided adequate visualization and approximation of critical structures. None of the 3 bones demonstrated damage to the ossicular chain, cochlea, jugular bulb, carotid artery, or facial nerve based on gross inspection or CT (**Figures 2 and 3**). Bone covering the cochlea and internal carotid was as thin as 0.5 mm, demonstrating the critical need for highly accurate surgical navigation.

Discussion

Using a navigation-assisted transcanal endoscopic approach, we demonstrate the ability to reach the IAC without violating the cochlea. Access to the IAC is commonly achieved through a translabyrinthine, retrosigmoid, or middle fossa craniotomy; however, each carries a risk of morbidity—from hearing loss to facial nerve injury, cerebrospinal fluid leak, and brain retraction.⁶ In contrast, a transcanal retrocochlear approach to the IAC may decrease morbidity and prove useful for direct delivery of chemotherapy, brachytherapy (for schwannomas), and emerging biologics for the treatment of hearing loss.

There are notable limitations to a transcanal retrocochlear approach: First, the transcanal approach is technically challenging given the lack of appropriately sized and angled surgical instruments. Second, drilling near the cochlea or the IAC may lead to unforeseen injury that may not be identified in a cadaveric study, such as hearing or vestibular dysfunction. Third, patients with a high-riding jugular bulb, an aberrant carotid, or a lack of subcochlear tunnel may not be candidates for this approach. The limited sample size may underrepresent the proportion of anatomic variants in which the proposed technique will be appropriate. Finally, the use of navigation in otologic surgery is in its development, and accuracy remains system and operator dependent. A larger study that highlights anatomic variation, navigation system accuracy, and preprocedure imaging landmarks will be crucial to determine the clinical feasibility of the proposed technique.

Conclusion

We demonstrate an endoscopic transcanal, retrocochlear approach to the IAC using endoscopy and navigation technology that spares the cochlea in a pilot cadaveric study.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We thank Jeananne Phillips, manager of the Joseph B. Nadol Jr Otolaryngology Surgical Skills Training Lab, and Jerry Baker, Medtronic Surgical Technologies, for technical support.

Funding source: Medtronic Surgical Technologies research grant; sponsor was not involved in any capacity in the study beyond supplying funding for cadaveric specimens and surgical instruments.

References

1. Gunkel AR, Voge M, Martin A, Bale RJ, Thumfart WF, Freysinger W. Computer-aided surgery in the petrous bone. *Laryngoscope*. 1999; 109:1793–1799. [PubMed: 10569409]
2. Kohan D, Jethanamest D. Image-guided surgical navigation in otology. *Laryngoscope*. 2012; 122:2291–2299. [PubMed: 22961537]
3. Marchioni D, Alicandri-Ciufelli M, Rubini A, Presutti L. Endoscopic transcanal corridors to the lateral skull base: initial experiences. *Laryngoscope*. 2015; 125(suppl 5):S1–S13. [PubMed: 25703066]
4. Presutti L, Nogueira JF, Alicandri-Ciufelli M, Marchioni D. Beyond the middle ear: endoscopic surgical anatomy and approaches to inner ear and lateral skull base. *Otolaryngol Clin North Am*. 2013; 46:189–200. [PubMed: 23566905]
5. Tarabichi M, Marchioni D, Presutti L, Nogueira JF, Pothier D. Endoscopic transcanal ear anatomy and dissection. *Otolaryngol Clin North Am*. 2013; 46:131–154. [PubMed: 23566901]
6. Bennett M, Haynes DS. Surgical approaches and complications in the removal of vestibular schwannomas. *Otolaryngol Clin North Am*. 2007; 40:589–609. [PubMed: 17544697]

Figure 1. Preoperative temporal bone computed tomography and early endoscopic transcanal approach. (Additional figure information available in Appendix 1, at www.otojournal.org/supplemental.)

Figure 2.
Anatomic landmarks of transcanal retrocochlear approach. (Additional figure information available in Appendix 1, at www.otojournal.org/supplemental.)

Figure 3. Postoperative evaluation of the transcanal retrocochlear approach based on computed tomography. (Additional figure information available in Appendix 1, at www.otojournal.org/supplemental.)