Published in final edited form as:

Am J Otolaryngol. 2017 ; 38(5): 518–520. doi:10.1016/j.amjoto.2017.03.014.

Quantitative imaging analysis of transcanal endoscopic Infracochlear approach to the internal auditory canal

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Abstract

Purpose—A transcanal endoscopic infracochlear surgical approach to the internal auditory canal (IAC) in a human temporal bone model has previously been described. However, the proportion of patients with favorable anatomy for this novel surgical technique remains unknown. Herein, we perform a quantitative analysis of the transcanal endoscopic infracochlear corridor to the IAC based on computed tomography.

Materials and methods—High resolution computed tomography scans of adult temporal bones were measured to determine the accessibility of the IAC when using an endoscopic transcanal, cochlear-sparing surgical corridor.

Results—This approach to the IAC was feasible in 92% (35 of 38) specimens based on a minimum distance of 3 mm between the basilar turn of the cochlear and the great vessels (jugular bulb and carotid artery).

Conclusions—Infracochlear access to the IAC is feasible in the majority of adult temporal bones and has implications for future hearing preservation drug delivery approaches to the IAC.

Keywords

Transcanal; Endoscopic ear surgery; Otoendoscopy; Infracochlear; Internal auditory canal; Drug delivery

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Conflicts of interest: None.

1. Introduction

Endoscopic ear surgery (EES) techniques have opened the door for minimally invasive surgical portals to the lateral skull base [1–3]. Traditionally, operative approaches to the internal auditory canal (IAC) require middle or posterior fossa craniotomy [4,5]. Complications associated with craniotomy surgery for IAC exposure include hearing loss, vestibular dysfunction and cerebrospinal fluid leak [1,6]. Newer transcanal endoscopic-assisted techniques to access the IAC have to this point only been possible following sacrifice of cochlear structures [7,8].

Transcanal endoscopic or microscopic infracochlear petrosectomy has been described [9–11]. Using a similar approach and combined with real-time surgical navigation, EES may enable transcanal approaches to the IAC that preserve cochlear anatomy [12]. Potential indications for a hearing preservation transcanal surgical corridor to the IAC include management of vestibular schwannoma (VS) (for surgical resection and local immunotherapy), as well as future drug delivery technologies to regenerate the auditory nerve [13–16].

The proportion of patients with anatomy favorable for an endoscopic transcanal approach to the IAC is unknown. In this study, we utilize *a priori* imaging criteria based on previous descriptions to determine patient eligibility [12,17,18]. Specifically, we perform a morphometric analysis of the infracochlear corridor to the IAC based on computed tomography (CT) of adult patients with and without VS. The relationship of the infracochlear corridor to the petrosal course of jugular bulb (JB) and internal carotid artery (ICA) are quantified. We hypothesize that 1) the IAC can be reached using a transcanal endoscopic infracochlear approach and 2) most adult patients have favorable anatomy for this novel technique.

2. Methods

Inclusion criteria consisted of consecutive adult patients with and without VS with high resolution CT temporal bone imaging. Exclusion criteria included age ≥ 18 years, prior otologic surgery, or chronic middle ear disease.

Axial CT scans were analyzed using a standard imaging platform (Synapse, Fujifilm Holdings, USA). Slice thickness varied between 0.25 or 0.63 mm, depending on scanning protocol. The infracochlear route between JB and ICA represents its narrowest point and was quantified. The horizontal distances between JB and ICA were measured in each CT slice, starting with the slice inferior to the basal turn of cochlea (superior extent of infracochlear tunnel) and extending to the level where the JB and ICA converge to a distance of <3 mm apart (inferior extent of infracochlear tunnel) (Figs. 1–2) [12]. To calculate the horizontal infracochlear tunnel diameter, the distance between the JB and ICA at the halfway point between the superior and inferior borders was calculated (or an average of two middle sections, if an even number of sections). To determine the vertical infracochlear tunnel diameter, the number of sections from the selected inferior tunnel border to the basal turn of the cochlea were summated and multiplied by slice thickness.

In terms of candidacy for transcanal surgical approach, surgery was deemed contraindicated in patients with a vertical or horizontal diameter <3 mm, as this tunnel size would be too small for passage of 2.0 mm burrs and not allow for access to the IAC using curved instrumentation. Additional contraindications included a JB abutting cochlear promontory, evidence of an aberrant carotid, and/or a sclerotic petrous apex without appreciable air or fat cells [19,20].

3. Results

A total of 38 ears were analyzed (18 patients with VS and 20 control ears). Mean maximum width between the JB and ICA was 8.37 mm (± 2.12). The mean vertical diameter was 6.22 mm (± 2.75) and the mean horizontal tunnel diameter was 5.39 mm (± 1.15) (Table 1). Thirty-five of the 38 temporal bones had sufficient infracochlear diameter dimensions (>3 mm) to ensure passage of dissection instruments to the IAC. One temporal bone presented with a high riding jugular bulb with a minimum vertical diameter <2 mm and two others had a minimum vertical diameter <3 mm. Lastly, two of the 38 ears had evidence of a sclerotic petrous apex. Mean measurements between the two groups of patients (with and without VS) were not significantly different (p value = 0.05, student's *t*-test).

4. Discussion

To reach the IAC without damaging the cochlea, the infracochlear corridor must have specific anatomical geometry to allow for adequate visualization while avoiding the JB and IAC [12]. First, to allow for the safe passage past the JB and IAC, the diameter of the infracochlear tunnel must be larger than 3 mm to accommodate both an endoscope and drill. Second, a 1–2 mm diamond burr must fit through the corridor [12]. Finally, to perform the internal auditory canalotomy, a curved curette is required, necessitating wide angle of approach.

Few reports have examined dimensions of infracochlear approaches to the inner ear. We determined that a transcanal endoscopic infracochlear tunnel to the IAC was possible in 92% of CT scans. Similar imaging studies have demonstrated the feasibility of transcanal infracochlear approaches to the petrous apex [12,18,21,22].

There are several limitations to this study. First, although a radio-graphic analysis of a theoretical infracochlear corridor was conducted, it is possible that there may be unaccounted for impediments to creating an infracochlear tunnel. Second, the quantitative analysis was done using two-dimensional CT scans, which can make it difficult to visualize structures in three dimensions, particularly as the tunnel is in a parasagittal plane.

5. Conclusion

Based on CT imaging criteria, a transcanal endoscopic infracochlear approach for minimally invasive access to the IAC is feasible in the majority of adult patients.

Acknowledgments

Financial disclosures: This study was funded in part from a research grant from Medtronic Foundation/Medtronic Surgical Technologies (MDT agreement # A 1218298).

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

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Fig. 1.

A. Sagittal model of the infracochlear surgical approach to the ICA. B. Illustration of an infracochlear tunnel and adjacent key structures. C. Illustration of the boundaries of the infracochlear tunnel with horizontal diameter [A] and vertical diameter [B].

Fig. 2.

A. Coronal view of temporal bone highlighting promontory (black arrowhead) and infracochlear air cells (white arrowhead). B. Axial view of temporal bone at basal turn of cochlea (black arrowhead). C. Measurements of most superior extent of infracochlear tunnel. D. Measurements at most inferior aspect of infracochlear tunnel. Internal carotid artery, ICA; Jugular bulb, JB.

Table 1
Dimensions of transcanal infracochlear tunnel to IAC

Patient group	Maximum width between ICA and jugular bulb inferior to basal turn	Vertical diameter of infracochlear tunnel	Horizontal diameter of infracochlear tunnel
Intact ears (n = 20)	8.56 ± 2.41 mm	6.22 ± 3.48 mm	5.59 ± 1.41 mm
VS ears (n = 18)	8.16 ± 1.78 mm	6.22 ± 1.73 mm	5.17 ± 0.756 mm
Total ears (n = 38)	8.37 ± 2.12 mm	6.22 ± 2.75 mm	5.39 ± 1.15 mm