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# Base of Endoscopic Ear Surgery

Camille Levie, Patrick Levie

Department of Otorhinolaryngology and Head & Neck Surgery, Chirec, Brussels, Belgium

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**ABSTRACT**

Endoscopic ear surgery is developing rapidly. This article aimed to review the rationale with advantages and disadvantages of endoscopic ear surgery compared to microscopic ear surgery as well as the current indications in the field of otology and neurotology, limitations, terminologies, and approaches. A review of the literature on PubMed was performed using the keywords "endoscopic ear surgery," "ear surgery," "endoscopy," and "ear endoscope" to select relevant published articles. The main advantage of endoscopic ear surgery is an improved visualization of the surgical field. It provides a high-resolution, wider, and more magnified view of the middle ear and the ability to look "around the corners" to visualize otherwise "hidden areas." Transcanal endoscopic ear surgery allows minimally invasive technique by transforming the external auditory canal into a natural access point to the middle ear. It also allows a better understanding of the middle ear physiology (the ventilation pathways and middle ear folds). Endoscopic ear surgery has, however, some disadvantages, with it being a 1-handed surgical technique as the main limitation. Other limitations are an easily impaired visual field by bleeding or fogging on the lens, a narrow surgical space, and a steep learning curve. Endoscopic ear surgery is a safe and effective technique and a valid alternative to the microscope. It allows for improved surgical visualization and the ability to look "around the corners" with minimally invasive access. It holds a great promise in otology, and the indications for endoscopic ear surgery are constantly evolving.

**Keywords:** EES, endoscopic ear surgery, otoendoscopy, otology, transcanal endoscopic surgery

## Introduction

An endoscope is a rigid optical instrument with a lens and alongside a light source for visualization of cavities. Endoscopic ear surgery (EES) is defined by using a rigid endoscope during otologic surgery to visualize the middle ear; this is in contrast with the traditional microscopic ear surgery (MES) where a microscope is used. Endoscopic ear surgery has gained a lot of importance in otologic surgery as an adjunct or in some cases as a replacement of the MES.

It was first introduced in otology during the late 1960s. Initially, the endoscope was used as a diagnostic tool of the auditory canal to look at the tympanic membrane as an aid to microscopes to determine diagnoses and later to observe transmeatal the middle ear structures and anatomy.[1] Later in the 1990s, following these anatomical studies, it was used as an aid in cholesteatoma surgery for the detection of residual or recurrent disease. The following years, starting with the pioneers Thomassin and Tarabichi, it has grown from an observation tool to a surgical tool to perform surgical dissection during otologic ear surgery.[2,3]

### Principles of Endoscopic Ear Surgery

Endoscopic ear surgery has several advantages over the traditional microscopic approach, with the main advantages being an improved visualization of the middle ear, as shown in Figure 1.[4] It provides a high-resolution, wider, and more magnified view of the middle ear and the ability to look "around the corners" with minimally invasive access.

The microscope has a forced straight view through the auditory canal of the middle ear. The view of the tympanic cavity with the microscope during transcanal surgery is defined and limited by the narrowest segment of the auditory canal, as shown in Figure 2.[5] Some areas are thereby difficult to access. Because of the limited straight view, a postauricular incision and mastoidectomy is often needed, as shown in Figure 2, to create a parallel port through the mastoid to access the epitympanum, facial recess, and hypotympanum.[5,6] This means that (healthy) mucosa and bone of mastoid and/or external auditory canal have to be removed simply for access purposes. Even with extensive mastoidectomy, some areas such as the hypotympanum and sinus tympani are minimally accessible and remain hidden, which

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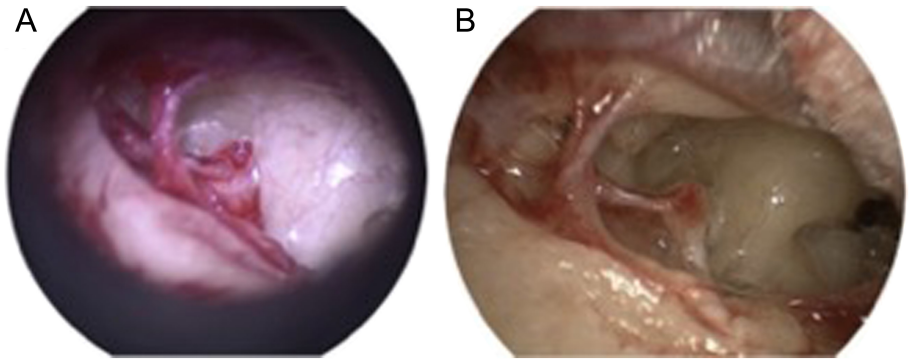


**Figure 1.** Microscopic and endoscopic views of the right middle ear. (A) Microscopic view of the right middle ear (patient is in supine position) taken at highest magnification with an HD 3-CCD video camera. (B) Endoscopic view of the same ear, demonstrating a wide-field view that has greater detail, depth, and clarity (0° endoscope, held in the right hand).[4]

risks leaving residual disease during, for example, cholesteatoma surgery removal.

In contrast, the view with the endoscope during transcanal surgery is not limited since the endoscope bypasses the narrow segment and the light source is located at the distal tip of the endoscope which gives a wider view and the possibility to "look around corners" (even with a 0° endoscope), as shown in Figure 3.[5,6]

The ability to "look around corners" by using angled endoscopes is a very important advantage of EES. Exploration of every single compartment and of hidden recesses like the sinus tympani, the anterior tympanic space, and the protympanum with such a magnification is almost impossible with microscopic traditional approach. Exploration of every single compartment is necessary for radical removal of pathology and especially the exploration of hidden recesses, considering that most residual cholesteatoma are found in some hidden recesses (anterior epitympanum and facial recess).

In a 3-dimensional middle ear model, Bennett et al[7] simulated the microscopic and endoscopic view and compared the visualization of every subsegment.

All compartments were significantly better visualized with an endoscope compared to a microscope, except the antrum. A 0° endoscope is adequate for visualization of most subregions of the middle ear, but the use of an angled endoscope further improves the visibility of most hidden areas such as the epitympanum and facial recess, as shown in Figures 4 and 5.[7]

The antrum is inadequately visualized by neither the microscope nor the endoscope, and a mastoidectomy should be considered for optimal visualization. This model has no consideration of bone removal.

Another anatomic observation is the relation between the auditory canal and the epitympanum.

Transcanal approach uses the auditory canal as a natural access to the middle ear, and if a straight axis line is drawn through the auditory canal, it ends in the epitympanum rather than the mesotympanum with only the scutum in the way, as shown in Figure 6. This almost universal anatomic orientation and removal of the scutum bone allow wide and open transcanal access to the epitympanum, which is the natural cul de sac of the external auditory canal (and is the most frequent site of primary cholesteatoma formation).[6]

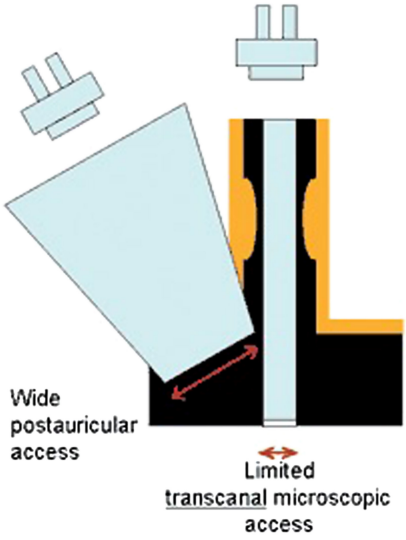


**Figure 2.** The view from a microscope during transcanal approach and retro-auricular approach.[5]

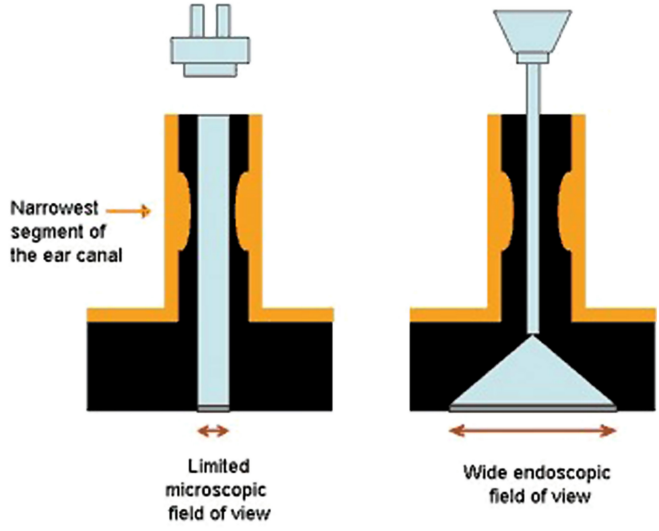


**Figure 3.** The view from an endoscope during transcanal approach.[5]

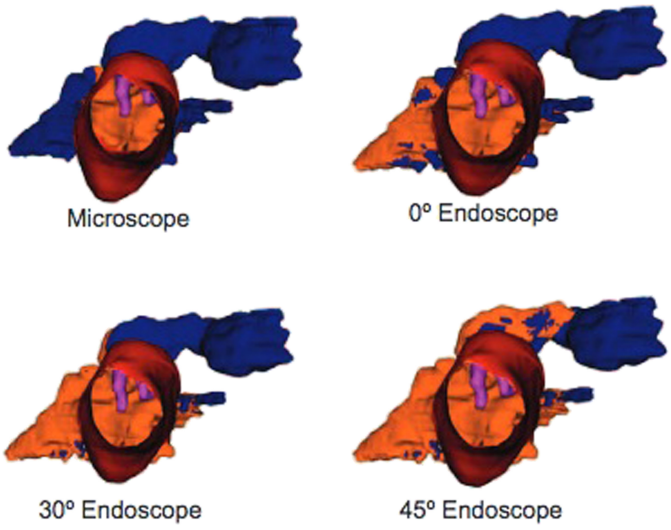


**Figure 4.** Visualization of the middle ear with ossicles present: Red: external auditory canal; magenta: ossicles; orange: regions of the middle ear that are viewable; blue: regions of the middle ear that are hidden.[7]

As indicated earlier, the main advantage of the endoscope is the enhanced surgical visualization, but there are also other advantages.

Transcanal endoscopic ear surgery (TEES) is minimally invasive by transforming the external auditory canal into a natural access point to the middle ear, with sparing of the bone and mucosa of the mastoid, auditory ear canal, or middle ear. This necessitates far less soft-tissue removal to reach the middle ear, and there is no need for stitching and closing the ear. This leads ultimately to a shorter operating time but also less surgical morbidity and shortened healing time.[8]

The endoscope allows a better approach and magnification of tiny structures. To change magnification, the surgeon needs simply to move the endoscope closer to the structure in question, and there is no need for refocusing when changing position; this in contrast to the microscope.

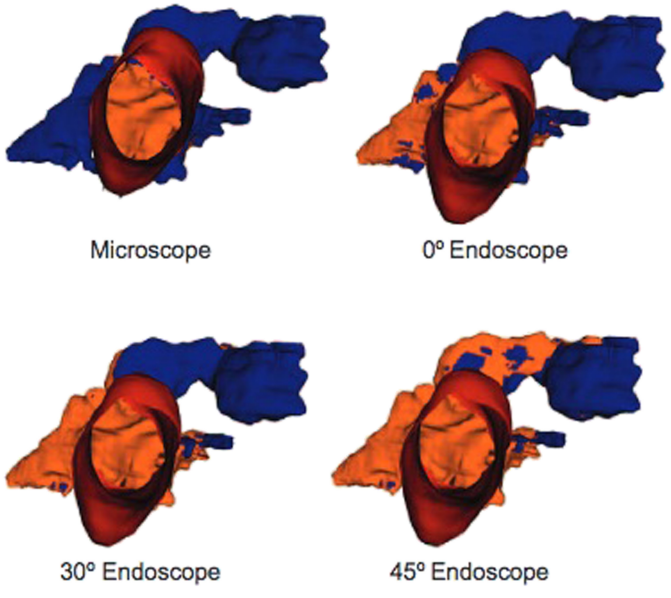


**Figure 5.** Visualization of the middle ear with ossicles absent: Red: external auditory canal; orange: regions of the middle ear that are viewable; blue: regions of the middle ear that are hidden.[7]

**Figure 6.** A coronal computed tomographic section of the temporal bone, which shows that an axis line drawn through the ear canal ends in the attic rather than the mesotympanum.[6]

In microscopic surgery, the "working space" had an upside-down cone shape that requires more bone removal superficially to obtain access and prevent the surgeon from "digging into a hole."

The "working space" in endoscopic surgery has a cone shape and the top needs only to be wide enough to admit endoscope and surgical instruments.

The endoscope also has the ability to visualize past the shaft of larger surgical instruments and gives a bird's eye view of the field beyond the shaft of the instrument. In contrast, the view of the microscope is compromised further by the introduction of instruments and possibly by the surgeon's hands.[1]

This new way of looking at the anatomy allows a better understanding of the middle ear physiology and in particular of the ventilation pathways and middle ear folds that might cause pathology if impaired. It increases the insight of middle ear diseases and their progression through temporal bone and allows one to perform a more "physiologic" surgery.

The main differences between MES and EES are listed in Table 1, based on a similar table described by Kozin et al[4]:

## Disadvantage and Limitation

The EES has, however, some disadvantages compared to the MES.[1] The main disadvantage is that it is a 1-handed surgical technique, with only 1 hand available to hold an instrument as the second hand generally holds the endoscope. The learning curve is different and steeper than that of the traditional microscopic technique. It must be performed step by step. Surgeons experienced with endoscopy will find the technique easy to master, but surgeons who have limited themselves to an entirely microscopic otology practice are likely to find EES more difficult to perform. Despite this, with sufficient training and practice, the technique is available to all.

**Table 1. Main Differences Between Microscopic and Endoscopic Ear Surgery**

| | Microscope | Endoscope |
|---|---|---|
| Type of dissection | 2-handed | 1-handed |
| Resolution | High | High |
| Field of view | Narrow | Wide |
| Ability to "look around corners" | No | Yes |
| Access point needed for visualization | Wide | Narrow |
| Binocular vision | Yes | No |

The loss of depth perception and binocular vision is another disadvantage, but this is easily compensated for with experience.

A narrow canal can be a pitfall, with a narrow space limited for instruments and endoscope.

Bleeding curtails the visual field during endoscopic surgery far more than in microscopic surgery since the view is considerably magnified by the endoscope. Good hemostasis and controlling of bleeding are necessary, and the use of aspiration instruments can facilitate the operative gesture.

## Indication and Contraindication

The indications for EES are constantly evolving. Initially, it was used for its enhanced visualization in cholesteatoma surgery and tympanoplasty.[3] The development of EES causes a rapid growth in other indications for EES.

Indications for EES as described by Kozin et al[4,9] are the following:

- *External ear*:
  - Canaloplasty
  - Repair of exostosis
  - Cholesteatoma
  - Debridement and biopsy
- *Middle ear*:
  - Myringotomy
  - Myringoplasty
  - Medial graft tympanoplasty
  - Lateral graft tympanoplasty
  - Retraction of the tympanic membrane
  - Acquired cholesteatoma
  - Congenital cholesteatoma
  - Neoplasms of the middle ear (e.g., glomus tympanicum)
  - Ossiculoplasty
  - Stapes surgery
- *Inner ear/skull base*:
  - Intracochlear schwannoma
  - Small symptomatic neoplasms of the facial nerve in the internal auditory canal fundus
  - Petrous apex cyst
  - Repair of perilymph fistulas (congenital or traumatic)
- *Middle cranial fossa*:
  - Repair of superior canal dehiscence
- *Posterior fossa/cerebello-pontine angle*:
  - Identification of residual schwannoma in internal acoustic canal (IAC) fundus
  - Localization and plugging of externalized air cells during IAC to reduce the risk of CSF leaks.

There are no proven absolute contraindications to EES. Any otological surgery performed with a microscope can be assisted by an endoscope.[9]

## Endoscopic Ear Surgery Terminologies and Classification System

The growth of EES has made the use of an ear endoscope part of mainstream practice, from an observational or diagnostical to surgical use.

Various terminologies have been applied to describe the use of an endoscope to visualize ear anatomy. Kozin et al[9] encourage standardized definitions as ESS becomes more widespread:

- Otoendoscopy: Use of the rigid (or flexible) endoscope for inspection of the outer ear, middle ear, mastoid, or lateral skull base. Otoendoscopy may be used in the clinical setting to inspect the tympanic membrane (TM) or middle ear through a perforation and can be used in the operating room setting to look around corners and assess for residual disease.
- Endoscopic ear surgery: Use of the endoscope for simultaneous visualization and dissection of the outer ear, middle ear, and/or mastoid. Typically, the endoscope will be used with one hand, while the dissecting instrument is applied with the other hand, in a fashion similar to functional endoscopic sinus surgery. This applies to transcanal, transmeatal (canal wall down cavity), transmastoid, and transcranial lateral skull base approaches.
- Transcanal endoscopic ear surgery: This refers to EES techniques in which the external auditory canal is used as the primary surgical portal to access the TM, middle ear, and, in very specialized cases, the inner ear and lateral aspect (fundus) of the internal auditory canal.

Currently, there is no standard recognized classification system to describe EES.

The Massachusetts Eye and Ear Infirmary EES classification, designed by Cohen et al in 2016, is a validated classification tool that quantifies the use of endoscope during middle ear surgery.[10,11]

*Massachusetts Eye and Ear Infirmary Transcanal Endoscopic Ear Surgery classification system:*[11]

- Class 0: Operative microscope alone with no use of the endoscope
- Class 1: Endoscope used for inspection/observation only; no dissection
- Class 2a: Mixed microscopic/endoscopic dissection; <50% of dissection with endoscope
- Class 2b: Mixed microscopic/endoscopic dissection; >50% of dissection with endoscope
- Class 2c: Endoscope-only case transitioned to microscopic case requiring mastoidectomy
- Class 3: Endoscope only with no operative microscope (TEES)

By definition, class 3 means a TEES, with no postauricular incision for surgical access.

### Current Endoscopic Ear Surgery Approaches

Normally in traditional microscopic surgery, the nondominant hand is mostly used for holding a suction tube for suction of blood from the operative field.

In contrast, the EES is a 1-hand surgery where the nondominant hand holds the endoscope, while the dominant hand holds the instruments and undertakes the surgery. Like previously described, EES can have anatomical and intraoperative limitations that lead to the necessity of converting to open surgery. This must be discussed preoperatively with the patient. Both endoscope and microscope and instruments should be accessible in the operating room.

## Conclusion

Endoscopic ear surgery is developing rapidly. The wide and magnified field of view afforded by the endoscope allows a better visualization of all compartment and "hidden recesses" of the middle ear. Transcanal endoscopic surgery is a minimally invasive procedure, which uses the external auditory canal as the most logical, direct, and natural portal to access the middle ear without the need for a retro-auricular approach or incision. Understanding of the anatomy and physiology of the middle ear has become easier with the use of an endoscope. It helped to develop new concepts in the surgical treatment of middle ear pathologies, especially in cholesteatoma surgery. Endoscopic ear surgery holds a great promise in otology, and the indications for EES are constantly evolving.

**Data Availability Statement:** The data that support the findings of this study are available on request from the corresponding author.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Concept – C.L.; Design – C.L.; Supervision – P.L.; Literature Review – C.L.; Writing – C.L.; Critical Review – P.L.

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