



## Review

## Role of endoscopy in surgical management of cholesteatoma: A systematic review

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## ABSTRACT

Endoscopes are increasingly being used in cholesteatoma surgeries either as an adjunct to microscopes or sometimes exclusively. Their role at present is more as adjunct to microscope which still remains the work-horse for mastoidectomy. However, as endoscopy and endoscopic instruments are increasingly getting refined, role of endoscopy in management of cholesteatoma is continuously being appraised with progressively newer studies. This review aims to assess outcomes of several studies in which endoscopic techniques were used in cholesteatoma surgery and recognize common trends. An extensive review of literature on this theme was performed. Sixteen studies comprising of 1685 patients treated endoscopically either exclusively or in combination with microscope were included. Intra-operatively, in 267 (15.82%) cases, residual cholesteatoma was identified by endoscope in hidden areas after completion of surgery with microscope. On follow-up, recidivism was identified in 108 cases (6.4%) in second look procedures. Common sites of recurrence were hidden areas like sinus tympani. This review while acknowledging the value of microscope, highlights the merit of endoscope usage in cholesteatoma surgery and its role in reducing recurrence.

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## 1. Introduction

The surgical microscope revolutionised the field of otologic surgery by magnifying and illuminating limited confines of

temporal bone with its particular complex anatomy. Apart from allowing two-handed surgery, binocular vision of microscope imparts better depth perception as compared to endoscope. As such most otologists will consider microscope indispensable for otological surgery. However, blind spots or so called 'hidden areas' resulting from straight-line vision offered by microscope has prompted otologists 'to think out of the box' and develop novel ways to explore these areas. Use of endoscope to complement microscope, is one such advancement in otologic surgery (Tarabichi, 2000). Coupled with high definition camera system,

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straight and angled endoscopes offer advantage of higher magnification, wider views, precise localization of disease, 'looking around corners' and visualisation of hidden areas with light delivery closer to area of interest (Ismet Emrah Emre et al., 2020).

Even with endoscopes, surgical principles remain the same and cholesteatoma is traced from its origin and followed up to fundus. Complementary use of endoscope helps in decision-making, permits completion of cholesteatoma surgery with lesser bone removal (due to wide angle of vision) and better preservation of normal mastoid mucosa (Verma et al., 2017). In middle ear, endoscopes score over microscope in affording clear visualisation of hidden areas of retro-tympanum, anterior epitympanum, and protympanum besides mesotympanic structures. Some authors have claimed better visualisation and understanding of ventilation pathways, with resultant benefit in surgical outcome (Marchioni et al., 2011).

Nevertheless, objective evaluation in a scientific manner is essential for any new technique proposed before wide acceptance. As compared to sinus surgery where endoscope has found wide acceptance, in middle ear surgery the use of endoscope still remains debatable. Several studies have analysed benefits of otoendoscopy either as adjunct to microscope or exclusively in middle ear and mastoid surgery for cholesteatoma. Although early results are encouraging, limitations imposed by single-handed technique have to be considered. Few reviews have analysed these studies in depth. The present review aims to objectively evaluate results of such studies to arrive at consensus about utility of endoscopes in cholesteatoma surgery.

## 2. Materials & methods

We reviewed papers on the use of endoscopy in otological surgeries published till date, manually from scientific journals, publications and electronically through databases such as PUBMED, EBSCO, Web of science, SCOPUS, Google scholar, open access texts etc. using search terms such as "middle ear cholesteatoma", "use of endoscopes" and "adjunctive otoendoscopy"

After using these search-words various articles were obtained and further evaluated.

### Inclusion criteria

- 1) English language.
- 2) All articles in which endoscope was used as primary tool in surgery for cholesteatoma.
- 3) All articles in which surgery for cholesteatoma was done with combination of microscope and endoscopes.

### Exclusion criteria

- 1) Articles not related to ear pathology.
- 2) Animal or laboratory based research.

All the articles fulfilling the inclusion criteria were considered. These articles were then further analysed and the following results were obtained.

## 3. Results

After conducting electronic search with above key words, 68 articles were identified initially and after conducting full-text retrieval and discarding studies that did not meet the inclusion criteria the results were further narrowed down to 16 publications (from 1999 to 2019) consisting of 1685 cases in all and total of 1687 surgeries with a mean follow-up ranging from 11 months to 78 months (Table 1). Some retrospective studies have not mentioned follow-up period.

It is observed that 3 studies (Tarabichi, Migirov and Barakate) reported only exclusively endoscopic surgeries while 2 studies

(Presutti et al. and Marchioni et al.) reported a combination of exclusively endoscopic cases and cases with adjunctive endoscopy while other 11 studies reported cases where endoscope was used along with microscope for surgery.

Overall in 302 (17.92%) cases, exclusively endoscopic surgery was performed for cholesteatoma, while in 1385 (82.19%) operations endoscopes were used to complement microscope.

Intra-operatively, in 267 (15.82%) cases, residual cholesteatoma was identified by endoscope in hidden areas after completion of surgery with microscope. In postoperative follow-up, 108 (6.4%) patients showed residual or recurrent (recidivism) pathology in hidden areas.

## 4. Discussion

Microscope and endoscopes are both tools and as such should be readily and judiciously employed by otologist for patients benefit, providing dry ear with best possible hearing outcome. Residual cholesteatoma is due to incomplete removal at primary surgery and is often due to incomplete clearance of inaccessible areas such as sinus tympani. Although modern day surgical microscope offers unprecedented view of middle ear and mastoid during otology surgery, visualisation of recesses in middle ear is occasionally constrained due to its straight line vision and illumination. At such times for clearing disease in hidden areas, the surgeon has to choose between excessive drilling of bone and retracting soft tissues or employing blind, blunt probing (Kozin et al., 2015).

Endoscopes along with high definition camera systems with their ability to look around corners and project (on screen) panoramic magnified images of middle ear has led to a complete transformation in middle ear surgery (Marchioni et al., 2011; Marchioni et al., 2013). Endoscopes provide unprecedented views of hidden areas such as facial recess, sinus tympani, anterior epitympanic spaces, etc. (Marchioni et al., 2010).

Mastoid surgery still remains the preserve of microscope with endoscopes frequently being used only as adjunct. Using endoscopes exclusively in cholesteatoma surgery has not gained wide spread acceptance. Several reasons exist; comfort of operating with two hands is missing in endoscopes, lack of depth perception with resultant disorientation, training workshops focussing only on microscope. Two-handed surgery is often necessary in dissection of cholesteatoma from dehiscent facial nerve, ossicles, and stapes footplate. Ossicular reconstruction too is very difficult to perform with one hand. Lack of optimized endoscopy instruments can be frustrating. Also, using mastoid drill with endoscope is challenging for most surgeons. While drilling there is constant problem of surgical field getting obscured by blood, bone dust and irrigating solution. Endoscopic hydro-mastoidectomy has been described to overcome this problem, where drilling and endoscopic visualisation is done under water, with continuous irrigation washing out bone dust and blood (Nishiike et al., 2019).

The endoscopic technique has a learning curve with results depending on surgeon's skill and experience. For the novice, endoscopic technique may be fraught with complications. Endoscopic surgeon views the monitor resulting in dissociation of visual and motor axis and poor depth-perception. There may be direct trauma from endoscope tip to ossicles, dehiscent seventh nerve and low-lying tegmen (Badr-El-Dine et al., 2013). Furthermore, there is potential for thermal injury with heating of endoscope tip and concerns have been raised about long-term safety (Kozin et al., 2015; Kozin et al., 2014; I. Bottrill et al., 1996). It is strongly recommended that light intensity be kept below 50% at all times (Kozin and Daniel, 2017).

As endoscope itself occupies part of ear canal, instrumentation is cumbersome, often allowing only single handed surgery. Although,

**Table-1**  
Salient features of studies reviewed.

Authors Year	No of cases	Exclusive endoscopy	Endoscope as adjunct	Intra-operative residuals seen with endoscope after microscopic dissection	Recidivism	Mean follow up (Months)	Type of Study
Good G, Isaacson G.1999	29	0	29	7	2	N/A	Retrospective
Haberkamp TJ, Tanyeri H (1999)	15	5	10	N/A	6	N/A	Retrospective
Yung MW (2001)	231	0	231	N/A	15	78	Retrospective
Badr El-Dine M (2002)	92	0	92	21	3	11	Prospective
El- Meselaty K et al. (2003)	40	0	40	16	0	12–18	Retrospective
Tarabaichi M (2004)	73	73	0	–	5	43	Retrospective
Badr El-Dine M (2009)	294	0	294	49	8	28.2	Retrospective
Barakate M. & Botrill I. (2008)	66	68 <sup>a</sup>	0	–	14	16	Retrospective
Ayache S. et al. (2008)	80	0	80	35	11	17	Retrospective
Presutti L. et al. (2008)	32	6	26	12	2	34	Retrospective
Migirov L. et al. (2011)	30	30	0	–	0	12	Retrospective
Sajjadi H. (2013)	249	0	249	80	24	24	Retrospective
Marchioni et al. (2013)	146	120	26	N/A	11	31	Retrospective
Sarcu D, Isaacson G. (2016)	42	0	42	7	7	N/A	Retrospective
Verma B et al. (2017)	116	0	116	13	0	12	Prospective
Elfeky, AEM. et al. (2019)	150	0	150	27	N/A	N/A	Prospective
Total	1685	302	1385	267	108		

N/A: Not Available.

<sup>a</sup> 68 operations performed on 66 patients.

many endoscope holders have been developed, a static endoscope will seldom allow access to two instruments, and by impeding free movement of instruments adversely affect precision. Concerns have also been raised about increased risk of thermal injury with static endoscope. On the other hand, single handed technique allows precision surgery with freely moving endoscope and instruments zooming onto the pathology. To overcome limitation of single handed technique in dissection, special instruments have been developed combining suction port to ear surgery instruments (Badr-El-Dine et al., 2013). Other limitations of endoscopes are frequent fogging and smearing of endoscope tip necessitating frequent cleaning and application of defogging agents which increases operative time. Finally, the cost of equipment involved (endoscopes, coupler, high definition camera, monitor) is a disadvantage, considering often it is adjunct and not substitute for microscope.

Compared to microscope, endoscope employs distal illumination at tip which ensures optimal visualisation of recesses. Angled lenses coupled with high definition camera system give wide panoramic images. Hamed Sajjadi et al. did a retrospective chart review (1994–2004) and found that endoscope helped in identifying cholesteatoma in hidden areas in primary surgery, and reduced rate of residual cholesteatoma to 9.7% in closed cavity. However cholesteatoma was not totally eliminated and sinus tympani still remained commonest site of residual (Sajjadi, 2013).

In our review observational endoscopic ear surgery studies were subjected to outcome analysis. Its role in identification and removal of cholesteatoma residues in primary and second-look surgery appears to be invaluable. Consistently, various authors have observed that endoscopes score over microscopes in identifying cholesteatoma in hidden areas.

In this review the common areas where residual disease was identified intraoperatively with endoscope by various authors, after completion of mastoid surgery with microscope, were sinus tympani, facial recess and anterior epitympanic space. Marchioni et al. have described three types of sinus tympani depending upon its depth and have observed that it is common area of recidivism in most studies (Marchioni et al., 2011). In our review we observed

that sinus tympani was commonest site of recidivism even in second-look procedures.

The two approaches of intact canal-wall and canal-wall down still remain the mainstay of cholesteatoma management. Advantages of intact canal wall approach are better preservation of middle ear anatomy, simpler postoperative care and maintenance and allowing aquatic pursuits in postoperative period (Tos and Lau, 1989; Nikolopoulos and Gerbesiotis, 2009). However, it is often associated with higher rates of recidivism, thus requiring strict follow-up and second-look surgery to rule out recurrence (Ho and Kveton, 2003; Syms and Luxford, 2003). Due to these disadvantages, many otologists prefer to drill down posterior canal in cholesteatoma surgery (Nyrop and Bonding, 1997; Quaranta et al., 1988). Improved visualisation of disease and improved disease clearance are believed to result in reduced recidivism and better 'disease-free' outcomes (Hulka and McElveen, 1998; Palva, 1987). Although open technique decreases rate of recurrence, recurrence rates as high as 9% have been described presumably due to incomplete access to sinus tympani with microscope even after lowering canal wall. Literature shows that recurrence rates are as high as 20% in intact canal-wall surgeries, while being often lower than 7% in canal wall down mastoidectomies (Zinis et al., 2010).

Whichever procedure is used, there is a limitation of visualising hidden areas and the results in both approaches can be improved with use of endoscope. For example in a large series of cholesteatoma managed with adjunctive endoscopy, Yung reported a residual rate of 9.4% for closed-cavity and 8.7% for open cavity. This study reveals that endoscopes have brought down recurrence rates in closed techniques to almost open technique recurrence rates (Yung, 2001). Recent studies exploring exclusive endoscopic cholesteatoma surgery have demonstrated safety profile of endoscopes in adult patients without significant complications.

In light of these studies, routine use of endoscopes as adjunct to microscopes in surgical management of cholesteatoma can be safely recommended with a clear benefit of visualisation of hidden areas. However while endoscope use appears to reduce recidivism especially in intact canal wall surgery, its use in canal-wall down procedures is not associated with marked reduction in recurrence.

Further even after use of endoscope in primary surgery in all studies, sinus tympani still remained most common site of recurrence in second-look, questioning the merit of endoscopes in eliminating disease in hidden areas.

Literature on exclusive use of endoscope as operative tool in ear surgery is limited as this is clearly in its infancy. Exclusively endoscopic ear surgery is currently practiced by select group of endoscopic ear surgeons, with long standing specialized experience in this field. Prospective comparative studies with long term follow-up with one arm offering only microscope and other arm offering only endoscopic surgery are clearly needed before exclusively endoscopic surgery can be recommended. But these are difficult and using both tools to complement each another rather than compete, may be the way forward.

Vast majority of studies being on adjunctive use of endoscopes rather than exclusive use, underlines the undisputed role of microscope in mastoid surgery.

This review is not without limitations and some articles may have been missed. Introduction of inadvertent biases by both our exclusion criteria and the non-standardized outcome analyses in different studies cannot be ruled out. Non-English articles may have yielded disparate outcomes. Several studies lacked long-term follow up and data on hearing outcomes or second look procedure. Most studies were retrospective. Studies included herein are spanning two decades which have witnessed rapid upgradation of endoscopy, associated instrumentations, image-capture, finesse and experience. Best attempts were made to fit dissimilar data into comparable and interpretable datasets. It is acknowledged that data reorganization may be subject to investigator interpretation. It has to be noted that most of these studies were done by proponents of ear endoscopy and none of the studies were randomised controlled trials.

In summary, this review clearly demonstrates a growing body of literature which favours use of endoscopes either exclusively or with microscope in cholesteatoma management.

## 5. Conclusion

This review validates utility of endoscopes in cholesteatoma surgery. Whether used exclusively or with microscope they help in decision making intraoperatively, as well as checking for disease in hidden areas like sinus tympani. While their use seems to lower recidivism especially in intact canal wall surgery for cholesteatoma, their utility in canal wall down surgery seems more to limit unnecessary bone dissection than reducing recurrence. While microscope still remains the workhorse for cholesteatoma management, endoscope is increasingly becoming an indispensable accessory. It scores over microscope in visualising middle ear structures but microscope affords greater comfort in mastoid while drilling. Rapid advances witnessed in this technique necessitate ongoing studies for fresh perspectives.

## 6. Future recommendations

Surgeons embarking on endoscopic techniques for ear surgery need additional training and skill development for single handed surgery and for monitor based camera assisted surgery. Acquaintance with camera and monitor settings, knowledge of optical chain are also desirable for optimum results. Familiarisation of entire surgical team is possible only with routine use of endoscopy for all otologic cases. To master the steep learning curve, surgeons must undertake hands-on cadaveric dissection courses and start with simple procedures like myringotomy. Its necessary to integrate both tools at cadaver dissection courses, so that trainee is well acquainted with benefits and limitations of both techniques and

adopts a balanced approach with judicious use of each and without hesitancy to use both in tandem. While endoscope is undoubtedly a useful tool, basic surgical principles still remain same and must be adhered to while using it for cholesteatoma management.

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## Declaration of competing interest

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