REVIEW
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Indications of Endoscopic or Microscopic Approach in Ear Surgery According to Current Evidence from the Literature

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ABSTRACT

Alongside the historical use of the microscope, endoscopic ear surgery has been developed for several years. Its advantages are now widely recognized, for example its wider view and its clear superiority to detect "hidden cholesteatoma". However, its use remains restricted to some teams, and its indications and applications are still debated in the otologist community. This review of the literature presents advantages, results, and limitations of both approaches. Moreover, the article highlights current evidence of equivalence or superiority of one of the other approach according to the different otologic surgical procedures. However, more studies about endoscopic ear surgery are required with longer follow-up and larger sample size. Finally, authors proposed a decision-making tree to guide the ear surgeon to the best practice.

Keywords: Endoscopy, middle ear, ossicular chain reconstruction, otologist, otosclerosis, tympanic membrane perforation, tympanoplasty

Introduction

Currently, training and practice in otologic surgery is still performed exclusively with a microscope in many otological teams. However, indications and applications of the endoscopic approach are still a highly debated subject in the otologist community, despite its indisputable advantages, for example the wider view. For otologic surgeons used to the microscope, the learning curve is also an important question. The anatomy of the ear is complex, and mastering the use of the endoscope can take a while. Moreover, losing 3D vision by switching from 2-handed microscopic surgery to 1-handed endoscopic surgery does not really help either. Finally, maintaining a dry operating field using a single hand can be tricky.

The goals of this review are to highlight the advantages and disadvantages of both approaches related to the different middle ear or external ear canal (EAC) surgeries and to guide the reader to the best practice according to the existing literature and the experience of the authors. A practical decision tree is also proposed to help less-experienced endoscopic ear surgeons in daily practice.

State of the Art in the Literature

Table 1 summarizes the existing literature about endoscopic versus microscopic otologic surgery. The different papers are classified according to surgical procedures.

Discussion

As in the previous section, the following discussion is organized by the type of surgery. Figure 1 proposes a decision-making tree for surgical treatment of chronic otitis, based on the current literature evidence.

Type I Tympanoplasty

First and most importantly, both endoscopic and microscopic approaches for type I tympanoplasty achieve the same rates of tympanic membrane closure (85%-89%), of hearing improvement, and of complications (6%-7%).[1-3,17] One of the main advantages of the endoscopic approach is the broader view, which facilitates the visualization of the tympanic membrane especially in the case of angled EAC, the temporomandibular joint herniation, or anterior perforation.[1-3,18-22] Thanks to this

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Table 1. Review of the Literature about the Advantages and Disadvantages of Endoscopic Versus Microscopic Ear Surgery, According to the Surgical Procedure

Author and Year of Publication	Paper's Information	Advantages of EES vs. Microscopic Approach	Disadvantages of EES vs. Microscopic Approach	Equivalent Results Between EES and Microscopic Approach	Potential Bias
Type I tympanoplasty					
Akyigit 2017[1]	Review of the literature about endoscopic tympanoplasty	Larger view Narrower incision No canaloplasty needed Shorter operating time Less postoperative pain and shorter recovery time Better subjective cosmetic outcomes Better visualization of hidden parts (anterior perforation, facial recess, and hypotympanum) Less general anesthesia needed	1-hand surgery 2D view with less accurate perception of depth Condensation on the endoscope Need of a good hemostasis of the EAC Risk of thermal damage (especially with xenon) Steep learning curve Trauma due to unintentional head movements	Same results in terms of hearing and recurrence of perforation	
Tseng 2017[2]	Meta-analysis about outcomes of endoscopic versus microscopic tympanoplasty, 4 studies included (266 patients, 2 RCT, and 2 retrospective cohort studies)	Better subjective cosmetic outcomes Less canaloplasty needed General anesthesia not needed		The same mean tympanic membrane closure rates (85%-86%) Same hearing improvement	Few studies available Low sample size
Manna 2019[3]	Meta-analysis, 16 studies (1323 ears) included, published between 2008 and 2019, about primary underlay tympanoplasty	Lower canaloplasty rate Better subjective cosmetic outcomes Shorter mean operative time	Steep learning curve (60 cases to obtain the same results as with the microscope)[4]	Same audiological outcome Same complication rate (6%-7%) Same graft success rate at final follow-up (87%-89%)	Variation among surgical techniques (in terms of incision, tympano-meatal flap, and ossicular reconstruction) No information and groups equivalence about the magnitude and location of the perforation Variation in follow-up (3 to 12 months)
Cholesteatoma removal					
Thomassin 1993[5]	Retrospective study on 2 consecutive case series: cholesteatoma operated by microscope only versus combined technique with microscope and endoscope	Less recurrent cholesteatoma after 12-18 months in combined approach (5.5% vs. 47.7%)			

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Table 1. Review of the Literature about the Advantages and Disadvantages of Endoscopic Versus Microscopic Ear Surgery, According to the Surgical Procedure (*Continued*)

Author and Year of Publication	Paper's Information	Advantages of EES vs. Microscopic Approach	Disadvantages of EES vs. Microscopic Approach	Equivalent Results Between EES and Microscopic Approach	Potential Bias
Presutti 2014[6]	Systematic review of the literature about outcomes of endoscopic surgery (alone or combined) for primary middle ear cholesteatoma, 7 articles published between 2002 and 2013 (515 patients)	Less recurrent or residual cholesteatoma (9% in EES vs. 19% in CWU microscopic technique) Less mastoidectomy needed			Short follow-up, low sample size
Kozin 2015[7]	Review of the literature about EES, 91 articles from 1967 to 2014	Clear advantage of the combined approach: discovery of "hidden" residual cholesteatoma in 50% of the cases			Bias of publication: no publication of negative results Short follow-up Lack of data about recurrence and success rates
Das 2019[8]	RCT, comparison of endoscopic versus microscopic transcanal approach for attic cholesteatoma, 78 patients	Better area of exposure Better visibility of middle ear structures Shorter operating time Less postoperative pain Better long-term outcomes (less recurrence or cartilage displacement or retraction pocket formation)	Bleeding increases the operating time, the risk of damaging critical structures, and the risk of leaving behind residual disease	Same vertigo rate at 1 week postoperative Same hearing results No facial nerve injury	Low sample size
Ryan 2020[9]	Review of the literature about pediatric cholesteatoma	Less recurrence Better postoperative hearing thresholds following EES but better preoperative thresholds Better postoperative quality of life	Canaloplasty sometimes needed EES restricted to middle ear cholesteatoma (no extension in the mastoid)		Selection bias: less advanced disease treated by EES Low sample size
Hu 2020[10]	Systematic review of the literature about studies comparing exclusive EES versus exclusive microscopic approach for acquired cholesteatoma, 17 articles included about adults and children	Less recurrence (less than 7% vs. 20% in microscopic CWU) Less residual cholesteatoma More preservation of the ossicular chain Better postoperative auditory outcomes Shorter operating time Shorter healing time Less morbidity	1-hand surgery Challenging in case of bleeding or narrow EAC Contraindicated in case of labyrinthic fistula, tegmen defect, cholesteatoma expanding beyond aditus ad antrum		Selection bias: possible less advanced cholesteatoma operated with endoscope Short follow-up

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Table 1. Review of the Literature about the Advantages and Disadvantages of Endoscopic Versus Microscopic Ear Surgery, According to the Surgical Procedure (*Continued*)

Author and Year of Publication	Paper's Information	Advantages of EES vs. Microscopic Approach	Disadvantages of EES vs. Microscopic Approach	Equivalent Results Between EES and Microscopic Approach	Potential Bias
Ossiculoplasty					
Isaacson 2017[11]	Review of the literature about endoscopic ossiculoplasty	Less scutum removal needed to visualize and address malleus or incus fixation Better visualization of the ossicular pathology, of the prosthesis coupling, and of the round window reflex	Potential for mechanical or thermal trauma More difficult placement and stabilization of autologous or prosthetic materials due to 1-hand surgery and monocular vision	Same complication rate	Limited audiometric outcomes available
Manzoor 2019[12]	Review of the literature about endoscopic versus microscopic ossiculoplasty, 3 studies included from 2017 to 2019, 108 ears	Potential advantage to diagnose ossicular or mucosal abnormalities		Same audiometric outcomes Same extrusion rate Same operating time	No data about long-term outcomes
Das 2020[13]	RCT, 118 adults with ABG ≥ 25 dB, use of PORP and TORP (different subgroups)	Earlier hearing improvement for PORP (probably due to better visualization and better preservation of normal mucosa)		Same mean operative time (136 ± 11 minutes) Same audiological results at 6 months Same rate of complication (retraction pocket, prosthesis displacement, extrusion of the prosthesis, and graft failure)	Small sample size
Stapes surgery					
Isaacson 2018[14]	Review of the literature about endoscopic stapes surgery, 9 articles included, published between 1999 and 2016	Better visualization in narrow EAC Less chorda tympani manipulation and injury (due to better visualization and less need for scutum removal) Less dysgeusia at 6 months postoperative	The work on the footplate and the prosthesis placement is more complicated due to the decreased perception of depth	Same auditory results Scutum removal mostly needed for instrument access to the footplate of the stapes Same rate of dizziness	

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Table 1. Review of the Literature about the Advantages and Disadvantages of Endoscopic Versus Microscopic Ear Surgery, According to the Surgical Procedure (*Continued*)

Author and Year of Publication	Paper's Information	Advantages of EES vs. Microscopic Approach	Disadvantages of EES vs. Microscopic Approach	Equivalent Results Between EES and Microscopic Approach	Potential Bias
Manna 2019[3]	Meta-analysis, 5 studies about stapes surgery (283 ears) from 2014 to 2018	Better visualization with less drilling of the EAC needed, responsible for less postoperative pain and less chorda tympany injury (20.4% for microscope and 7.4% for EES)	Steep learning curve (20 procedures needed to obtain the same results than with a microscope)[15]	Same rate of postoperative dizziness Same audiological outcomes Same operating time	Only 5 studies included High variation in follow-up (1 to 12 months)
External auditory canal surgery					
Kozin 2015[16]	Retrospective study about 4 patients, mean follow-up of 3.5 months	Improved visualization			Low sample size

2D, two-dimensional; ABG, air bone gap; CWU, canal wall up; EAC, external auditory canal; EES, endoscopic ear surgery; PORP, partial ossicular replacement prosthesis; RCT, randomized controlled trial; TORP, total ossicular replacement prosthesis.

larger view, a few retro-auricular approaches can be avoided, which is worth in terms of minimal invasive surgery and cosmetic outcomes. In the case of a very narrow EAC that does not allow visualization or access of the microinstruments, a canaloplasty can be performed, both under endoscopic and microscopic approaches. An advantage of transcanal approach, either under endoscope or microscope, is the shorter surgical time, the decreased postoperative pain, faster recovery, and better subjective outcomes.[1-3,20,23-25]

On the other hand, the endoscopic approach also has disadvantages. The first one is the 2-dimensional view with loss of depth perception.[1] However, the dynamic use of the endoscope in expert hands restores depth perception to a certain extent. The second one is the limitation of the surgery to 1 hand, the other hand being occupied with holding the endoscope.[10] Bleeding can then be especially challenging depending on the surgeon's experience. A third disadvantage of EES is the theoretical risk of thermal damage.[1,11] In contrast to studies in other medical fields,[26,27] no such complications have been reported in the ear,[28] but the facial nerve, the cochlea, and the vestibule are particularly sensitive to a rise in temperature.[29,30] It is recognized that avoiding temperatures above 40°C would likely prevent middle and inner ear complications,[28] but special attention is needed in case of facial nerve dehiscence. The dynamic use of the endoscope relatively protects the ear structure from heat trauma, which could be increased in case of fixed position, as with the use of an endoscope holder. However, more studies are needed to support this hypothesis.

Finally, other much less relevant arguments have been reported in the literature in favor of one or the other approach, for example the slow learning curve in EES.[1,3,4] However, this argument is inherent to any new technique and cannot be a reason not to do it if it represents a benefit for the patients. Another unsubstantiated criticism of the EES is the risk of trauma in case of head movements.[1] However, this could also be caused by the microinstruments in the microscopic approach.

In conclusion, both endoscopic and microscopic approaches are adequate for type I tympanoplasty, and the choice of one or the other will depend on the surgeon's experience.

Cholesteatoma Removal

The endoscope offers a clear advantage in the treatment of cholesteatoma. It is widely accepted that its use allows a significant reduction, at least by half, of recurrence and residual cholesteatoma rates, thanks to optimized middle ear visualization.[5-10] This broader view may also avoid disruption of the chain in case of cholesteatoma with intact ossicular chain.[10] In many cases, an endoscopic check of totality of resection of cholesteatoma after microscopy-guided surgery reveals residues, which were not perceived using the microscope. Even if most areas of the middle ear can be exposed by large drilling under microscopic control, some areas still remain unreachable. Furthemore, extended drilling can lead to immediate complications (opening of the dura, facial nerve injury, especially in case of dehiscence, perilymph fistula, etc.) or delayed complications (meningocele, retracted eardrum due to lesion of the tympanic sulcus, etc.). In the end, the choice has to be made for either the exclusive or the combined endoscopic approach. Currently,

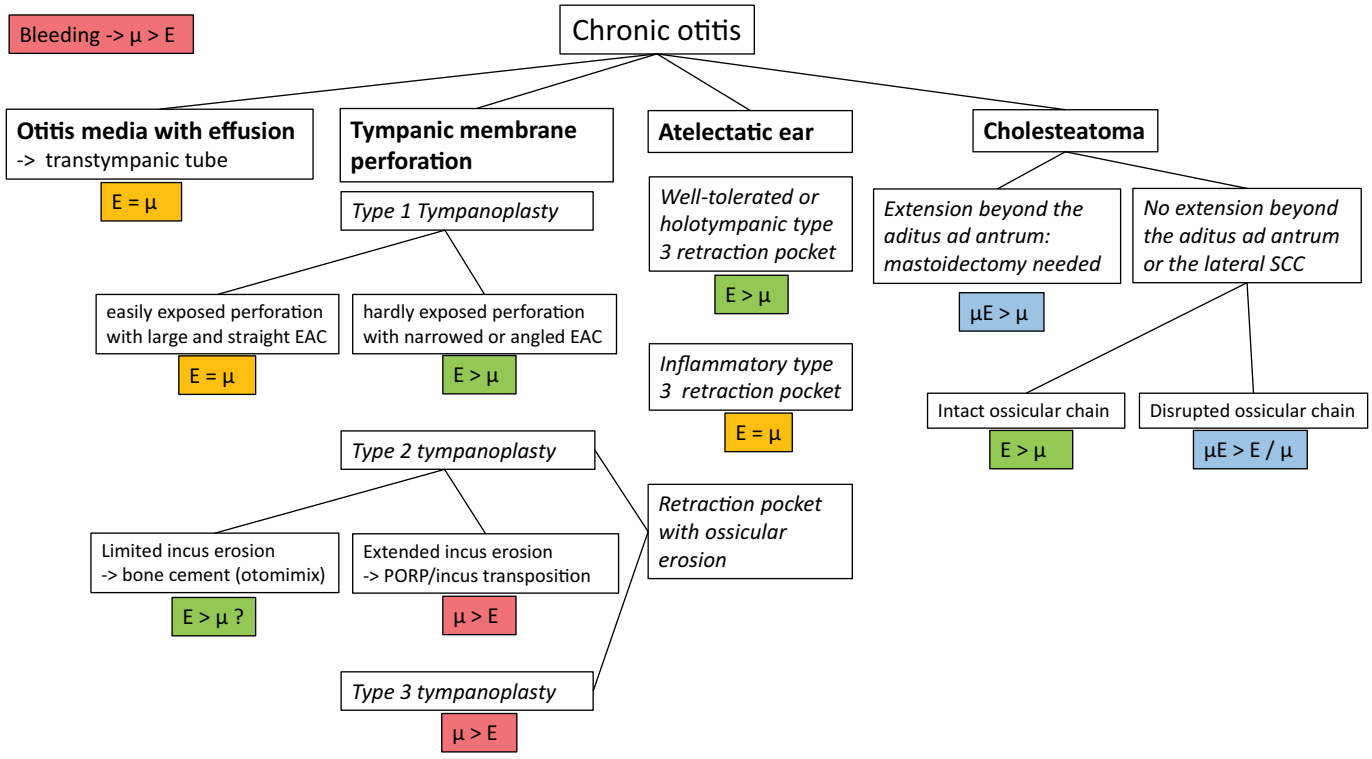

Figure 1. Decision-making tree for surgical treatment of chronic otitis. For each surgical indication, the superiority or equality between the use of the endoscope and the use of the microscope is given. Cases where both tools achieve the same results are in yellow (E = μ), those where the endoscopic approach is superior to the microscopic approach are in green (E > μ), those where the microscopic approach is superior to the endoscopic approach are in pink (μ > E), and those where the combined approach is preferable to either approach are in blue (μE > μ or E). E = endoscopic approach, μ = microscopic approach, μE = combined approach.

the literature is not able to give a definite answer as there is lack of data and too limited follow-up in total endoscopic cholesteatoma surgery.[7,10] For cholesteatoma limited to the middle ear, the auditory outcomes seem to be better with the endoscope compared to the microscope. However, some authors argued that it could be due to a selection bias with less advanced cholesteatoma treated by the endoscope.[9,10] In any case, this question remains open and needs more randomized controlled trials. We think that it is important to make a clear distinction between 2 situations: those where the use of the microscope is deemed necessary and those where the use of the microscope depends on the experience and the habits of the surgeon.

We recommend a combined technique in the following situations:

- In cholesteatoma
  - Extending
    - toward the mastoid beyond the lateral SCC,
    - toward the apex,
    - intracranially (or patient presenting preoperative signs of meningeal complications).
  - With erosion of
    - a large area of the tegmen tympani,
    - more than one-third of the posterior wall of the external auditory canal,
    - the hypotympanum, suggesting a possible contact between the cholesteatoma and the jugular bulb.
  - With the presence of preoperative facial palsy;
  - With a complete mastoid air cell opacification on temporal bone imaging, which makes it difficult to evaluate the possible extent of cholesteatoma inside the mastoid
  - With multiple recurrence;
- When patient is on antiplatelets or anticoagulants;
- When patient has long-standing otorrhea with major inflammation of middle ear mucosa.

On the contrary, the following situations can be managed exclusively with an endoscope:

- Congenital middle ear cholesteatoma;
- Cholesteatoma limited to the external attic space;
- Cholesteatoma limited to the middle ear with no major complication, such as perilymphatic fistula or tegmen defect[10];
- Cholesteatoma of retrotympanum (with limited bone erosion).

The literature lists several arguments in favor of the exclusive use of the endoscope, such as

- Reduction in postoperative pain, which is true if neither a mastoidectomy nor a retroauricular incision is made.[8]
- Less recurrence: this is thought to be related to reduced drilling of the sulcus which in turn reduces the risk of tympanic membrane retraction. It also decreases the risk of graft displacement.[8]

The literature favors a combined approach for optimal bleeding control (such as in major middle ear inflammation). Potential

bleeding could significantly increase the surgical time. Indeed, it leads to tricky conditions to explore the important areas, such as the retrotympanum, the ossicular chain, and the attic.[8]

Ossiculoplasty

In contrast to the clear benefit of the use of the endoscope in cholesteatoma surgery, its advantages in ossiculoplasty are more debated. Most importantly, the results between the 2 approaches are similar in terms of audiometric outcomes at 6 months, of complication rate (displacement or extrusion of the prosthesis and graft failure), and of operating time.[11-13] On the one hand, the main advantage of the endoscope is the better and faster diagnostic accuracy of potential ossicles or round window abnormalities due to its enhanced vision,[12] which could allow a faster hearing improvement.[13] Moreover, the notch in the tympanic sulcus that is regularly necessary in the microscopic approach to allow a good visibility of the stapes and the oval fossa can be kept smaller in EES, reducing the risk of secondary tympanic membrane retraction or lesion of the chorda tympani.[11] On the other hand, performing an ossiculoplasty using 1-hand can be challenging, especially in the case of bleeding.[11]

The 1-handed EES also requires the intervention of a physical assistance to drill an incus, and the absence of immediate suction can be deleterious when using too liquid cement for chain reconstruction, with the risk of cement going on the footplate. A second point of attention in ossiculoplasty using EES is that approaching the ossicular chain to obtain optimal vision increases the risk of unintentional contact, with potential damage to the inner ear function. As a matter of fact, the use of the endoscope does not give force feedback, unlike when using microinstruments. Third, the risk of thermal damage is higher since the endoscope must be closer to the middle ear structures, with less camera mobility during the placing step of ossiculoplasty.[11]

To summarize, the debate about the use of endoscopy in ossiculoplasty is still ongoing, and more studies are needed to confirm results from the existing literature that report similar results. In any case, ossiculoplasty using the endoscope can be challenging and must be performed by surgeons already experienced with EES.

Stapes Surgery

The advantages and disadvantages of the endoscopic approach of stapes surgery are widely discussed in the existing literature. However, the use of either tool may depend on the surgeon's preferred technique. As a matter of fact, the use of a CO_2 laser such as the SurgiTouch scanner (Lumenis Be Ltd., Yokneam, Israel) requires that the Acuspot micromanipulator (Lumenis Be Ltd., Yokneam, Israel) is fixed on the microscope. It allows for a calibrated and safe platinotomy. In this case, considering the endoscope is not even relevant. At the other side, in case of use of a fiberoptic laser or even exclusively "cold" instruments, the endoscope can be considered. It will provide a clearer image of the footplate,[14] allowing better placement of the piston. This better visualization may avoid scutum removal and decrease chorda tympani manipulation or injury.[3,14] However, even if scutum removal is not needed for visualization, this may be necessary to allow access to the instruments.[14]

In terms of results, the hearing outcomes and the rate of postoperative dizziness are similar for both the endoscope and the microscope.[3,14] The assertion that it is not possible to precisely evaluate the size of the piston with the endoscopic view being 2-dimensional, which is often cited in the literature, is unfounded. In fact, there is little variation in piston size, with most of them being around 4.75 mm of length. Additionally, using a micro-measuring device allows for accurate sizing of the piston, whether under microscopic or endoscopic control.

The risk of thermal damage with the endoscope should not be taken lightly. We are faced with an "open" inner ear, and we all know that placement of the piston can last from seconds up to several "long" minutes, which in turn increases the risk of perilymph heating. Furthermore, some might argue that, thanks to the endoscope, the creation of a notch at the tympanic sulcus is avoided (or at least kept small). This would reduce postoperative pain.[3] As otosclerosis surgery is known to cause almost no pain, this statement should be further investigated in more specific and especially larger studies.

Of course, these points concern classical otosclerosis, with an intact long process of incus. In case of a defect at its level, a specific piston may be needed. It can be fixed on the residual long process or on the handle of the malleus. Then, one should resort to the use of both hands. In that case, the microscope is preferred. Indeed, we regard disposing of both hands as more important than having better vision. Should there be any doubt concerning the correct placement of these specific pistons, then it could still be checked using the endoscope.

External Auditory Canal Surgery

Surgery of the ear canal is performed for diverse conditions including but not limited to cysts at the distal third of the canal (epidermoid, sebaceous, etc.), osteomas, exostoses, stenoses, and osteitis. Its spectrum goes from a simple biopsy or local excision to a meatoplasty or a canaloplasty. It would be too exhaustive here to compare both benefits and drawbacks of microscopic versus endoscopic use for these diseases. As for other surgical indications, endoscope improves visualization.[16] Ear canal surgery is generally performed on a straight axis, a necessary condition for the use of the microscope. Therefore, the panoramic view of the endoscope is less relevant. Moreover, using the drill in canals which are often narrow is not an easy task. One would need sufficient experience to combine it with the use of the endoscope.

Conclusion

Both microscopic ear surgery and EES have their own particularities. The endoscope allows for minimal invasive ear surgery, with a larger view of the surgical field. In experienced hands, the dynamic use of the endoscope compensates for the lack of the microscopic 3D vision. However, EES might get seriously complicated by uncontrolled bleeding. Indeed, 1-handed hemostasis can be difficult. In some types of surgery, 1 of both techniques is superior, even indispensable. This is the case when cholesteatoma extends beyond the aditus ad antrum, which requires mastoidectomy under microscopic approach. On the contrary, the endoscope enables the detection of residual cholesteatoma missed by the microscope. In these cases, the combined approach is preferred over a single approach.

In many surgical indications, the endoscope seems to have equivalent outcomes and complication rates compared to the microscope. However, studies with long-term follow-up and larger sample sizes are required.

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