

## Main Article

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## Abstract

**Objective.** This study aimed to assess whether increasing operative experience results in better surgical outcomes in endoscopic middle-ear surgery.

**Methods.** A retrospective single-institution cohort study was performed. Patients underwent endoscopic tympanoplasty between May 2013 and April 2019 performed by the senior surgeon or a trainee surgeon under direct supervision from the senior surgeon. Following data collection, statistical analysis compared success rates between early (learning curve) surgical procedures and later (experienced) tympanoplasties.

**Results.** In total, 157 patients (86 male, 71 female), with a mean age of 41.6 years, were included. The patients were followed up for an average of 43.2 weeks. The overall primary closure rate was 90.0 per cent.

**Conclusion.** This study demonstrates an early learning curve for endoscopic ear surgery that improves with surgical experience. Adoption of the endoscopic technique did not impair the success rates of tympanoplasty.

## Introduction

The use of endoscopes in otological practice was described in the 1980s for the viewing and photographing of mastoid cavities.<sup>1</sup> However, the use of the endoscope instead of the microscope as a primary intra-operative viewing tool has only become established relatively recently, and is increasingly being accepted as an integral component of middle-ear surgery.<sup>2,3</sup>

The wide field of view offered by the endoscope has overcome reservations about the difficulties of one-handed surgery. Despite this, the transition to endoscope from microscope in ear surgery does have a learning curve, prompting many ear surgeons with years of experience with the microscope to be less enthusiastic. Nonetheless, once the initial challenge of one-handed surgery is overcome, the endoscope provides a much better view into the middle ear than a microscope. Transcanal surgery with an endoscope often avoids scars and head bandages, increasing the patient's comfort post-operatively.

In this article, we present a review of 157 endoscopic tympanoplasties performed at a single centre by the senior author (CC) since starting his total endoscopic ear surgery practice, and we examine the learning curve with respect to endoscopic middle-ear surgery.

## Materials and methods

### Ethical considerations

This project was registered locally as an audit and was approved by the institute's audit department.

### Study group

Consecutive patients undergoing total endoscopic ear surgery between May 2013 and April 2019 were included in this retrospective study. Their records and audiograms were reviewed.

All procedures were performed by the senior author himself or by a trainee under direct guidance. Patients were, on average, reviewed at 12 weeks and 6 months post-operatively. Audiograms were performed during the follow-up appointment. Graft integrity was checked at every visit; an intact graft on follow up was classed as a successful outcome. Adverse events were defined as facial nerve palsy and dead ear.

### Statistical analysis

Statistical analysis was performed using Excel<sup>®</sup> spreadsheet software (Microsoft<sup>™</sup>, 2016), and Prism 6 analysis and graphing software (GraphPad Software, La Jolla, California, USA).

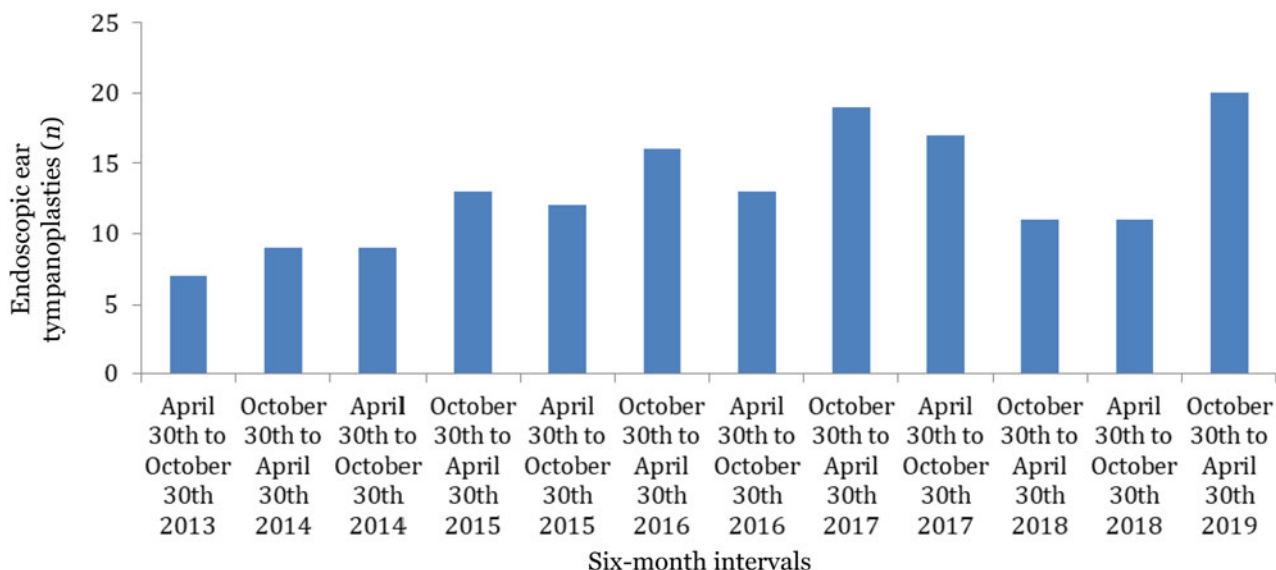


Fig. 1. Number of endoscopic ear tympanoplasties over six-month intervals, showing an overall increase in cases over time.

**Results**

Over a period of 71 months, 157 patients underwent endoscopic tympanoplasty and were included in the study. The study population consisted of 71 females and 86 males with a mean age of 41.6 years. The mean follow-up duration was 43.2 weeks (range, 2–234 weeks). The number of patients undergoing endoscopic myringoplasty increased steadily over a period of time (Figure 1), from seven in the first six months after commencing endoscopic ear surgery to three times as many in the later assessment period.

**Surgical results**

No major adverse events were noted. No endoscopic approach had to be converted to a microscopic approach. Follow-up information was available for 147 of the 157 patients (2 were lost to follow up and incomplete information was available about graft status in the remaining 8).

The overall intact graft rate of the study population at follow up was 90.0 per cent (132 out of 147). We further examined the graft success rates in initial cases versus later cases to determine if success rates changed with surgical experience. The graft success rates were found to be lower (75 per cent) in the first cohort of patients (analysed as 20 cases per cohort). The intact graft rates increased to over 90 per cent in subsequent cohorts of patients (Figure 2). These data demonstrate the senior author’s learning curve with respect to endoscopic ear surgery.

We further analysed the five tympanoplasty graft failures in the initial cohort with regard to possible contributing factors to the graft failures. All cases had small residual perforations. No significant factors were identified in the graft failure cohort that could explain the failures, such as co-existing infection at the time of the surgery, size of the perforation and general health of the patient. However, with respect to graft material per se, Biodesign® had been used as graft material in four out of these initial five myringoplasty procedures. However, over the whole series, the graft success with Biodesign was similar to that for autologous materials, indicating a further learning curve with Biodesign compared to conventional graft materials.

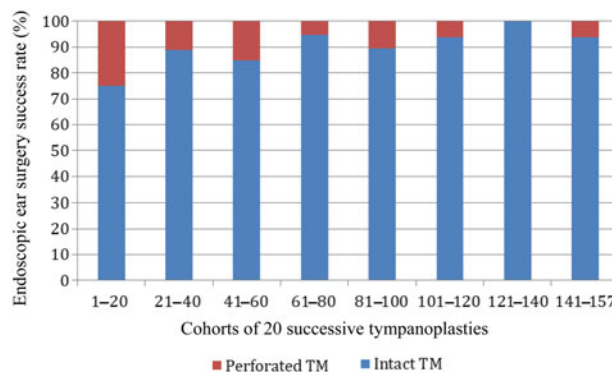


Fig. 2. Bar chart demonstrating the success rate of endoscopic ear surgery per cohort of 20 successive tympanoplasties. TM = tympanic membrane

**Hearing results**

Post-operative hearing results were examined in 102 of the 157 patients. Eleven patients with failed grafts and a further 44 patients with incomplete data (typically the absence of air or bone conduction levels on pure tone audiometry) were excluded from the analysis.

No significant hearing loss was noted post-operatively in the study population. The pre-operative and post-operative bone conduction thresholds were found to be similar (18.1 dB vs 18.7 dB). In the tympanoplasty-only cohort (82 patients), the air–bone gap improved from 22.0 dB pre-operatively to 16.6 dB post-operatively. In the tympanoplasty and ossiculoplasty cohort (20 patients), the air–bone gap improved from 34.0 dB pre-operatively to 22.0 dB post-operatively.

**Discussion**

The endoscopic transcanal approach provides an excellent view of the ear canal, entire tympanic membrane and tympanic space, including the attic, facial recess and hypotympanum, making it ideal for tympanoplasties. Our results demonstrate that a surgeon can pick up the necessary endoscopic skills relatively quickly and achieve acceptable success rates, while delivering the reduced morbidity associated with total endoscopic ear surgery.

In our experience, when embarking on endoscopic ear surgery, it is best to start with simple procedures like myringoplasty or tympanoplasty that are likely to go well. This allows the surgeon to become accustomed to the different field of view, and to develop the skills necessary for haemostasis and one-handed operating.

No specialist equipment is necessary. Standard ear microsurgery instruments were used for the tympanoplasties throughout this series, although specialist equipment is required for endoscopic cholesteatoma surgery. We found that bending the fine end attachment to a disposable sucker to a 90° angle adapted it to be a useful tool for working around corners. The operating microscope is replaced with an endoscopic stack with a three-chip camera. A 4 mm, 0° endoscope, 14–16 cm long, is suitable for most resectional and reconstructive work, with angled scopes being used primarily for confirming complete disease removal. Angled scopes are likely to be used for cholesteatoma surgery rather than endoscopic tympanoplasties. A 0° endoscope provides the widest field of view and is therefore the best option for adequate orientation.

An initial challenge with total endoscopic ear surgery is in raising a tympanomeatal flap, a step that would have been simple for the surgeon operating with the microscope. Without the ability to continuously remove blood from the bone–flap interface, this step becomes tougher. In this series, it took about twenty surgical procedures before this step could be performed endoscopically with an ease comparable to procedures performed with a microscope. The primary learning points to reduce bleeding when raising a tympanomeatal flap are: adequate pre-operative canal preparation with adrenaline (both topical and subcutaneous), and improved instrument and endoscope control to reduce unintended canal trauma and the resultant bleeding. The advantages of the endoscopic procedure become easier to appreciate once the raising of a tympanomeatal flap is mastered. As soon as the middle ear is opened, excess blood drains into the hypotympanum and the wide endoscopic view becomes apparent.

Following the first 20 procedures, the technique became increasingly routine. By the time 40 cases had been completed, endoscopic ear surgery became the primary procedure for all tympanic membrane perforations, ossiculoplasties and indeed for the middle-ear component of cholesteatomas (data not shown). Once 60 cases had been completed, the senior author became more comfortable with the endoscopic view of the middle ear than with the microscopic view.

An important decision in endoscopic tympanoplasty concerns the choice of graft material. Several graft materials have been trialled, including tragal cartilage and perichondrium. As one of the goals of total endoscopic ear surgery is to avoid a scar, the senior author regularly uses Biodesign tissue grafts. These are made from a natural material derived from porcine submucosal intestinal tissue. Their use avoids an incision, and the grafts are easier to handle than fascia or cartilage. However, it is important to remember that Biodesign grafts have a reduced hydrostatic effect on the undersurface of the tympanic membrane compared to fascia. This could result in graft failures, and can explain some of the initial failures in this study. In order to counteract this, increased middle-ear packing with Spongostan™ (an

absorbable haemostatic gelatine sponge) was used to support the Biodesign graft against the undersurface of the tympanic membrane. A further modification was to pull the Biodesign graft through the tympanic membrane anteriorly or under the anterior annulus, thereby improving contact with the tympanic membrane.

- The endoscope allows for a wider field of view when compared to the microscope in tympanoplasty
- Transcanal surgery with an endoscope often avoids scars and head bandages, enhancing patient comfort post-operatively
- There is no significant difference in success rates of endoscopic tympanoplasty and microscopic surgery
- Surgeons can obtain endoscopic skills relatively quickly, achieving acceptable success rates after only 20 cases
- Manual bending of the fine end attachment to a disposable sucker to 90° is useful for working around corners
- A 4-mm, 0° endoscope, 14–16 cm long, is suitable for most resectional and reconstructive work, with angled scopes being used primarily for confirming complete disease removal

We recommend attending an endoscopic ear course prior to embarking on total endoscopic ear surgery, irrespective of previous experience with microscope-assisted ear surgery. Spending time in an operating theatre with a surgeon experienced in total endoscopic ear surgery will also help in the transition from microscope-assisted ear surgery to total endoscopic ear surgery. It is imperative that trainee surgeons are proficient in microscope-assisted ear surgery before or while learning total endoscopic ear surgery.

## Conclusion

Over 150 endoscopic tympanoplasties performed by a senior otologist have been reviewed and an early learning curve was demonstrated. Initial failures were noted with endoscopic tympanoplasty; however, a successful graft uptake rate of 90 per cent was achieved after the initial learning curve. With surgical experience, endoscopic ear surgery can deliver results on par with microscope-assisted surgery, while reducing patient morbidity.

Key points when transitioning to endoscopic ear surgery are: start with simple cases; persevere; take time and effort to achieve adequate canal vasoconstriction prior to surgery; and start with a 4 mm, 0° endoscope.

**Competing interests.** None declared

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