

## Case Control Study

## Endoscopic ear surgery: A case series and first United Kingdom experience

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### Abstract

**AIM:** To present the United Kingdom's first case series of 70 otological cases of endoscopic and non-endoscopic ear surgeries.

**METHODS:** Prospective case series incorporating a range of endoscopic procedures performed using a 4 mm, 18 cm rigid endoscope, performed by a single surgeon at a single centre. Primary outcome measures included mean average pre and post-operative air-bone gap hearing thresholds and duration of surgery.

**RESULTS:** Thirty-eight patients underwent endoscopic assisted ear surgery and 32 underwent non-endoscopic assisted ear surgery. In both surgical groups, there was a significant difference between pre and post-operative mean air-bone gaps ( $P = 0.02$ ). Mean operating time was comparable between both groups. Eight patients developed post-operative complications.

**CONCLUSION:** Endoscopic ear surgery can be performed safely in a range of otological procedures. This has the potential to become a well-established surgical option for middle ear surgery in the near future. Advantages and limitations are discussed.

**Key words:** Endoscopic; Mastoid; Surgery; Imaging; Otology; Cholesteatoma

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**Core tip:** The role of endoscopic ear surgery is yet to be properly established but as more otologists adopt this technique, its role will become much more clearly defined and may lead to widespread use based upon positive outcomes for surgery. As with every new surgical technique, a learning curve must first be overcome before reliable conclusions can be drawn about its use. Our series has shown the benefits of using this technique in limited cholesteatoma disease and in providing a good view during revision mastoid surgery with simple pathology.

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## INTRODUCTION

The advantages of using endoscopes in surgery are well described and relate mainly to their portability and ability to provide clear, high quality images<sup>[1]</sup>. Endoscopes can also be used in theatre and the outpatient setting. In particular, the benefits for middle ear surgery include the ability to visualise poorly seen structures, such as the hypotympanum and sinus tympani, which are often an obstacle during the open-technique approach<sup>[2]</sup>. In addition, their use *via* the permeal approach in bypassing a narrow isthmus can provide direct access and a wide view into the middle ear for surgery<sup>[3-5]</sup>. Benefits of using an endoscope can therefore decrease operating time due to the reduction in time need to gain access into the middle ear cleft<sup>[6]</sup> and the subsequent closure at the end of the procedure. The disadvantages of endoscopes used in ear surgery include operator dependence (especially in relation to the one-handed technique), restricted views from narrower endoscopes (*e.g.*, 2.7 mm as compared to 4 mm), the ability to manage complications such as bleeding within a narrower operating field, loss of depth perception, limited magnification, and the need for further training in their use<sup>[4,5]</sup>. Furthermore, when used solely in a permeal approach, the surgeon must use a one-handed technique for instrumentation and there may be difficulty passing other instruments alongside, even in wide ear canals. Certainly there is no scope for using the operating drill in its present form.

Endoscopic ear surgery can be applied to a variety of operations including; grommet insertion, myringoplasty<sup>[2]</sup>, attic retractions<sup>[6]</sup>, cholesteatoma surgery<sup>[7-15]</sup>, stapedectomy<sup>[1,15]</sup>, benign neoplasms of the middle ear<sup>[16]</sup> and neuro-otological procedures<sup>[4,17,18]</sup>. Based on the literature their use has been most commonly described for middle ear disease (cholesteatoma). It has been suggested that preservation of middle ear mucosa by limited surgery using the endoscope can improve the re-aeration of the mastoid cavity leading to better outcomes in surgery<sup>[2]</sup>. There are also roles in "second look" middle ear surgery using 30 degree endoscopes to check for disease clearance<sup>[14,19]</sup>.

Many of the surgeries described above are derived from international case series from France, Germany, Italy, India, UAE, China, Egypt, Iran and the United States<sup>[1,5,12-14,17-24]</sup>. We present the first United Kingdom case series that uses a permeal exclusively endoscopic approach<sup>[20]</sup>.

## MATERIALS AND METHODS

We describe a case series of 70 patients who

underwent either endoscope-assisted or non-endoscope-assisted ear surgery by a single senior surgeon in a district general hospital. Data collection was carried out prospectively for endoscopic cases and retrospectively for non-endoscopic cases where all cases were performed within a 2 year period (2012-2014). A 4 mm diameter, 18 cm long rigid endoscope was used in all cases. Primary outcomes include mean average pre and post-operative air-bone gap hearing thresholds or duration of surgery, depending on the type of surgery. Pre and post-operative audiometric data using both air and bone conduction (at 500 Hz, 1 KHz, 2 KHz and 4 KHz frequencies) was recorded. Complications were noted. Statistical analysis was performed using GraphPad Prism (GraphPad Software Inc, La Jolla, CA, United States).

### Statistical analysis

The statistical methods of this study were reviewed by Virk J, Cambridge University graduate. The dataset was principally descriptive with simple paired t-testing only.

## RESULTS

Seventy patients underwent surgery between the ages of 7-85. Of these, 38 underwent endoscope-assisted ear surgery (Group A) and 32 underwent non-endoscope-assisted ear surgery (Group B). All cases were performed under general anaesthesia. Imaging was reviewed prior to surgery. An endoscope was used exclusively for all patients who underwent endoscope-assisted ear surgery, except in parts of an operation which required the use of a microscope (*e.g.*, mastoid portion of modified radical mastoidectomy or canal wall up mastoidectomy). Procedures in Group B patients were preferentially performed with the microscope such as revision stapedectomies under local anaesthetic or those with extensive disease and the endoscope was not used during the procedure. No cases were converted from endoscopic to open operations. Both groups were matched as closely as possible for type of surgery and demographics.

In Group A, 20 patients had had previous surgery to the operated ear (*i.e.*, ipsilateral ear) compared to 7 patients in Group B. A summary of different operations within Group A and B are shown in Table 1. Tables 2-6 summarise data for each operative group.

Overall, air-bone gap closure was achieved within 10 dB in 9 patients (5 Group A vs 4 Group B), within 10-30 dB in 18 patients (8 Group A vs 10 Group B), over 30 dB in 9 patients (2 Group A vs 7 Group B), over-closure in 5 patients (4 Group A vs 1 Group B) and no change in 25 patients (18 Group A vs 7 Group B). In both groups, there was a significant difference between pre and post-operative mean air-bone gaps ( $P < 0.05$ ) (paired *t* test,  $P = 0.036$  group A and  $P = 0.002$  for group B) for patients who underwent stapedectomy, where air-bone gap was a primary

**Table 1 Summary of procedures**

Procedure (including revision surgery)	Endoscopic assisted	Non-endoscopic assisted
	Group A	Group B
Ventilation Tube insertion	1	2
Myringoplasty, tympanoplasty, ossiculoplasty, Tympanotomy	10	10
CSOM and cholesteotoma surgery	15	10
Stapedectomy	11	9
Petrosectomy	1	1
Total	38	32

**Table 2 Ventilation tube insertion**

No.	Age	Side	Duration (min)	Previous ipsilateral surgery	Pre-op mean air-bone gap <sup>1</sup>	Post-op mean air-bone gap <sup>1</sup>	Closure	Follow up (mo)	Complications
Endoscopic assisted, Group A									
1	15	R	25	No	22.5	0	Within 10-30 dB	4	None
Non-endoscopic assisted, Group B									
1	14	R + L	20	No	25	10	Within 10-30 dB	9	None
2	53	R + L	15	No	20	20	No change	24	Recurrent otitis media with effusion

<sup>1</sup>Mean gap calculated over 4 frequencies (500 Hz, 1 KHz, 2 KHz, 4 KHz).

**Table 3 Myringoplasty, Tympanoplasty, Ossiculoplasty and Tympanotomy**

No.	Age	Details	Side	Duration (min)	Previous ipsilateral surgery	Pre-op mean air-bone gap <sup>1</sup>	Post-op mean air-bone gap <sup>1</sup>	Closure	Graft material	Follow up (mo)	Complications
Endoscopic assisted, Group A											
1	63	Myringoplasty	R	66	Yes	Dead ear	Dead ear	No change	Conchal cartilage	1	Tragal abscess and otitis externa
2	37	Myringoplasty	L	60	No	15.5	12.5	No change	Temporalis fascia	4	None
3	55	Myringoplasty	L	45	Yes	5	5	No change	Composite tragal graft	4	None
4	16	Revision myringoplasty	R	45	Yes	0	0	No change	Tragal cartilage	5	None
5	22	Tympanoplasty	R	88	No	0	0	No change	Composite tragal graft	12	None
6	45	Tympanoplasty	L	101	Yes	20	15	Within 10-30 dB	Tragal cartilage	4	None
7	32	Tympanoplasty	L	98	No	7.5	6.25	Within 10 dB	Tragal cartilage	2	None
8	46	Tympanoplasty	L	111	Yes	18.75	23.3	No change	Tragal cartilage	2	None
9	35	Tympanoplasty	R	121	No	30	11.25	Within 10 dB	Not stated	3	None
10	34	Ossiculoplasty	R	123	Yes	42.5	12.5	Within 10-30 dB	Not stated	10	None
Non-endoscopic assisted, Group B											
1	12	Myringoplasty	R	55	No	12.5	11.25	Within 10-30 dB	5	5	None
2	9	Myringoplasty	L	130	No	27.5	Not available	Not available	Temporalis fascia	Lost to follow up	None
3	30	Revision myringoplasty	L	97	No	16.25	15	Within 10-30 dB	Temporalis fascia	12	None
4	66	Tympanoplasty	L	127	Yes	Not available	Not available	Not available	Not stated	5	Will need ossiculoplasty
5	59	Tympanoplasty	L	114	No	15	40	> 30 dB	Not stated	4	Scarring, false fundus recurrence
6	33	Tympanoplasty	L	174	No	Dead	Dead	No change	Composite tragal graft	5	None
7	10	Tympanoplasty	L	88	No	23.75	21.25	Within 10-30 dB	Temporalis fascia	3	None
8	21	Tympanoplasty	R	92	No	16.25	6.25	Overclosure	Temporalis fascia	10	None
9	63	Tympanoplasty	R	100	No	Dead	Dead	No change	Not stated	3	None
10	50	Revision tympanoplasty	R	101	Yes	0	20	> 30 dB	Tragal cartilage	2	None

<sup>1</sup>Mean gap calculated over 4 frequencies (500 Hz, 1 KHz, 2 KHz, 4 KHz).

outcome.

Mean operating times were as follows; ventilation

tube insertion 25 min vs 17.5 min in (Group A, *n* = 1 vs Group B, *n* = 2), myringoplasty, tympanoplasty,

Table 4 CSOM and cholesteatoma surgery

No.	Age	Details	Side	Duration (min)	Previous ipsilateral surgery	Pre-op mean air-bone gap <sup>1</sup>	Post-op mean air-bone gap <sup>1</sup>	Closure	Graft material	Follow up (mo)	Complications
Endoscopic assisted, Group A											
1	42	Mastoidectomy	L	211	No	7.5	7.5	No change	Temporalis fascia	6	None
2	40	Revision mastoidectomy	R	155	Yes	40	40	No change	Not stated	3	None
3	7	Tympanoplasty and mastoid exploration	L	169	Yes	13.75	5	Overclosure	Conchal cartilage	3	None
4	35	Tympanotomy	L	48	No	25	25	No change	Not stated	2	None
5	18	CWU mastoidectomy	L	195	No	7.5	17.5	Within 10 dB	Conchal cartilage	7	None
6	52	CWU mastoidectomy	L	287	Yes	20	18.75	> 30 dB	Tragal cartilage	6	None
7	13	Revision CWU mastoidectomy	L	188	Yes	11	25	> 30 dB	Tragal cartilage	2	None
8	47	MR mastoidectomy	R	287	No	27.5	23.75	Within 10-30 dB	Not stated	2	None
9	40	MR mastoidectomy	L	223	Yes	Data unavailable	16.25	Within 10-30 dB	Tragal cartilage	2	Post op. pain
10	28	Revision MR mastoidectomy	L	228	Yes	21.25	21.25	No change	Not stated	4	None
11	41	Revision MR mastoidectomy	L	140	Yes	31.25	31.25	No change	Not stated	4	None
12	35	Revision MR mastoidectomy	R	95	Yes	42.5	42.5	No change	Not stated	6	None
13	85	Revision MR mastoidectomy	L	110	Yes	20	20	No change	Not stated	11	None
14	68	Revision MR mastoidectomy	L	155	Yes	45	50	No change	Temporalis fascia	3	None
15	43	Revision MR mastoidectomy		78	Yes	Dead ear	Dead ear	No change	Not stated	4	Transient delayed facial palsy
Non-endoscopic assisted, Group B											
1	8	CWU mastoidectomy	L	220	No	17.5	12.5	Within 10-30 dB	Temporalis fascia	12	None
2	52	CWU mastoidectomy	L	286	No	27.5	25	> 30 dB	Not stated	7	None
3	13	Revision CWU mastoidectomy	L	189	Yes	7.5	30	Within 10-30 dB	Tragal cartilage	5	None
4	70	MR mastoidectomy	L	131	No	13.75	20	> 30 dB	Composite tragal graft	3	None
5	42	MR mastoidectomy	R	255	No	28.75	35	> 30 dB	Temporalis fascia	3	None
6	34	MR mastoidectomy	R	312	No	33.75	37.5	> 30 dB	Composite tragal graft	2	None
7	73	Revision MR mastoidectomy	L	150	Yes	Dead ear	Dead ear	No change	Tragal cartilage	9	None
8	77	Revision MR mastoidectomy	L	179	Yes	2.5	21.25	Within 10-30 dB	Tragal Cartilage	8	None
9	56	Revision MR mastoidectomy	L	251	No	20	10	Within 10-30 dB	Temporalis ascia	4	None
10	78	Revision MR mastoidectomy	R	199	No	Dead ear	Dead ear	No change	Not stated	6	None

<sup>1</sup>Mean gap calculated over 4 frequencies (500 Hz, 1 KHz, 2 KHz, 4 KHz). CWU: Canal wall up mastoidectomy; MR: Modified radical mastoidectomy.

tympanotomy and ossiculoplasty 85.8 min vs and 107.8 min (Group A,  $n = 10$  vs Group B,  $n = 10$ ), CSOM and cholesteatoma surgery 171 min vs 217.2 min (Group A,  $n = 15$  vs Group B,  $n = 10$ ), stapedectomy 136.5 min vs 175.2 min (Group A,  $n = 11$  vs Group B,  $n = 9$ ) and petrosectomy 387 min vs 253 min (Group A,  $n = 1$  vs Group B,  $n = 1$ ).

Graft material was used in a total of 30 patients (15 vs 15 patients from Group A and B respectively). Choice of graft material varied from tragal cartilage (7 vs 5), conchal cartilage (3 vs 0), composite tragal graft (2 vs 4), temporalis fascia (3 vs 6) and fascia lata and fat (1 vs 0) from patients in Group A and B respectively.

**Table 5 Stapedectomy**

No.	Age	Details	Side	Duration (min)	Previous ipsilateral surgery	Pre-op mean air-bone gap <sup>1</sup>	Post-op mean air-bone gap <sup>1</sup>	Closure	Prosthesis	Follow up (mo)	Complications
Endoscopic Assisted, Group A											
1	30	Stapedectomy	L	149	No	28.75	10	Overclosure	SMart piston	9	None
2	57	Stapedectomy	L	119	No	11.25	15	Within 10-30 dB	SMart piston	3	None
3	43	Stapedectomy	R	137	No	35	6.25	Within 10-30 dB	SMart piston	6	None
4	44	Stapedectomy	R	145	No	32.5	10	Within 10-30 dB	SMart piston	4	None
5	32	Stapedectomy	R	150	No	25	26.25	No change	Plastipore PORP	5	None
6	39	Stapedectomy	R	115	No	40	13.75	Within 10 dB	PORP	3	None
7	45	Stapedectomy	R	151	No	38.75	40	Overclosure	Porphexpiston	2	Infection in mastoid cavity
8	33	Stapedectomy	R	125	No	13.75	6.25	Overclosure	SMart piston	5	None
9	37	Revision stapedectomy	L	139	Yes	25	17.5	Within 10 dB	SMart piston	8	None
10	32	Revision stapedectomy	L	142	Yes	60	60	No change	SMart piston	2	Labyrinthitis
11	47	Revision stapedectomy	R	129	Yes	16.25	20	Within 10-30 dB	SMart piston	7	None
Non-endoscopic Assisted, Group B											
1	48	Stapedectomy	R	254	No	45	7.5	< 10 dB	fluoroplastic piston	11	None
2	44	Stapedectomy	R	230	No	21.25	Not available	n/a	Fluoroplastic piston	Lost to follow up	
3	45	Stapedectomy	L	118	No	26.25	8.75	< 10 dB	Smart piston	5	None
4	41	Stapedectomy	R	265	No	37.5	13.75	Within 10-30 dB	Smart piston	3	None
5	41	Stapedectomy	L	253	No	33.75	16.25	Within 10-30 dB	Smart piston	13	None
6	42	Stapedectomy	L	98	No	32.5	20	Overclosure	Fluoroplastic piston	22	None
7	40	Stapedectomy	L	169	No	40	5	< 10 dB	Fluoroplastic piston	14	None
8	56	Revision stapedectomy	L	111	Yes	20	10	< 10 dB	Fluoroplastic piston	5	None
9	38	Revision stapedectomy	R	79	Yes	26.25	21.25	> 30 dB	Fluoroplastic piston	8	Planned for revision revision surgery

<sup>1</sup>Mean gap calculated over 4 frequencies (500 Hz, 1 KHz, 2 KHz, 4 KHz). PORP: Partial ossicular replacement prosthesis; n/a: Not Applicable.

Eight patients developed post-operative complications that later resolved including otalgia, recurrent otitis media with effusion, transient delayed facial palsy, labyrinthitis, tragal abscess and tympanic membrane perforation and infection of the mastoid cavity (see Tables 2-6). Three patients were planned for further surgery at follow up. Mean post-operative follow up was 8.8 mo; 2 patients were lost to follow up.

## DISCUSSION

### Ventilation tube insertion

Only one patient in our case series had ventilation tube insertion lasting 25 min. Though numbers are extremely low, and therefore difficult to analyse, this operation took 7.5 min longer than the mean duration of non-endoscope-assisted surgery. In contrast, a recent study examining 260 endoscopic grommet insertions demonstrated operating times between 5 and 10 min in all cases<sup>[2]</sup>. Another study has shown that there is no significant difference in duration compared to using a microscope, though it does

advocate the use of an endoscope when ventilation tube placement is technically difficult<sup>[21]</sup>.

### Myringoplasty, Tympanoplasty and Tympanotomy

This series demonstrates that the endoscope can effectively access the middle ear for these procedures. No further incisions were required and an exclusively permeal approach was used in all endoscopic procedures. Surgical outcomes were good in all cases (Table 2) with shorter mean operating times as compared to Group B (non-endoscope = assisted surgery), 85.8 min vs 107.8 min for Group A vs B respectively. This is a fairly accurate representation of true operating time, since the same numbers of operations were performed in each group. There is also evidence that excellent hearing thresholds can be achieved endoscopically, as reported by Balasubramanian and Venkatesan, who achieved pure tone average hearing thresholds of 20 dB in 50 myringoplasties performed endoscopically, further confirming the efficacy of this technique in selected cases<sup>[2]</sup>.



Table 6 Petrosectomy

No.	Age	Side	Duration (min)	Previous ipsilateral surgery	Pre-op mean air-bone gap <sup>1</sup>	Post-op mean air-bone gap <sup>1</sup>	Closure	Graft material	Follow up (mo)	Complications
Endoscopic assisted, Group A										
1	63	R	387	No	Dead ear	Dead ear	No change	Fat, Fascia lata	3	Intraoperative CSF leak; TM perforation
Non-endoscopic assisted, Group B										
1	79	R	253	No	Dead ear	90	No change	Not stated	6	referral for cochlear implant

<sup>1</sup>Mean gap calculated over 4 frequencies (500 Hz, 1 KHz, 2 KHz, 4 KHz). CSF: Cerebrospinal fluid; TM: Tympanic membrane.

### CSOM and cholesteatoma surgery

Mean operating time was shorter in Group A compared to Group B (171 min vs 217.2 min respectively). Since total number of operations here were not equal ( $n = 15$  vs  $n = 10$ ), it is unreliable to claim the difference between these figures is of clinical significance. Variation in anatomy and pre-operative disease state (*e.g.*, actively discharging ear), will also have implications on duration of operation due to technical difficulty.

Cholesteatoma can vary in anatomical spread and severity of disease. In widespread, severe cases, canal wall up mastoidectomy or modified radical mastoidectomy can be performed. Our case series shows a variation in the number of these procedures between both groups. Performing mastoidectomy exclusively with an endoscope is impossible, and therefore drawing comparisons between these groups is difficult, as the endoscope will not have been used during a proportion of surgery in Group A. However, only the endoscope was used for the entire operation where there were cases of limited cholesteatoma, or recurrent disease in revision surgery. Recent literature supports this, demonstrating that an exclusively endoscopic approach can be very useful as a "second look" surgery in order to identify residual cholesteatoma<sup>[11]</sup>.

The most widely documented use of endoscopic ear surgery has been for cholesteatoma disease. Some studies have examined the use of the endoscope as an adjunct for surgery. Residual cholesteatoma rates in closed cavity surgery have been documented around 9%, which is comparable to use with a microscope alone<sup>[14]</sup>. One study examined its use peri-operatively after surgery using the microscope. Residual disease was identified in 65/80 cases, and was documented to commonly occur on the stapes footplate, the stapes crura, and the sinus tympani<sup>[13]</sup>. The use of the endoscope has also been shown to decrease the rate of "open tympanoplasty" during this surgery. Results for localised attic disease have achieved air bone gap closure within 20 dB in around 90% of patients between 3 and 6 years follow up. Figures of 80% disease-free follow up have also been documented on 27 cases with limited attic retractions<sup>[6]</sup>. Our series demonstrates relatively efficient use of the

endoscope during revision surgery, which highlights the importance of a good visibility during technically challenging operations within the middle ear. However longer follow up is required to confirm its efficacy in these revision cases.

### Stapedectomy

Our case series of 11 stapedectomies performed using a 4 mm endoscope at 0 and 30 degrees demonstrated the preservation of the chorda tympani all cases, as well as achieving significant improvement in pre and post-operative air-bone closure ( $P < 0.05$ ) where thresholds were within  $< 30$  dB for all cases. By comparison, the 9 operations performed without the endoscope, also show significant improvement in pre and post-operative air bone gap ( $P < 0.05$ ), but with a longer mean duration of surgery (136.4 min vs 175.2 min for Group A and B respectively). First described by Poe in 2000, endoscopic stapedectomy has gone on to show promise in other countries across the world, achieving significant improvement in air bone gap by comparing pre and post-operative hearing thresholds<sup>[1,15]</sup>. Our series is in keeping with this.

### Petrosectomy

There are some reports of successful use of the endoscope during cholesteatoma surgery within the petrous apex, as was used for one case in our series<sup>[22]</sup>. Due to the discovery of a CSF leak intra-operatively, the duration of surgery is much higher compared to the non-endoscopic assisted surgery. It is difficult to compare these two surgical approaches for this operation from this single case series.

### Clinical applicability

Endoscopic surgery has also been used in a variety of neuro-otological procedures, including acoustic neuroma surgery. Some centres have also begun using it as the first surgical option or as an adjunct to conventional posterior tympanotomy approach in cochlear implantation<sup>[23-25]</sup>. Its benefit as an adjunct to conventional surgical techniques where wider exposure is required due to a limited direct vision has been well recognised<sup>[4,17,18]</sup>. Cadaveric studies using the endoscope alone have also documented superior views of the internal acoustic meatus over conventional

techniques, although clinical applicability for this may well take several years to develop<sup>[23,25]</sup>.

The endoscopic technique in ear surgery undoubtedly gives better quality images and access to blind sacs around the middle ear space that would otherwise not have been visualised adequately using a microscope, irrespective of surgical approach. It is minimally invasive thus providing better cosmesis in patients who do not wish to have a scar. Its use in the outpatient setting has gained popularity by consultant otolaryngologists and junior trainees due to its accessibility, portability and superiority over hand drawn diagrams of the tympanic membrane, which often can be unreliable and inaccurate. In addition, our series demonstrates a role in revision mastoid surgery in particular, where, for example, the cavity can be revised by curettage of a high "facial ridge" entirely endoscopically and permeatally.

The most commonly used rigid endoscopes are 18 cm long and 4 mm (as used for all operations in this case series). Some surgeons find this endoscope difficult to manoeuvre due to its length and larger diameter, and advocate using a paediatric nasal endoscope which is 2.7 mm diameter and 11 cm long<sup>[1]</sup>. However these endoscopes generate poor views and 3 mm endoscopes are available and better suited for ear surgery. Ideally, an endoscope with a small diameter, and shorter length, possibly with a modification to allow the surgeon to keep two hands free but that retains light intensity within a wider field, would be ideal for operating on the middle ear.

In addition, it is worth noting that there is a learning curve when using any new technique. This may be improved for otolaryngologists where we regularly use the endoscope during endoscopic sinus surgery for example.

### Limitations

The numbers for each operation in our prospective case series is low, leaving the study underpowered. However, this case series serves as a pilot study to open the debate of endoscopic ear surgery in the United Kingdom. To enhance our results, more cases would need to be examined in a similar prospective fashion. Only then could reliable conclusions be drawn from comparing endoscopic and open techniques.

Another limitation is the small number in each group, addressed above in regard of the power of the study, alongside the groups being somewhat heterogeneous particularly in the largest group of mastoid and tympanoplasty surgery. However we need to group the surgeries into a grading from simple to complex and these groupings certainly serve to follow this. The groupings, like the above point, serve to illustrate the possibilities of the endoscope rather than to compare the surgeries themselves. Likewise, including in our series, grommet insertion and petrosectomy demonstrates the utility of the

endoscope, despite the few numbers. This will be of value and interest to the readership to investigate further despite the small numbers.

The role of endoscopic ear surgery is yet to be properly established but as more otologists adopt this technique, its role will become much more clearly defined and may lead to widespread use based upon positive outcomes for surgery. As with every new surgical technique, a learning curve must first be overcome before reliable conclusions can be drawn about its use. Our series has shown the benefits of using this technique in limited cholesteatoma disease and in providing a good view during revision mastoid surgery with simple pathology.

## COMMENTS

### Background

Endoscope assisted ear surgery is increasingly common. However its role has not been properly elucidated. The authors investigate potential roles across a range of otological procedures.

### Research frontiers

Minimal access surgery from robotic to endoscopic approaches are being increasingly analysed.

### Innovations and breakthroughs

This study highlights the role of endoscope surgery in revision mastoid surgery alongside the more well-established role in stapedectomy. The endoscope allows excellent visualisation of the middle ear cleft and any cholesteatoma.

### Applications

The endoscope can assist in mastoid surgery, particularly in revision cases. It also has a role in stapedectomy and other middle ear surgery.

### Peer-review

Authors described their experience about endoscopic ear surgery. As mentioned by authors, this surgical procedure has already been described in case series numerically significant.

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