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An endoscopic hydro-mastoidectomy technique for cholesteatoma surgery

S Nishiike[1], T Imai[2], S Uetsuka[1], T Michiba[1], N Ashida[1], Y Otami[1], K Tsujimura[1], T Sudo[1] and M Saito[1]

[1]Department of Otorhinolaryngology – Head and Neck Surgery, Osaka Rosai Hospital, Sakai and [2]Department of Otorhinolaryngology – Head and Neck Surgery, Osaka University Graduate School of Medicine, Suita, Japan

Abstract

Objective. Endoscopic hydro-mastoidectomy, in which mastoidectomy is performed underwater, can be employed during transcanal endoscopic ear surgery for cholesteatoma removal. It was hypothesised that endoscopic hydro-mastoidectomy might take less time than endoscopic non-underwater mastoidectomy because the endoscope does not need to be removed for cleaning.

Methods. This study compared the mastoidectomy and total operative durations between the endoscopic hydro-mastoidectomy ($n = 25$) and endoscopic non-underwater drilling (control, $n = 8$) groups. Moreover, it compared the size of resected areas of the external auditory canal between the two groups.

Results. The mastoidectomy time of the endoscopic hydro-mastoidectomy group was significantly shorter than that of the control group ($p < 0.01$). The total operative time did not differ significantly between the endoscopic hydro-mastoidectomy and control groups ($p = 0.17$). The resected area was significantly larger in the endoscopic hydro-mastoidectomy group than in the control group ($p < 0.05$).

Conclusion. Endoscopic hydro-mastoidectomy enables more extensive bone resection within a shorter period.

Introduction

Recently, transcanal endoscopic ear surgery has been used to treat cholesteatoma, even in cases where the cholesteatoma extends beyond the attic and into the mastoid cavity.[1–4] In order to remove a cholesteatoma from the mastoid cavity via transcanal endoscopic ear surgery, it is necessary to perform transcanal endoscopic mastoidectomy.

During transcanal endoscopic ear surgery for cholesteatoma removal, we perform the mastoidectomy underwater.[4] We named this technique endoscopic hydro-mastoidectomy. In this method, bone dust and blood are washed out from the surgical field, improving the surgical view during the mastoidectomy. In addition, saline perfusion reduces the risk of heat damage compared with endoscopic non-underwater mastoidectomy.

In the era of the coronavirus disease 2019 (Covid-19) pandemic, we must reduce the risk of physicians being exposed to viruses.[5,6] High-speed drilling of the mastoid bone generates aerosols, which might cause the airborne transmission of viruses. Various countermeasures can be considered to reduce the risk of viral transmission. Personal protective equipment, a barrier drape such as the OtoTent[7] and room ventilation are useful to reduce the risk. It would also be preferable if the time needed for mastoidectomy were shorter.

During endoscopic hydro-mastoidectomy, the surgeon performs mastoidectomy without having to remove the endoscope for cleaning; therefore, we hypothesised that endoscopic hydro-mastoidectomy might require less time than the endoscopic non-underwater mastoidectomy procedure. This study compared the durations of the mastoidectomy procedure and the entire operation between patients who underwent endoscopic hydro-mastoidectomy and those who underwent endoscopic non-underwater mastoidectomy during transcanal endoscopic ear surgery. Moreover, it compared the size of the resected areas between the two groups.

Materials and methods

This study retrospectively collected clinical data from patients who: (1) underwent transcanal endoscopic ear surgery for cholesteatoma with mastoid extension between October 2012 and February 2018; (2) underwent mastoidectomy involving the use of a drill during transcanal endoscopic ear surgery; and (3) had the size of the resected area of their external auditory canal measured.

Cholesteatoma surgery was performed in 224 ears of 224 patients during the study period. The inclusion criteria of the study were patients who underwent primary transcanal endoscopic ear surgery with mastoid extension whose resected area was measured. We routinely measured the size of the resected area of the external auditory canal using a

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Author for correspondence:
Dr Suetaka Nishiike,
Department of Otorhinolaryngology – Head and Neck Surgery,
Osaka Rosai Hospital, 1179-3 Nagasonecho, Kita-ku, Sakai, Osaka 591-8025, Japan
E-mail: snishiike@osakah.johas.go.jp

paper template, as described in the 'Measurement of resected area' section.[3] The number of the patients decreased, but this did not significantly affect the results. The exclusion criteria were: patients whose resected area was not measured, those in whom most of the external auditory canal was destroyed by cholesteatoma, and patients in whom most of the external auditory canal was resected with curettes and chisels.

Thirty-three patients met the inclusion criteria. The patients were divided into two groups: an endoscopic hydro-mastoidectomy group ($n = 25$), in which the drill was used underwater, and a control group ($n = 8$), in which the drill was not used underwater and saline was intermittently applied with a syringe (Table 1).

At our department, all transcanal endoscopic ear surgery related mastoidectomies were initially performed via the endoscopic non-underwater procedure; they were not carried out underwater. Recently, transcanal endoscopic ear surgery has been performed with endoscopic hydro-mastoidectomy. As the patients in this study were treated in the transitional period from endoscopic non-underwater mastoidectomy to endoscopic hydro-mastoidectomy, the senior operator arbitrarily allocated the cases. For the reason described, there are more cases of the new endoscopic hydro-mastoidectomy technique than the transitional endoscopic non-underwater mastoidectomy technique.

Surgical procedure

In total, 11 surgeons performed 33 surgical procedures involving 33 patients. Their experience of middle-ear surgery ranged from 3 to 28 years. Each operation was performed by two surgeons: the senior operator (SN) and another surgeon.

The endoscopes (Storz, Tuttlingen, Germany) measured 2.7 mm in diameter and 18 cm in length, and had angles of 0°, 30° or 70°.[3,4] Illumination was generated by a light-emitting diode and transmitted to the endoscope via a fibre-optic light cable (Storz). High-resolution images were obtained with a full high-definition camera and viewed on a 26 inch (66 cm) monitor (Storz).

For the endoscopic hydro-mastoidectomy, a curved, round, coarse, diamond bur (diameter of 2.0 or 3.0 mm) was attached to an otological drill (Visao; Medtronic, Minneapolis, USA) (Figure 1a).[4] A lens-cleaning sheath (Endo-Scrub; Medtronic) was fitted to the endoscope. The bur and the tube of the sheath were connected to an integrated power console system (Medtronic). The surgeons regulated the infusion of saline solution by stepping on a footswitch linked to the power console with their right foot, and controlled the rotation of the drill by stepping on another footswitch with their left foot.

General anaesthesia was administered to all 33 patients. A circumferential incision from the 12 o'clock position to the 6 o'clock position was performed in the external auditory canal under endoscopy, and a tympanomeatal flap was elevated in all cases.[3,4] The scutum and the superior and/or posterior bone of the external auditory canal were resected via endoscopic hydro-mastoidectomy. The perfused saline flowed out of the external auditory canal and into the cavity of the concha, and an assistant collected it using suctioning (Figure 1). A 1–2 cm retroauricular skin incision was made to harvest a connective tissue graft for reconstructing the eardrum and an auricular cartilage graft for reconstructing the external auditory canal and/or the ossicular chain.

Generally, the scope of second-look surgery was decided during the initial surgical procedure, based on the characteristics and extent of the cholesteatoma.[3]

Table 1. Patients' characteristics

Parameter	EHM group	Control group
Time period	June 2015–February 2018	December 2014–September 2017
Patients (*n*)	25	8
Sex (*n*)		
– Males	13	5
– Females	12	3
Age (years)		
– Range	13–79	27–71
– Mean	52	48
Side of pathology (*n*)	_	_
– Right	9	4
– Left	16	4

EHM = endoscopic hydro-mastoidectomy

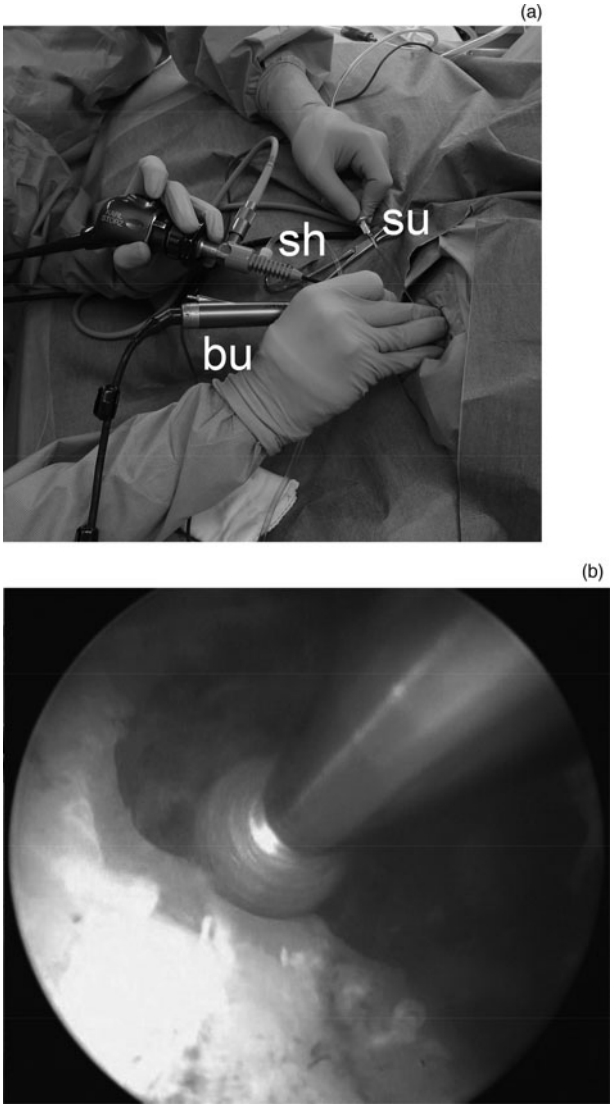

Fig. 1. Endoscopic hydro-mastoidectomy. (a) A curved bur with an otological drill (bu) and a rigid endoscope with a lens-cleaning sheath (sh) are inserted into the external auditory canal by a surgeon. An assistant collects the overflow from the external auditory canal using suctioning (su). (b) Endoscopic hydro-mastoidectomy provided a good surgical view by washing away bone dust and blood from the surgical area during drilling.

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The ossicular chain was reconstructed with pieces of auricular cartilage. The size of the resected area of the external auditory canal was measured using a paper template. Then, it was constructed with pieces of cartilage. The external auditory canal was packed with gelatine sponge followed by Merocel® packing.

Mastoidectomy time

The mastoidectomy time was calculated from the intraoperative video recording. It was defined as the time from the start of the resection procedure to the end of the resection procedure. The start of the resection procedure was defined as the timepoint on the video when the drill touched the bone. The end of the resection procedure was defined as the timepoint when the drill was removed from the bone, immediately before the cholesteatoma removal procedure was started. Single or multiple drilling procedures, the drill being moved in and out, and additional saline irrigation were considered to be a series of mastoidectomy procedures.

The endoscopic mastoidectomy is an on-demand mastoidectomy. After surgeons have performed the mastoidectomy to a certain extent, they stop the procedure once and see if there has been enough drilling for cholesteatoma removal. If it is still insufficient, they repeat the mastoidectomy. During non-underwater mastoidectomy, additional saline irrigation is added separately from the mastoidectomy. As it is cumbersome to measure the times of these procedures separately, they were counted as a series of mastoidectomy procedures.

Total operative time

The total operative time – that is, the duration of the entire operation – was obtained from the surgical records.

Measurement of resected area

During the cholesteatoma surgery performed as part of the transcanal endoscopic ear surgery, we reconstructed the resected external auditory canal with a cartilage graft.[3] Before reconstructing the external auditory canal, we first constructed a paper template of the resected part of the external auditory canal, and then, using the shape of the template as a reference, we trimmed the cartilage tissue.

After surgery, we used a scanner to capture an image of the paper template produced during the reconstruction of the resected external auditory canal and calculated the area of the template. We used the area of the template to determine the size of the resected area.[3]

Data analysis

The statistical analyses of the results were performed using SSPS Statistics version 25 for Windows (IBM, Chicago, Illinois, USA). Continuous variables are expressed as mean ± standard error values. The student's *t*-test was used to analyse continuous variables with normal distributions, while the Mann–Whitney U test was used to analyse continuous variables with non-normal distributions. Comparisons between groups were performed using Pearson's chi-square test.

Results

Regarding the repair of the ossicular chain, no reconstruction was performed in 12 cases, an intact chain was preserved in 9 cases, and reconstruction between the incus and stapes head was carried out in 4 cases in the endoscopic hydro-mastoidectomy group, whereas no reconstruction was performed in 4 cases, an intact chain was preserved in 1 case, and reconstruction between the incus and stapes head was carried out in 2 cases in the control group ($p = 0.263$).

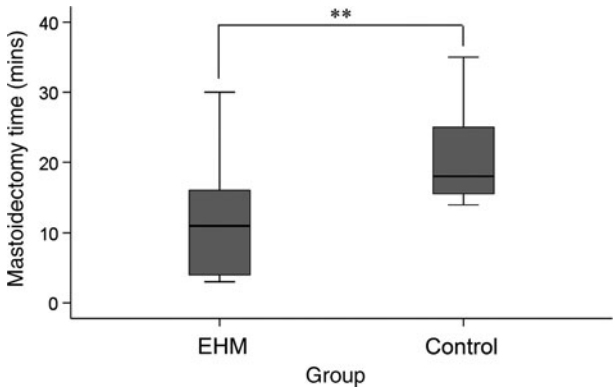

Fig. 2. Comparison of the mastoidectomy time between the endoscopic hydro-mastoidectomy (EHM) and control groups. **$p < 0.01$. mins = minutes

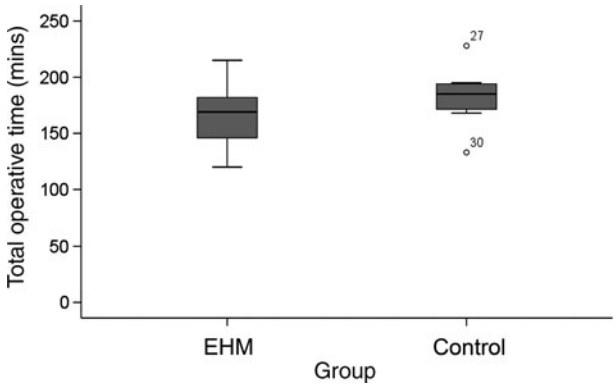

Fig. 3. Comparison of the total operative time between the endoscopic hydro-mastoidectomy (EHM) and control groups. mins = minutes

One patient in the endoscopic hydro-mastoidectomy group had concomitant inner-ear and facial nerve anomalies, and another patient in the endoscopic hydro-mastoidectomy group had a lateral semicircular canal fistula. Their total operative time exceeded 200 minutes.

The mean mastoidectomy time of the endoscopic hydro-mastoidectomy group (11.2 ± 1.4 minutes) was significantly shorter than that of the control group (20.8 ± 2.5 minutes) ($p < 0.01$; Figure 2). The mean total operative time did not differ significantly between the endoscopic hydro-mastoidectomy group (166.8 ± 5.7 minutes) and the control group (182.8 ± 9.5 minutes) ($p = 0.17$; Figure 3).

The mean size of the resected area of the external auditory canal was significantly larger in the endoscopic hydro-mastoidectomy group (50.6 ± 3.2 mm^2) than in the control group (36.4 ± 5.7 mm^2) ($p < 0.05$; Figure 4).

In both groups, there were no severe intra- or post-operative complications, such as meningitis, vertigo, cerebrospinal fluid leakage or facial palsy. Generally, healing occurred quickly.

Discussion

There are several problems with endoscopic transcanal mastoidectomy performed as part of transcanal endoscopic

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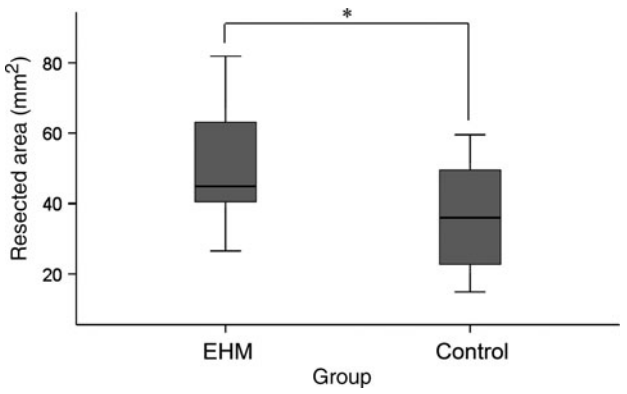

Fig. 4. Comparison of the size of the resected area between the endoscopic hydro-mastoidectomy (EHM) and control groups. *$p < 0.05$.

ear surgery.[3,4] In order to gain access to the narrow and deep surgical space, generally a shafted curved bur is attached to an otological drill system. However, the bur does not provide saline, and bone dust and blood can obscure the surgical field. There is also a possibility of undesired heat damage to the surrounding tissues. Our endoscopic hydro-mastoidectomy technique resolves these problems.[4] In endoscopic hydro-mastoidectomy, the operator performs the mastoidectomy underwater using a lens-cleaning system, which perfuses the surgical space with saline. This provides a clear surgical view by washing away bone dust and blood from the surgical area. In addition, the saline perfusion reduces the risk of heat damage.

In this study, endoscopic hydro-mastoidectomy took less time to perform than the endoscopic non-underwater mastoidectomy procedure. In addition, endoscopic hydro-mastoidectomy enabled a greater amount of bone to be resected within a shorter period. However, the total operative time was not significantly shorter in the endoscopic hydro-mastoidectomy group. The mastoidectomy time accounts for 3–10 per cent of the total operative time; therefore, reducing the mastoidectomy time might not make a significant difference to the total operative time.

Possible explanations for these findings are that the mastoidectomies in the endoscopic hydro-mastoidectomy group were easier than those in the control group, or that more advanced cases, which presumably would have involved longer cholesteatoma resection times, were allocated to the endoscopic hydro-mastoidectomy group. Actually, one of the cases in the endoscopic hydro-mastoidectomy group involved concomitant inner-ear and facial nerve anomalies, and another involved a lateral semicircular canal fistula.

The reason why a greater area of bone was removed in the endoscopic hydro-mastoidectomy group was as follows: during endoscopic mastoidectomy, the limit of mastoidectomy is observed as the edge of the external auditory canal, which is usually observed in the corner of the endoscopic view. Because bone dust and blood are washed out from the surgical field during endoscopic hydro-mastoidectomy, the limit is clearly visible, resulting in a greater area of bone being removed in this group.

As this study had a retrospective design, the allocation of patients to groups might have affected the abovementioned findings. Although the more advanced cases may have been allocated to the endoscopic hydro-mastoidectomy group, the mastoidectomy time for this group was shorter, indicating that endoscopic hydro-mastoidectomy contributed to reducing the mastoidectomy time. However, the skill of the physicians and/or the learning curve for the endoscopic hydro-mastoidectomy procedure might also have affected these results.

The Covid-19 pandemic has spread around the world. Drilling through the mastoid bone creates significant clouds of droplets and aerosols. If any of these clouds were to contain the virus, such drilling could risk infecting everyone in the operating theatre.[5,6] High-speed drilling of the mastoid bone might cause greater spread of particles than high-speed drilling of the nasal cavity because the walls of the nasal cavity probably prevent the spread of some material.[8] We reported previously that in transcanal endoscopic ear surgery, the area of the resected cholesteatoma is small, suggesting that transcanal endoscopic ear surgery generates a smaller amount of aerosol than microscopic surgery, and the external auditory canal might prevent the spread of aerosols.

The mastoidectomy time of endoscopic hydro-mastoidectomy was shorter than that of the endoscopic non-underwater procedure, suggesting that endoscopic hydro-mastoidectomy is safer than the endoscopic non-underwater drilling procedure in terms of aerosol production.

- Endoscopic hydro-mastoidectomy, in which a mastoidectomy is performed underwater, can be employed during transcanal endoscopic ear surgery for cholesteatoma removal
- This technique provides a clear surgical view by washing out bone dust and blood from the surgical area
- Endoscopic hydro-mastoidectomy enables more extensive bone resection within a shorter period than endoscopic non-underwater mastoidectomy

During endoscopic hydro-mastoidectomy, the mastoidectomy is performed underwater; thus, we consider that aerosols might not be produced, or even if they are, the amounts produced might be minimal. In addition, an assistant immediately collects the perfusion overflow from the external auditory canal using suctioning, reducing the risk of physicians' exposure to viruses. Thus, it is suggested that endoscopic hydro-mastoidectomy is a safe procedure and is recommended for cases requiring mastoidectomy in the Covid-19 era. In fact, we have conducted research on aerosol generation during endoscopic hydro-mastoidectomy compared with microscopic mastoidectomy. The results showed that endoscopic hydro-mastoidectomy produces less aerosol than microscopic surgery. We are now preparing to submit that paper for publication.

Conclusion

Endoscopic hydro-mastoidectomy took less time to perform than endoscopic non-underwater mastoidectomy. Endoscopic hydro-mastoidectomy enabled a larger amount of bone to be resected within a shorter period. The total operative time of the endoscopic hydro-mastoidectomy group was not different from that of the control group.

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Competing interests. None declared.

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