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# An endoscopic Ear Trainer for the low-resource setting

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## Main Article

Mr M P A Clark takes responsibility for the integrity of the content of the paper

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## Abstract

**Background.** Endoscopic ear surgery is a technique that is growing in popularity. It has potential advantages in the low-resource setting for teaching and training, for the relative ease of transporting and storing the surgical equipment and for telemedicine roles. There may also be advantages to the patient, with reduced post-operative pain, facilitating the ability to complete procedures as out-patients.

**Methods.** Our Ear Trainer has previously been validated for headlight and microscope otology skills, including foreign body removal and ventilation tube insertion, in both the high- and low-resource setting. This study aimed to assess the Ear Trainer for similar training and assessment of endoscopic ear surgery skills in the low-resource setting. The study was conducted in Uganda on ENT trainees.

**Results.** Despite a lack of prior experience with endoscopes, with limited practice time most participants showed improvements in: efficiency of instrument movement, steadiness of the camera view obtained, overall global rating of the task and performance time (faster task performance).

**Conclusion.** These results indicate that the Ear Trainer is a useful tool in the training and assessment of endoscopic ear surgery skills.

## Introduction

Endoscopic ear surgery is a technique that has grown in popularity in recent years. It has potential advantages over traditional microscopic techniques that may well transfer to the low-resource setting. For instance, the ability for pathology and the operative technique to be observed equally well by the surgeon and local staff was helpful in teaching and training in an ear camp in Nepal.[1] The relative ease of transporting and storing the equipment was noted, along with the ease with which the technique would lend itself towards telemedicine roles. Reduced post-operative pain and an increase in day-case surgery rates might also be advantages.

The technique arguably requires the acquisition of a novel set of technical skills. The non-dominant hand is required to hold the endoscope steadily to obtain the surgical view, whilst the dominant hand performs all the other tasks. When compared to traditional microscopic techniques, the surgeon has effectively gone from two hands to one. For many, this is the most challenging aspect of the technique and the reason that even established surgeons will often experience a learning curve when starting to use the new technique. This highlights the need for a simulator, on which the technique can be practised and skills can be assessed in a safe environment, outside of the operating theatre and prior to patient contact.

The Ear Trainer used in this study has been developed and evaluated over the last 10 years. It was first evaluated for headlight and microscope tasks, ranging from the removal of foreign bodies from the ear canal through to tasks requiring manipulative skills in the middle ear. Both face and construct validity was demonstrated;[2] the Ear Trainer had realistic dimensions and layout, and as such was an accurate representation of the real anatomy that a surgeon or other healthcare professional would encounter. When tasks were performed and assessed on the Ear Trainer, one was able to differentiate between novices and experts. This initial assessment of the Ear Trainer was made on participants in the UK and the findings were then confirmed in the low-resource setting.[3]

This study aimed to determine whether the Ear Trainer could be used in a low-resource setting for the training and assessment of endoscopic ear surgery technical skills in surgical trainees and practising surgeons.

## Materials and methods

Ethics board approval for this research project was acquired from Mbarara University of Science and Technology in Uganda. The study was conducted on 18 ENT trainees attending the annual temporal bone dissection course at Mbarara University of Science and

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Technology, Uganda, in January 2017. Participants came from a range of countries, namely Uganda, Kenya, Tanzania, the Congo, Somalia and Ethiopia. Informed consent was obtained. It was explained to the participants that enrolment in the study was voluntary and that they could withdraw at any time from participating in the study, with no effect on future academic evaluations during their training. Participants were not given any compensation or remuneration for participation in this study.

Demographic data of the participants were collected, along with their previous experience with simulators, endoscopes and the assessed tasks (foreign body removal, ventilation tube insertion), performed by any technique, throughout their career.

### Equipment

The Telepack endoscopic video unit (TP 100 – Tele Pack X LED; Karl Storz, Tuttlingen, Germany), with keyboard, a Telecam one-chip camera head (Karl Storz), and a 3 mm diameter, 14 cm length Hopkins telescope, were used with the Ear Trainer for study purposes. This facilitated video recording of the procedures performed by the participants. The limited ear instruments included a speculum, myringotomy blade, blunt right-angled hook and straight microneedle.

### Assessments

The surgical performance of each participant was assessed before and after self-directed practice on the Ear Trainer.

Participants initially received an introduction to the Ear Trainer; this consisted of watching a demonstration and an instructional video (Appendix 1, available on *The Journal of Laryngology & Otology* website), with staff available to answer questions. This was followed by limited free time to become familiar with the instrument set-up prior to initial assessment.

After the initial assessment, participants were given up to 5 days to practise the tasks performed at the initial encounter, with the Ear Trainer made available early each morning and in free time during the temporal bone course they were attending. Time dedicated to practice was recorded in a logbook. Participants were then re-evaluated. Senior staff were available to offer guidance if requested, but this was not formally offered.

The assessment tasks were video recorded through the endoscope camera. The participants could not be identified from the content of the video recordings. The files were anonymously saved; they were encoded so that the evaluator was blinded to the participant. All video analysis was performed by one author (MPAC), a fellowship-trained senior otologist experienced in endoscopic ear surgery. Assessment of surgical performance utilised a validated measurement tool: a global rating scale and task-specific checklist. The task-specific checklist was adapted according to the limits of this low-fidelity simulator (Appendix 2).

Two assessable tasks with a five-point Likert rating scale were used: (1) foreign body removal from the external auditory canal (a bead with a central lumen, positioned such that the lumen could not be seen upon initial inspection); and (2) myringotomy and ventilation tube insertion (with cigarette paper acting as the tympanic membrane, as this required a delicate touch to avoid inadvertent damage).

## Results

### Participants' experience

A total of 18 participants were studied. Over 80 per cent had two years' experience working in ENT, with the other participants having either one or three years' experience. None of the participants had prior experience of using an endoscope in the ear. Seven had no prior experience of using a rigid endoscope in any situation, with the same number having less than a total of 5 hours of such experience, largely through having attended a functional endoscopic sinus surgery course. Only four participants had more than 6 hours of experience.

All participants had experience at removing foreign bodies from the ear: over 60 per cent had removed more than 20 in their practice, and the remainder had removed more than 50. This had usually been performed with a headlight. Over half had never inserted a ventilation tube before, and only two had performed this procedure more than six times.

On average, each candidate practised for 2 hours and 45 minutes on the Ear Trainer (range, 45 minutes to 6 hours).

### Foreign body removal video assessment results

None of the participants damaged the tympanic membrane, implying that, with a bead placed midway in the external auditory canal, none had gross issues with depth perception using the endoscope. Half of the participants achieved the task by passing the hook only once or twice into the external auditory canal, both before and after practice. All other participants showed a reduction in the number of times the hook was passed after practice, except for one. Over 80 per cent showed an improved rating in steadiness of view after practice (as judged on a five-point scale, where a stable, un-wobbling, central image was the goal). The overall global rating of the task increased with practice in half of the participants, remaining the same for the rest. Nearly 90 per cent of participants got quicker at the task after practice.

### Ventilation tube insertion video assessment results

Over 80 per cent of participants showed a reduction in the number of times the myringotome was passed into the external auditory canal after practice; those that showed no improvement could not do so, as they only passed it once the first time around. No one got worse. Over half of the participants improved the position of their myringotomy incision with practice; one-third stayed the same, having it correct before practice and after. Three participants showed slightly worse positioning. Over 60 per cent of participants showed a reduction in the number of attempts needed to successfully insert the ventilation tube; four participants had the same number of attempts after practice, and three took one more attempt after practice than before. Before practice, over 80 per cent of participants had successfully placed a ventilation tube. All those that failed before practice achieved the task successfully after practice. Over 80 per cent showed an improved rating in steadiness of view after practice. The overall global rating of the task increased after practice for over 80 per cent of participants, with no decreases. Nearly 90 per cent of participants got quicker at the task after practice.

## Discussion

The Ear Trainer is a useful tool in the training and assessment of endoscopic ear surgery skills. In a group of ENT trainees

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**Fig. 1.** Self-directed practice.

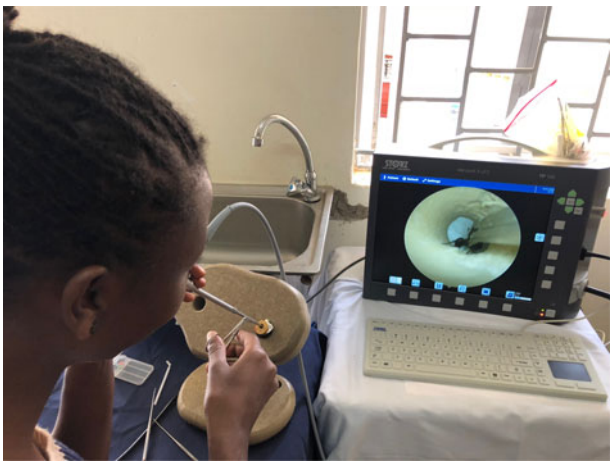


**Fig. 2.** Removal of a live termite.

and practising surgeons with limited experience overall, very limited experience using rigid endoscopes and no experience using them in the ear, participants displayed a rapid attainment of endoscopic ear surgery skills whilst performing simple, routine ear procedures following limited practice.

Depth perception in endoscopic ear surgery has been raised as a potential challenge (compared to a microscopic view), yet no participants caused inadvertent damage to the tympanic membrane during foreign body removal. Steadiness of view prevents a moving, wobbly image that makes the task more challenging to perform. In both tasks assessed, the overall steadiness of view improved by over 80 per cent. Efficiency of movement, assessed by counting the number of times instruments were passed, and the number of attempts at foreign body removal or ventilation tube placement, showed improvement with practice. Even before practice, all participants could successfully complete foreign body removal; however, practice made them more efficient. After practice, all were successfully placing ventilation tubes. The time taken to perform the tasks decreased for both tasks in 90 per cent of participants.

Hearing loss is a common debilitating condition worldwide. Chronic suppurative otitis media affects many millions of people worldwide, whilst wax occlusion and foreign bodies in the ear form frequent practical problems that can be more simply resolved.[4] The Ear Trainer was designed with the intention that it be used for training and assessment in the low-resource setting. The provision of healthcare services in African countries, for example, is a difficult and complex problem. One obstacle is the challenge of providing effective medical education. With far greater time and resource constraints as compared to high-resource settings, learners are challenged by the need for a steep learning curve, and they may be burdened with greater responsibility following less practice than that given to trainees in high-income countries.

One avenue of medical education that may be underutilised is simulation.[5] Simulators are well suited to provide error-based learning without putting patients or students at risk.[6] Medical education outside a real operating theatre allows for objective performance measures and standardisation of the learning process.[7] Skill acquisition can be tailored to individuals, and skills can be practised repeatedly, accounting for different learning speeds.[8] Retention and accuracy have been shown to increase with the use of simulators. Simulation with direct practice has also been shown to be superior to traditional methods for acquiring a new skill.[9] Simulation can aid the development of skills in otolaryngology prior to their application in a clinical environment.[10] A virtual, high-technology simulator would be unrealistic in the low-resource setting. A low-fidelity simulator should be cost effective, avoid the need for maintenance and disposable components, and be easily portable. The Ear Trainer fulfils this role.

Endoscopes have been used in ear surgery for approximately forty years, and acceptance of these techniques has grown recently. In a study of Canadian otolaryngologists, 70 per cent reported using an endoscope in their practice.[11] Endoscopic ear surgery has been shown to: improve the visual exposure of hidden structures and deep recesses, achieve a minimally invasive operation with greater healthy tissue preservation, and decrease residual disease and recurrence rates when compared to surgical procedures performed using the microscope alone.[12] Consequently, the acquisition of these skills should be highly beneficial in the management of ear disease. There may also be advantages in the teaching of all operating theatre staff, in that the operative image shown on a screen during endoscopic ear surgery can be viewed by the surgeon, trainees and scrub staff alike.

- Endoscopic ear surgery techniques are growing in popularity and application
- Endoscopic ear surgery has potential advantages when used in low-resource settings
- Simulation provides a recognised training platform to acquire surgical skills
- This article assesses an Ear Trainer previously validated for headlight and microscope ear surgery techniques in low-resource settings, and applies it to endoscopic ear surgery training
- The Ear Trainer can successfully be used to train and assess endoscopic ear surgery skills in the low-resource setting

The study participants were clearly interested in endoscopic ear surgery and in being up to date with what they considered to be the latest technology and techniques. All those approached consented to take part in the study. They were aware of endoscopic ear surgical procedures' growing place in otology, yet had no prior exposure to it. It was heartening to observe that the Ear Trainer never sat idle during the study period (Figure 1). Participants were observed undertaking

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ever-increasingly complex tasks: a variety of foreign bodies were introduced and retrieved, including a live termite (Figure 2); the cigarette paper tympanic membrane was incised and folded forward, as in a tympanoplasty procedure; central perforations were created and push-though grafts were placed after filling the middle-ear chamber with packing material.

### *Limitations*

Whilst the results lack statistical significance, with a small sample size, the overall trends recorded are compelling. It is possible that the tasks used were too simple, leading to a ceiling effect. Further analysis with more complex tasks would be helpful. The time that each individual practised was noted, but at times in retrospect. The data were not considered reliable enough to draw inferences regarding the time practised and potential improvements in endoscopic ear surgery skill acquisition.

## Conclusion

The Ear Trainer is equally as useful for training in lower- and higher-resource settings. This has been demonstrated for microscopic skills: it has been regularly used at the clinical skills stations of the British Academic Conference in Otolaryngology, at similar sessions at the Student and Foundation Doctors in Otolaryngology conferences, and as part of skill stations and objective structured clinical examinations at what have now become compulsory 'boot camps' for new specialist trainees in ENT in the UK. It is also now demonstrated to be effective for endoscopic ear surgery training in low-resource settings.

**Competing interests.** None declared

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## Appendix 1. Supplementary material of Ear Trainer instructional video

This video is available online at *The Journal of Laryngology & Otology* website, at https://doi.org/10.1017/S0022215119001257.

## Appendix 2. Task-specific score sheet

Foreign body removal

| | | | | | |
|---|---|---|---|---|---|
| Number of times hook is passed into EAC: | | | | | |
| State of TM at end of task | Normal | 2 | Slight damage | 4 | Extensive damage |
| Steadiness of view | Unstable, EAC often out of view | 2 | 3 | 4 | Steady, EAC central, always in view |
| Overall global rating of task completion | Unable to perform | 2 | 3 | 4 | Performs easily with good flow |
| Time taken to complete task: | | | | | |

Ventilation tube insertion

| | | | | | |
|---|---|---|---|---|---|
| Number of times myringotomy knife is passed into EAC: | | | | | |
| Successful siting of myringotomy incision | Correct ant-inf, tidy incision | 2 | 3 | 4 | Grossly incorrect, TM damage |
| Number of attempts to place VT | 1 | 2 | 3 | 4 | Failed |
| Successful placement of VT in incision? | No | | | | Yes |
| Steadiness of view | Unstable, EAC, often out of view | 2 | 3 | 4 | Steady, EAC central, always in view |
| Overall global rating of task completion | Unable to perform | 2 | 3 | 4 | Performs easily with good flow |
| Time taken to complete task: | | | | | |

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