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Using a 4K three-dimensional exoscope system (Vitom 3D) for mastoid surgery during the coronavirus disease 2019 pandemic

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Abstract

Objective. Microscopic surgery is currently considered the 'gold standard' for middle-ear, mastoid and lateral skull base surgery. The coronavirus disease 2019 pandemic has made microscopic surgery more challenging to perform. This work aimed to demonstrate the feasibility of the Vitom 3D system, which integrates a high-definition (4K) view and three-dimensional technology for ear surgery, within the context of the pandemic.

Method. Combined approach tympanoplasty and ossiculoplasty were performed for cholesteatoma using the Vitom 3D system exclusively.

Results. Surgery was performed successfully. The patient made a good recovery, with no evidence of residual disease at follow up. The compact system has excellent depth of field, magnification and colour. It enables ergonomic work, improved work flow, and is ideal for teaching and training.

Conclusion. The Vitom 3D system is considered a revolutionary alternative to microscope-assisted surgery, particularly in light of coronavirus disease 2019. It allows delivery of safe otological surgery, which may aid in continuing elective surgery.

Introduction

Microscopic surgery is currently considered the 'gold standard' for middle-ear, mastoid and lateral skull base surgery. Indeed, the microscope has evolved significantly into a highly precise device capable of three-dimensional (3D) imaging. Optimal visualisation with high resolution is important to prevent trauma to the fine anatomical structures in the ear. It enables the use of smaller instruments to perform more precise surgical manipulations.[1]

There are, however, several limitations associated with operating microscopes. They are bulky, with limited manoeuvrability, and can be awkward to manipulate whilst maintaining sterility. Furthermore, microsurgeons may well be particularly susceptible to musculoskeletal symptoms as a result of long periods of neck flexion and static posture. Babar-Craig *et al.* reported a 72 per cent prevalence, amongst UK otolaryngology surgeons, of neck and back pain, with otologists primarily affected. These findings were attributed to the frequency of microscope use.[2]

Since the development of the Hopkins rod in the 1960s, endoscopes have increasingly been implemented in otology practice, culminating in the emergence of transcanal endoscopic surgery, now considered a viable option. The endoscopic approach is minimally invasive, whilst enabling greater visibility of unexposed areas within the middle ear (e.g. the facial recess and sinus tympani), as it has a wider field of vision. Disadvantages include that surgery must be performed single-handed, which is particularly problematic if good haemostasis has not been achieved. High-resolution images can be obtained; however, mist often accumulates over the tip of the endoscope.[3]

More recent advancements have led to the development of the video-assisted telescope operating monitor ('VITOM'), or exoscope, which integrates a high-definition (4K) view and 3D technology. It has been reported that the 3D exoscope system is a viable alternative to the microscope in neurosurgery and ophthalmology.[4]

The coronavirus disease 2019 (Covid-19) pandemic has made operating using a microscope more uncomfortable and challenging for otolaryngologists given the additional burden of personal protective equipment (PPE). Although transmission of the novel severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) can occur via multiple routes, the highest risk is associated with aerosol-generating procedures (AGPs), which are prevalent in otolaryngology. Indeed, studies demonstrate that mastoidectomy with a high-speed drill is aerosol-generating.[5] Public Health England recommend enhanced PPE (filtering facepiece code 3 (FFP3) mask, face shield or visor, gown, and gloves) during AGPs. ENT UK have published a second microscope drape technique found to reduce aerosolisation, but limitations include its cumbersomeness. This may be mitigated somewhat by an exoscope system.

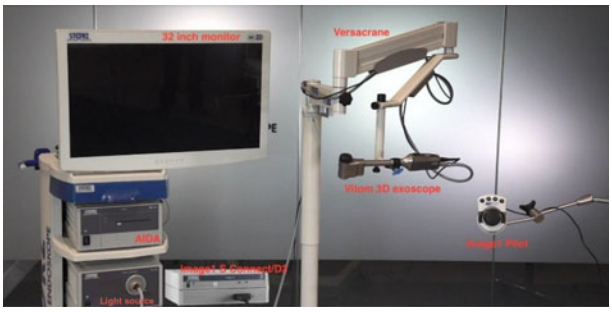

Fig. 1. Components of the Vitom 3D system (Karl Storz), with labels. AIDA = advanced image and data acquisition device

We describe the first UK case of combined approach tympanoplasty and ossiculoplasty for cholesteatoma using the Vitom 3D system exclusively, in the context of the coronavirus pandemic.

Technical description

Equipment

The Vitom® 3D system from Karl Storz comprises a 3D exoscope, a holding arm (Versacrane™), a separate controller (Image1 Pilot), a tower containing a light source (Power Led 300), a camera controller (Image1 S Connect), a link module (Image1 S D3), an advanced image and data acquisition device, and a 32-inch, 4K 3D monitor (Figure 1).

Operating theatre set-up

The procedure was carried out with the patient in the supine position with their head on a head ring, with the head rotated 30–45 degrees to the left. A facial nerve monitor was attached. The surgeon was positioned to the right of the patient's head, the scrub nurse at the head and the anaesthetist at the foot of the bed.

The exoscope, supported by the mobile autostatic arm, was positioned exterior to the body, within a sterile drape, at varying distances over the surgical field. It projects to a 3D monitor, positioned at eye level directly opposite the operating surgeon. The surgeon wore 3D polarisation glasses to observe the 3D stereoscopic images, thus enabling 3D exoscopic surgery. The joystick-like controller (Image1 Pilot) was mounted on the operating table proximal to the surgeon (Figure 2). Image orientation, quality, light intensity, magnification and focus were controlled with this. Setting up the exoscope took approximately 10 minutes, comparable to our experience with the microscope.

Procedure

Local anaesthetic was infiltrated and the ear suctioned. A post-auricular incision was made and an anterior periosteal flap elevated. A tympanomeatal flap was elevated. Cortical mastoidectomy and posterior tympanotomy were performed. Disease was removed in its entirety and sent for histology. An island conchal cymba graft with perichondrium was used to reconstruct the attic. A total ossicular replacement prosthesis was sized and placed on stapes suprastructure with the cartilage above. Bone pâté was used for the attic and external auditory canal. Betnovate and neomycin ointment was applied and a pack placed. Skin was closed with size 3–0 Vicryl and 4–0 Monocryl sutures.

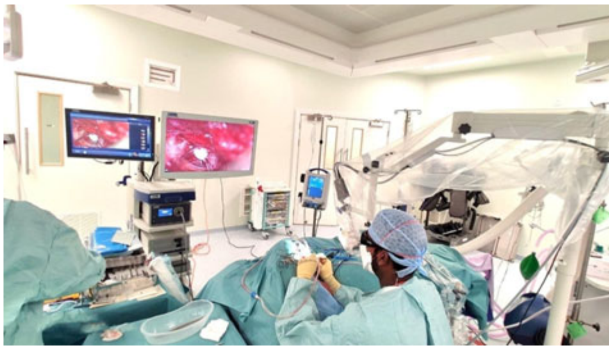

Fig. 2. Surgical positioning for three-dimensional exoscopic, right-sided, combined approach tympanoplasty and ossiculoplasty for cholesteatoma.

The total operative time was 3 hours; this is similar to the operating surgeon's experience with the microscope when considering the extent of disease. Additionally, the operating surgeon attended a training session on the Vitom 3D system using temporal bones, prior to performing the procedure, to gain some experience and confidence.

Results

Combined approach tympanoplasty and ossiculoplasty for cholesteatoma were performed successfully using the Vitom 3D system. The post-operative course was uncomplicated. The patient was discharged at day 1 post-operatively because of co-morbidities. At the two-week follow up, the graft was taking well and there was no evidence of any remnant disease.

Discussion

This case demonstrates the feasibility of the Vitom 3D system for ear surgery. The numerous advantages of this system, particularly in the context of the coronavirus pandemic, render it a viable option for enabling elective otological surgery to resume, whilst conferring confidence and comfort to the surgeon and trainees alike.

Ergonomically, the Vitom 3D system is superior to the microscope, as it allows otologists to operate in the head-up position, which is considered physiologically more comfortable. The operating surgeon was in agreement with this in our case. In 2019, Minoda and Miwa reported a seamless transition between exoscopic and endoscopic surgery, as both are performed in a head-up position.[4] The Vitom 3D system has been proposed as a complement to endoscopic approaches. The exoscope is small, light and compact. It does not dominate the surgical field, and it is easy to position precisely, whilst maintaining sterility. In line with other surgeons who have previously trialled the video-assisted telescope operating monitor, our surgeon found setting up easy and intuitive.[6]

The image quality derived from the Vitom 3D system is comparable to that of the microscope. Older models have been criticised for the lack of stereopsis, however. With advancements, the exoscope is capable of eight times the depth of field compared to the microscope, and nearly twice the magnification.[7] Neurosurgeons believe it to have greater potential for visualising around corners versus the microscope.[8] With 3D vision, the surgeon gets immediate feedback that is precise and safe, whilst operating at a minimal distance from the surgical field.

The 3D glasses enable visualisation of 3D real-time images and protect the eyes from aerosols. Exoscope use negates frequent misting of the eyepieces and blurred vision; these issues impede operations performed using a microscope whilst wearing enhanced PPE. There is a significant reduction in the clarity of verbal communication between operating theatre staff when wearing face masks and hoods. With the video-assisted telescope operating monitor, all team members can easily follow the surgical procedure on the 3D monitor; this engages the staff in the procedure, improving workflow.

A primary challenge in teaching otological surgery using the microscope is the variable views from the binocular lens, the microscope side-port and the two-dimensional images projected onto the monitors. It is often only the operating surgeon who is able to appreciate the quality of the surgical field images. Trainees and observers lack depth perception in their view, and frequently there is differing clarity and brightness.[9] With the Vitom 3D system, the supervisor, trainees and operating theatre staff share an identical image. It is therefore a useful training tool. It may increase confidence as supervisors guide trainees, in real time, through steps of the operation, also enhancing safety. The 3D exoscope can record images and videos digitally, which can be shared for teaching sessions or courses. Temporal bone surgery is technically challenging and high-risk. Knowledge of the anatomy is indispensable and the Vitom 3D system can demonstrate this. De Virgilio *et al.* recently demonstrated the feasibility of Vitom 3D system based microsurgery training in a cohort of medical students.[10] Currently, the training benefits are particularly pertinent, as the coronavirus pandemic has had an unprecedented impact on surgical practice and training, and the future remains uncertain.

Because of cost, it is often difficult to procure up-to-date technologies in the National Health Service. The cost of the exoscopic platform (approximately £120 000) is comparable to the operating microscope and about ten times lower than the da Vinci® robotic surgical system. The 3D exoscope is versatile and potentially cost-effective, with applications in several surgical disciplines as well as the subspecialties of ENT surgery. It has been trialled for transoral oropharyngectomy and mastoid surgery, with promising initial feedback.[6]

Despite the aforementioned advantages, there are drawbacks of the exoscope. We found that the light was too bright down the external auditory canal through a speculum. In order to overcome this, the brightness of the light source was reduced, improving the quality of the image projected. Crude manual adjustments are required to reposition the scope; some surgeons report that the main control button is highly sensitive, which can cause difficulties in achieving the desired image adjustments. With frequent readjustments, the fluidity of the operation may be impacted.[7] Finally, the exoscope is compatible with the carbon dioxide laser; work is currently underway to improve interference associated with the green light of the potassium-titanyl-phosphate laser.

- Microscopic surgery is currently considered the 'gold standard' for middle-ear, mastoid and lateral skull base surgery
- The coronavirus disease 2019 (Covid-19) pandemic has made microscopic surgery more challenging to perform
- The Vitom 3D system allows a revolutionary alternative to microscope-assisted surgery, particularly in light of Covid-19

Conclusion

We believe the Vitom 3D system has distinct advantages, particularly in the context of the coronavirus pandemic, that make it a revolutionary alternative to microscope-assisted surgery for middle-ear, mastoid and lateral skull base operations.

Competing interests. None declared

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