The challenge of performing mastoidectomy using the operating microscope with COVID-19 personal protective equipment (PPE)

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Abstract

Objective: As an aerosol generating procedure (AGP), mastoidectomy in the COVID-19 era requires healthcare workers to wear personal protective equipment (PPE); UK guidelines recommend an FFP-3 mask and full-face visor. The aim of this study was to examine the effect of wearing PPE on the view achieved using the operating microscope. Methods: Using the operating microscope, ENT surgeons were asked to view a target so that it filled the entire operating field. The distance between the surgeon's eye and the microscope was recorded and subsequently measured with the surgeon wearing a range of PPE. In each PPE condition, surgeons scored the visibility of the target; scores were used to calculate the visible area of the surgical field. Results: Eleven surgeons took part, generating 51 eye-microscope and target-view scores. Distance from the eye to the microscope inversely correlated with diameter and area visible (Pearson correlation coefficient -0.983 and -0.894 respectively; $p<0.001$). Use of PPE increased the eye-microscope distance and reduced the surgical view. The median area visible wearing the FFP-3 mask and full-face visor was 4% (range 4 – 16%). Conclusion: PPE consisting of an FFP-3 mask and full-face visor is incompatible with use of the operating microscope, with less than 10% of the surgical field visible in most cases. Solutions that allow for concurrent use of the operating microscope and drill during mastoid surgery are urgently required so that surgeons are adequately protected from COVID-19 transmission.

Introduction

The SARS-CoV-2 / COVID-19 pandemic presents a number of previously unconsidered challenges for otological surgeons. Not least of these is how to perform aerosol generating mastoid surgery whilst minimising the risk of coronavirus transmission to the surgeon and theatre staff.

Mastoid surgery involves the use of high-speed drills within the mastoid air-cell system and as such is considered to be an aerosol generating procedure (AGP). The mastoid air-cells are lined with respiratory mucosa, continuous with the middle ear and nasopharynx via the Eustachian tube. The middle ear has been demonstrated to harbour pathogens including coronavirus[1]. The plume of potentially virus-containing aerosol generated by the high-speed drill poses a risk to the surgeon and operating theatre staff[2,3].

The UK government and specialist healthcare bodies currently recommend the use of personal protective equipment (PPE) for all surgery involving the use of high-speed drills[4,5]. This includes, as a minimum, fluid-resistant long-sleeved gowns, gloves, filtering facepiece (FFP-3 rated) respirator masks and eye/face protection. Whilst some degree of eye protection is conferred by surgical masks with integrated visors or by polycarbonate safety spectacles, current Public Health England (PHE) guidance specifically recommends the use of a full-face shield or visor for AGPs[4].

The challenge specific to the otological surgeon is the need to use an operating microscope when performing mastoidectomy. The full-face shield recommended for AGPs introduces a physical barrier, increasing the

distance between the surgeon's eyes and the operating microscope eyepieces. This may reduce the microscopic view of the surgical field, making surgery more difficult and potentially increasing the risk of surgical error.

In order to quantify this concern, we undertook a study designed to examine the effect of different forms of PPE on the operator-microscope distance and the effect this has on the surgical view obtained by the operator.

Method

This study utilised a Zeiss OPMI Vario S88 microscope, used in operating theatres throughout our institution (Carl Zeiss AG, Jena, Germany). The microscope was set up in the normal position for ear surgery and focused on a scaled target used in competitive world archery (Figure 1). This target has 10, equally spaced concentric circles, with 5 coloured zones. The microscope was set with a focal length of 300mm and the position of the microscope and zoom were adjusted to ensure that the target filled the entirety of the view afforded by the microscope (with the outer edge of the target matching the perimeter of the surgical view).

ENT surgeons were asked to position themselves for using the microscope, with a comfortable posture that would allow them to operate for an extended period (Figure 1). Each surgeon adjusted the inter-pupillary distance, height of the chair and microscope angle to ensure an optimal and comfortable view. The surgeons were asked to state how much of the target they could see in their peripheral vision, whilst staring at the centre point with their head in the usual neutral position. A score of 1 (outer white ring) represented a full view of the target, with progressively higher scores indicating a more restricted view that allowed for visualisation of a central portion of the target only. The percentage of target visible was calculated from these scores (diameter and area). The distance between the most anterior aspect of the surgeon's cornea and the edge of the microscope eyepiece was measured to the nearest millimetre, with care taken to avoid parallax error. This was done with the aid of a ruler secured to the side of the microscope (Figure 1). This process was then repeated with the surgeon wearing an FFP-3 mask and various forms of eye/face protection. Scores for view (outer-most complete ring visible) and eye-microscope distance were recorded for each PPE condition. The PPE trialled is outlined in Table 1 and Figure 2. For the purposes of this study, combinations of PPE were categorised from A to E, with A representing no PPE and E representing a full face visor. Surgeons who wear prescription glasses for surgery continued to wear their normal glasses, with additional PPE.

Results

Eleven ENT surgeons took part in the study. All were comfortable and experienced in using the operating microscope. Grade of surgeon ranged from ST3 registrar to senior consultant. Inter-pupillary distance ranged from 58mm to 75mm (median 64mm). Four of the 11 surgeons wore prescription glasses for operating, and as such could not be tested at PPE level B (FFP3 mask with no eye protection or glasses). A total of 51 measures of eye-microscope distance and target scores were collected covering all of the defined PPE categories (A to E).

Eye-microscope distance and target visibility.

The diameter and area of the visible target was calculated for each score and expressed as a percentage of the overall target. Results are demonstrated in Figure 3. Both diameter and area of the target correlated highly to the eye-microscope distance (Pearson correlation coefficient -0.983 and -0.894 respectively; $p<0.001$).

Effect of PPE on eye-microscope distance and target visibility

The median and range of eye-microscope measurements and target visibility calculations are shown in Table 2. The normal eye-microscope working distance, without the use of PPE (defined as level A), was between 11 and 18 mm (median 13mm). All surgeons were able to achieve a full (100%) view of the surgical field/target when not wearing any PPE (PPE level A). The use of an FFP-3 mask, with progressively bulky eye protection, increased the working distance with a resultant reduction in surgical view. The use of a full-face visor (PPE level E) reduced the area of the surgical view to a median of 4% (range 4 – 16%).

Discussion

This workplace study, involving practicing ENT surgeons, supports our concern that use of PPE reduces the view of the operating microscopic field available to the surgeon. Data analysis shows an inverse correlation between eye-microscope distance and target view.

The use of FFP-3 masks with the surgeon's own prescription glasses or slimline polycarbonate safety glasses (PPE level C) or over-glasses (PPE level D) produced a highly variable effect on view. This depended on fit of the PPE to the surgeon's face and resultant increase in eye-microscope distance. It should be noted that neither of these PPE levels provides the droplet protection recommended by current UK COVID-19 PPE guidelines[4].

The use of a full-face visor satisfies the level of PPE recommended for AGPs such as mastoid drilling. However, the reduction in surgical view is severe, with less than 10% of the microscope view visible in most cases. This makes recommended AGP PPE incompatible with the use of the operating microscope at this time.

This study highlights the challenges facing otological surgeons in the era of COVID-19. Urgent action is needed to address this challenge, with the aim of providing a safe operating environment for otological surgeons whilst preserving the ability to deliver effective, safe surgical care. Variations in surgical technique may obviate the need for simultaneous use of high-speed mastoid drilling and the operating microscope (such as the use of endoscopic ear surgery, surgical loupes or 3-D exoscopes). A number of alternative approaches, such as use of the "double-drape" system have also been suggested[2,6,7]. Bespoke surgical shields that attach to the microscope may afford some protection to the surgeon. Any modification or devices, designed to shield the otological surgeon's eyes and face from the aerosol generated by mastoid drilling, must fulfil strict PPE requirements (preventing droplet contact with the surgeon's eyes) whilst also allowing relatively unhindered access to the microscope eyepieces.

Based on the data obtained in this study, a working distance of around 20mm is likely to preserve at least a 70% view of the microscopic field, with an ideal working distance of 15mm or less preserving almost complete view of the surgical field (90% or more). Individual surgeons may need to judge their level of confidence in performing safe otological surgery with even minor reductions in view. Data obtained in this study may be specific to the microscope and PPE used in our institute and should be interpreted with this in mind.

Conclusion

This study demonstrates that PPE including an FFP-3 mask and full-face visor is incompatible with use of the operating microscope; the view of the surgical field was reduced to below 10% in most cases. Urgent consideration needs to be given to solutions that allow for concurrent use of the operating microscope and drill that are required for mastoid surgery, whilst affording the surgeon adequate protection from viral transmission in the COVID-19 era.

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Figure legends

Figure 1 – Target and study set up, demonstrating surgeon's position and eye-microscope measurement.

Table 1 – Levels of PPE tested (including modifications for prescription spectacle wearers)

Figure 2 – PPE conditions tested in surgeons with and without prescription glasses. Pictures 1-5 show surgeon without prescription glasses. Pictures 6-9 show surgeon with prescription glasses. Value in parentheses corresponds to level of PPE defined in Table 1.

Figure 3 – scatter plots of results of eye-microscope measurements versus calculations of diameter (3a) and area (3b) of target visible.

Table 2 – Effect of different PPE on eye-microscope distance and target visibility.

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