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Virtual reality meets ENT: a low-cost high-fidelity teaching course for peritonsillar abscess drainage

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Main Article

Lavandan Jegatheeswaran takes responsibility for the integrity of the content of the paper

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Abstract

Background. This pilot randomised controlled trial evaluated virtual reality as a supplementary teaching tool for peritonsillar abscess drainage among third year medical students.
Methods. Twenty students were randomised to virtual reality-based or traditional teaching, each receiving a 90-minute session followed by an objective structured clinical examination and pre-/post-session knowledge tests. The virtual reality group used HTC Vive Focus 3 headsets with Virti, 3D Organon and EXR platforms.
Results. The virtual reality group scored higher in objective structured clinical examinations (26.9 vs. 21.5; $p = 0.005$) and reported greater procedural confidence ($p = 0.008$) and engagement ($p = 0.003$). Both groups improved knowledge ($p < 0.001$) without significant difference post-session ($p = 0.701$). Virtual reality was rated highly for effectiveness (9.6/10) and immersion (8.5/10) and had minimal cybersickness (1.8/10).
Conclusion. Virtual reality significantly enhances procedural confidence and performance. Its immersive format supports integration into surgical education, warranting further validation in larger studies.

Introduction

A peritonsillar abscess (quinsy) is the most common deep head and neck infection,[1] often arising from bacterial spread after acute tonsillitis, resulting in a polymicrobial pus collection.[2] If untreated, serious complications such as descending mediastinitis, retropharyngeal abscesses and necrotising fasciitis can occur.[3] Whilst there is no universally accepted best practice for treating a peritonsillar abscess, prompt treatment involves drainage of the abscess via needle aspiration or incision and drainage with a scalpel, antibiotic administration, analgesia, corticosteroids and hydration.[1] It is not uncommon for the most junior member of the ENT team to perform this procedure, which can be daunting for both the doctor and the patient.[4]

General practitioners (GPs) also play a key role in quinsy diagnosis, with studies showing they refer over 90 per cent of cases to ENT specialists.[5] However, many GPs report insufficient ENT education both at undergraduate and postgraduate levels, despite ENT conditions being a significant part of their workload, especially in paediatrics.[5,6] Patients with quinsy are likely to present to GPs complaining of dysphagia, odynophagia, fever, drooling, trismus and sore throat.[1] As this presentation is common but not unique to this condition, it is important that GPs feel confident in their ability to diagnose and advise correct treatment for quinsy. Misdiagnosis can lead to unnecessary patient discomfort and complications, highlighting the need for better ENT training at the undergraduate level.[4]

Currently, ENT training in medical school is limited, with placements averaging one to two weeks over five years, which many ENT consultants deem insufficient.[7] A study at Newcastle Medical School revealed less than 50 per cent of final years had attended an ENT clinic or theatre and urged for improvements to be made and the need to promote otolaryngology.[8,9] Lack of exposure, hands-on learning and inspiration for the specialty are persistent key issues noted in literature, and these begin at undergraduate level.[4,7–9]

Following the coronavirus disease 2019 (Covid-19) pandemic, online learning and interactive e-modules have been developed to aid teaching ENT anatomy and some common ENT procedures. While the use of online learning has improved confidence in some areas, limitations remain, particularly for procedural skills.[10] Interactive e-modules appear more beneficial for students,[11] allowing for its incorporation within virtual reality (VR) teaching. VR offers a promising solution for enhancing ENT education. VR platforms provide immersive, interactive simulations that improve cognitive and psychomotor skills through features like gesture controls, eye-tracking and spatial sound.[12–14] At undergraduate level, successful applications

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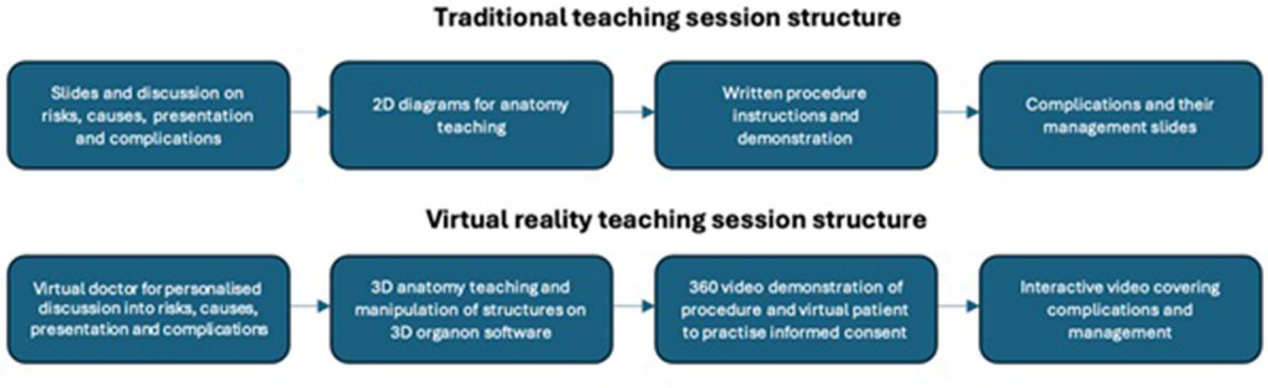


Figure 1. Teaching session structures.

have predominantly been found within anatomy teaching.[15,16] At post-graduate level, successful applications have been noted in ear surgeries, such as temporal bone dissection,[17] cochlear implant surgery[18] and cholesteatoma surgery,[19] but fewer focus on throat pathologies like quinsy.

Thus, this study aimed to develop a cost-effective VR teaching course to simulate quinsy drainage and examine its efficacy and suitability as a teaching tool in the medical student cohort. This could enhance ENT education, increase interest in the specialty and improve procedural skills for managing peritonsillar abscesses.

Materials and methods

Ethical approval for this study was given by the Biomedical and Scientific Research Ethics Committee (BSREC) at Warwick Medical School (WMS) and by the University of Coventry and Warwickshire NHS Trust Research and Development Department (BSREC-CDA-SSC2-2024- 18).

Third-year medical students from WMS were invited to an online sign-up for the study. This cohort was selected based on course structure.[20] Given that they would have finished their first clinical year in practice, this cohort would have the core knowledge and competencies to benefit from the workshop. As WMS consists of graduate-entry medical students, any participant with previous ENT experience or who had performed quinsy drainage was excluded from this study. Study participation was voluntary, and no identifying information, including email address, was collected to maintain anonymity.

Participants were subjected to simple randomisation into two study groups using research randomiser, a secure online software designed for research purposes. Both groups were given 90 minutes of teaching, either through traditional methods or through virtual reality headsets, with a quinsy drainage objective structured clinical examination (OSCE) assessment performed at the end of the study. The virtual reality workshop was delivered using HTC Vive Focus 3 headsets. The Virti platform was used to deliver the interactive virtual doctor and patient discussions, 3D Organon was used to deliver the virtual 3D anatomy and the EXR platform was used to showcase a 360 video demonstrating the procedural elements of quinsy drainage. The course content for both groups was reviewed, approved and delivered by an ENT consultant and registrar. Figure 1 details the exact breakdown of the teaching sessions delivered to both groups. To mitigate the impact of cybersickness in the VR teaching cohort,[21] regular short breaks were given and headsets were fitted to the participants.

A pre- and post-session questionnaire was distributed to assess participant's perception of confidence levels, interest in ENT and session enjoyment. Those randomly allocated to the VR teaching session were asked specific questions about motion sickness experienced during their session to assess the prevalence of cybersickness in this cohort. Pre- and post-session questionnaires are available to view in Appendix 1.

An OSCE-style skills assessment and pre- and post-session knowledge tests were also given to provide objective performance measures. Skills test marking criteria were based on an OSCE format which Warwick medical students are all familiar with and have previously passed. This was to minimise the impact of performance ability on scores. An example of the OSCE checklist is shown in Appendix 2. A pass mark of 75 per cent has frequently been suggested as appropriate in medical education studies and line with Kirkpatrick's levels of learning.[22,23] The same assessor was used for all participants to standardise the scoring.

The knowledge tests focused on the anatomy of the oropharynx (Appendix 3) and the optimal drainage location, which was difficult to assess during the OSCE. A photo of the oropharynx was given to both groups to determine where they would insert the needle to aspirate the abscess. The most appropriate position was determined by Delphi opinion sought by two ENT consultants. The distance the participants drew the X from the correct location was then measured pre- and post-session to determine if there was any significant change.

Statistics were performed using IBM SPSS Statistics 30.0.0.

Results

Twenty students were recruited for this pilot study. They were randomised accordingly so that there were 10 students in the VR teaching arm and 10 students in the traditional teaching arm. Pre-session questionnaires identified no statistical difference between the two groups concerning their subjective perception of confidence in the anatomy of the peritonsillar space ($p = 0.445$), confidence in identifying the signs and symptoms of a peritonsillar abscess (0.689) and confidence in performing a drainage of a peritonsillar abscess (0.746).

The majority of participants (strongly disagree 20 per cent [$n = 4$], disagree 40 per cent [$n = 8$]) stated that they did not have a good insight into what a career in ENT would entail.

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Both teaching groups were given identical pre- and post-session knowledge tests (Appendix 2). The anatomy aspect of the knowledge test was marked out of 7. The mean pre-knowledge test score was 5.2 for both groups ($p = 0.475$), suggesting a fair baseline knowledge amongst participants. 90 per cent of participants marked an unsafe location for drainage in the pre-knowledge test ($n = 18$). The mean distance from the optimal peritonsillar abscess drainage site in the pre-knowledge test was 2.34 cm for the traditional teaching arm and 2.49 cm for the VR teaching arm. Both teaching groups improved significantly in the post-session knowledge test with the mean distance from the optimal peritonsillar abscess drainage site being 0.98 cm in the traditional teaching arm ($p < 0.001$) and 0.90 cm in the VR teaching arm ($p < 0.001$). There was no significant difference between the post-session knowledge test scores being the two intervention arms ($p = 0.701$). A breakdown of scores can be seen in Table 1.

There was a significant improvement in the mean OSCE score performed post-session ($p = 0.005$) for the VR group (26.9) when compared to the mean OSCE score for the traditional group (21.5). The distribution of OSCE scores can be seen in Figure 2.

The breakdown of performance per section of the OSCE (Table 2) shows the VR group performing better in most of domains being tested, with statistically significant improvement noted in aftercare and monitoring ($p < 0.001$), local anaesthesia administration ($p < 0.001$), patient communication and consent ($p = 0.012$) and preparation for the procedure ($p = 0.002$).

Motion sickness amongst the participants in the VR teaching group was deemed to be low. Participants in this group responded positively across all domains in determining the effectiveness and usefulness of the teaching method for peritonsillar abscess drainage. A breakdown of mean scores can be seen in Table 3.

Table 1. Comparison of pre-session and post-session mean distances for optimal peritonsillar abscess drainage sites in both traditional and virtual reality teaching groups

	Mean distance (cm)			
Group	Pre-session	Post-session	Cohen's D	*p*-Value
Traditional	2.34	0.98	1.91	<0.001
Virtual reality	2.49	0.90	2.40	<0.001

Table 2. Comparison of individual OSCE score performance between traditional and VR teaching groups

	Mean OSCE scores		
Category	VR	Traditional	*p*-Value
Patient communication and consent	**36**	**28**	**0.012**
Preparation for procedure	**47**	**36**	**0.002**
Local anaesthesia	**29**	**17**	**<0.001**
Needle aspiration	49	48	0.62
Aftercare and monitoring	**39**	**24**	**<0.001**
Communication and patient interactions	29	26	0.42
Overall professionalism	20	20	1
Complication management	20	16	1

Note: Data in boldface are statistically significant.
Abbreviations: OSCE, objective structured clinical examination; VR, virtual reality.

Table 3. Breakdown of post-session VR-specific questionnaire scores

Question	Mean score (out of 10)
How effective was the VR in helping you visualise the anatomy of the peritonsillar space?	9.6 ± 0.966
How useful was the 360 simulation in demonstrating the procedure of draining a peritonsillar abscess?	8.3 ± 1.567
How immersive did you find the VR experience for learning a clinical skill?	8.5 ± 1.269
Did you find this an exciting and engaging way to be taught?	9.7 ± 0.675
Do you think VR resources are useful tools in supplementing traditional teaching in medical school?	9.3 ± 1.059
Did you experience motion sickness using the VR? (1 = not at all, 10 = yes, extremely badly)	1.8 ± 1.229

Abbreviation: VR, virtual reality.

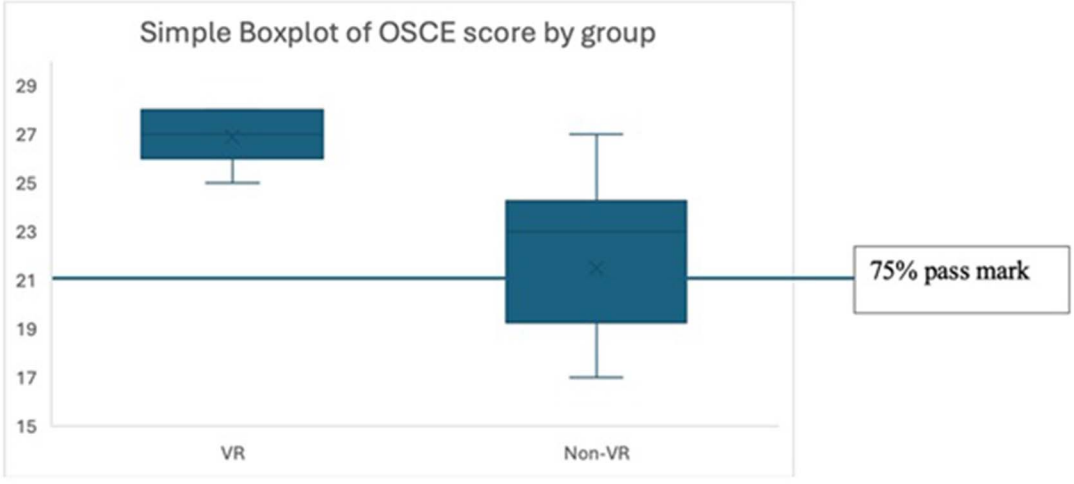


Figure 2. Simple box plots of objective structured clinical examination (OSCE) score by group.

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Table 4. Breakdown of individual post-session questionnaire responses between the traditional and VR teaching groups

Variable	Levene's test	*p*-Value	Interpretation	Mean difference
How satisfied were you with the teaching session?	Sig. = 0.339	Sig. 2-tailed = 0.077	No significant difference	1.10
Do you feel the session met your learning objectives?	Sig = 0.337	Sig 2-tailed = 0.072	No significant difference	1.20
How confident do you feel about performing peritonsillar abscess drainage after this session?	Sig = 0.219	Sig 2 tailed = 0.008	VR group scored significantly higher for this	2.00
How confident do you now feel about identifying the anatomy of the peritonsillar space?	Sig = 0.848	Sig 2 tailed = 0.002	VR group scored significantly higher for this	1.90
How well did the teaching method engage you during the session?	Sig = 0.025	Sig 2 tailed = 0.003	VR group scored significantly higher for this	1.80
Did the teaching you received increase your interest in ENT as a specialty?	Sig = 0.181	Sig 2 tailed = 0.371	No significant difference	0.90
Do you feel the session was beneficial at your level of training?	Sig = 0.295	Sig 2 tailed = 0.042	VR scored significantly higher for this	1.20
How effective were the teaching materials provided for the session?	Sig = 0.040	Sig 2 tailed = 0.001	VR scored significantly higher for this	2.80
Did you find this an exciting and engaging way to be taught?	Sig =0.015	Sig 2 tailed = <0.001	VR scored significantly higher for this	3.30

Abbreviation: VR, virtual reality.

Both teaching groups did not exhibit any statistical difference in: their satisfaction with the teaching session ($p = 0.077$); their perceptions of the learning objectives being met ($p = 0.072$); or their interest in ENT as a specialty increasing ($p = 0.371$) post-session. The VR teaching group showed significant differences in improvement with regards to: their confidence in performing peritonsillar abscess drainage ($p = 0.008$), their confidence with the anatomy ($p = 0.002$), their engagement of the teaching method ($p = 0.003$), their perception of the benefits of the teaching method ($p = 0.042$), the effectiveness of the teaching materials ($p = 0.001$) or their perceived excitement of the teaching method ($p < 0.001$). A breakdown of scores can be seen in Table 4.

Discussion

This study aimed to evaluate the effectiveness of VR in improving medical students' understanding and procedural competency in peritonsillar abscess drainage. The findings demonstrate that VR-based teaching significantly enhanced participants' confidence, engagement and performance in an OSCE-style assessment when compared to traditional teaching methods. These results support the growing body of literature advocating for the integration of immersive technology into medical education.

Current undergraduate exposure to ENT

The majority of participants in this study admitted to having limited insight into what ENT as a career would entail. This is mirrored in other studies in literature and may be partly down to the limited ENT experience that is provided to students during medical school.[7,8] In WMS, students experience one week of ENT-specific teaching in their first year of study, with this focusing predominantly on the anatomy of the ear, nose and throat. In the second year, WMS students do spend some time in ENT as part of their surgery rotation; however, the quality and quantity of the teaching experience is variable. This may explain the scores seen in the pre-session questionnaires and skills tests in this pilot study which highlighted a consistent lack of knowledge and confidence in performing a peritonsillar abscess drainage procedure. This trend is also seen in literature with many resident doctors feeling a lack of confidence across all ENT procedures.[4,9] With 90 per cent of participants originally indicating an incorrect peritonsillar abscess drainage location, this suggests having ENT-specific teaching workshops in this cohort would be beneficial, particularly as peritonsillar abscesses are the most common deep tissue infection of the head and neck.[1]

Whilst the decision to specialise has many contributing factors, there is evidence to suggest that effective surgical placements can increase the likelihood of students choosing a career in that specialty.[24] In this study, whilst there was no significant difference between the two teaching methods, there was an increase in the interest in ENT as a career post-session for both groups compared to pre-session scores. Promoting the specialty through engaging and effective surgical placements may increase student's interest in the specialty.[24]

Improvement in knowledge and procedural skills

Both the traditional and VR teaching groups showed significant improvement in their ability to identify the optimal drainage site for a peritonsillar abscess. The mean distance from the correct drainage location decreased significantly post-session in both groups ($p < 0.001$), indicating that the teaching intervention was

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effective. However, while both groups improved, the VR group outperformed the traditional group in the OSCE skills assessment (mean OSCE score: 26.9 vs. 21.5; $p = 0.005$). This aligns with previous studies where VR-based training enhanced procedural competence, particularly for surgical skills requiring spatial awareness and precision.[16–18]

The breakdown of OSCE performance highlights that VR training particularly benefited key procedural domains, such as local anaesthesia administration, procedural preparation and aftercare. This suggests that the immersive nature of VR enhances not only knowledge acquisition but also practical decision-making and confidence in procedural execution. These findings are consistent with existing literature on VR applications in surgical training, which suggests that VR provides a valuable supplement to traditional education by allowing for repeated, self-directed practice in a risk-free environment.[15,18,25]

Engagement and perceived effectiveness of VR teaching

Subjective feedback from participants further supports the advantages of VR-based education. The VR group rated the effectiveness of VR in visualising anatomy (9.6 ± 0.966) and its usefulness in demonstrating the procedure (8.3 ± 1.567) highly. Engagement scores were significantly higher in the VR group ($p = 0.003$), and students found VR to be a more exciting and engaging method of instruction ($p < 0.001$). These findings align with prior studies that emphasise the ability of VR to enhance engagement and motivation in medical training.[10,12]

It is important to consider whether the outcomes observed from this pilot study were the result of the use of the VR headset and the immersive experience it provides, or the interactive elements and educational quality of the software. We predict that, for this pilot VR cohort, it is a combination of both based on the feedback received, which described a positive experience with the VR headsets and software independently. There is a possibility that using the same software without the VR aspect on a 2D computer screen may provide the same educational benefit as utilising it on a VR headset. Future research comparing immersive (VR) and non-immersive (2D) delivery of the same educational content may help clarify the specific contribution of the VR headset.

While VR was not associated with a statistically significant increase in interest in ENT as a specialty ($p = 0.371$), the overall satisfaction with the session was high, indicating that VR can serve as an effective supplementary tool to traditional teaching. The absence of a significant increase in interest in ENT could reflect broader systemic issues, such as limited exposure to ENT in medical curricula,[4,5,8] rather than limitations in the teaching modality itself.

Relative costs of VR vs traditional teaching methods

VR typically involves higher upfront costs compared to traditional simulation models; primarily due to the expense of headset procurement and platform licensing. As VR in medical education is a rapidly evolving field, there is also a risk that current headsets may become outdated with newer models offering substantial improvements. However, VR offers significant advantages such as reduced staffing requirements for teaching sessions and the ability for learners to repeat sessions at minimal additional cost.[26] Over time, the authors predict that this could significantly reduce the cost per use. Nonetheless, a large-scale cost–benefit analysis is needed to validate this hypothesis.

Limitations

Despite the promising findings, there are limitations to this study. As this was a pilot study, the sample size was relatively small ($n = 20$), thus limiting the generalisability of the results. Another potential limitation is the short-term nature of the study. It is known that simulation allows participants to repeatedly practice a procedural skill, thus improving the participant's performance of the skill.[11,25] Future research should explore long-term retention of knowledge and skills following VR-based training.

Furthermore, while VR training was beneficial for procedural confidence and performance, it is unlikely to replace hands-on experience with real patients. Instead, VR should be viewed as a complementary tool that allows students to gain familiarity and confidence before performing procedures in clinical settings. Future studies should explore its integration into the broader medical curriculum, particularly for procedural training in specialties with limited undergraduate exposure, such as ENT.[4,9]

- Undergraduate exposure to ENT is limited in UK medical schools, leaving resident doctors underprepared for ENT emergencies, such as peritonsillar abscess drainage.
- Virtual reality (VR) has demonstrated educational benefits in surgical training, particularly in improving anatomical understanding and procedural skills.
- A cost-effective VR course was developed specifically to teach peritonsillar abscess drainage to medical students.
- Students taught using VR showed significantly improved objective structured clinical examination (OSCE) performance in key procedural domains compared to those receiving traditional teaching.
- VR-based teaching significantly enhanced learner engagement, confidence and perceived effectiveness, with minimal motion sickness reported.
- This pilot study supports the integration of immersive VR simulation into undergraduate ENT training to address current educational gaps.

Conclusion

This study supports the use of VR as a valuable tool for enhancing procedural education in ENT, particularly in peritonsillar abscess drainage. The significant improvement in OSCE performance, engagement and perceived effectiveness of VR-based learning suggests that it may bridge existing gaps in medical education. Given the ongoing advancements in VR technology and its increasing accessibility, its incorporation into medical training should be further explored. Future research with larger sample sizes and long-term follow-up will be crucial in validating these findings and optimising VR-based teaching methodologies for clinical education.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0022215125102983.

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Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional guidelines on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. Ethical approval for this study was given by the Biomedical and Scientific Research Ethics Committee (BSREC) at Warwick Medical School (WMS) and by the University of Coventry and Warwickshire NHS Trust Research and Development Department (BSREC-CDA-SSC2-2024-18).

Competing interests. The authors do not declare any conflicts of interest.

References

1 Peritonsillar abscess. In: http://www.ncbi.nlm.nih.gov/books/NBK519520/ [18 December 2024]
2 Klug TE, Rusan M, Fuursted K, Ovesen T. Peritonsillar abscess: complication of acute tonsillitis or Weber's Glands Infection? *Otolaryngol Head Neck Surg* 2016;**155**:199–207
3 Klug TE, Greve T, Hentze M. Complications of peritonsillar abscess. *Ann Clin Microbiol Antimicrob* 2020;**19**:32
4 Jegatheeswaran L, Naing TKP, Choi B, Collins R, Luke L, Gokani S, *et al*. Simulation-based teaching: an effective modality for providing UK foundation doctors with core ENT skills training. *J Laryngol Otol* 2023;**137**:622–8
5 Fitzsimons M, Williams K, Knowles S, Caroll C. Peritonsillar abscess at a dedicated otolaryngology emergency department. *Ir Med J* 2021;**114**:489
6 Dimitrov L, Unadkat S, Khanna A, Rennie C, Saleh H. ENT training amongst general practitioners: results from a questionnaire. *J Laryngol Otol* 2020;**14**:1–7
7 Khan MM, Saeed SR. Provision of undergraduate otorhinolaryngology teaching within General Medical Council approved UK medical schools: what is current practice? *J Laryngol Otol* 2012;**126**:340–4
8 Doshi J, Carrie S. A survey of undergraduate otolaryngology experience at Newcastle University Medical School. *J Laryngol Otol* 2006;**120**:770–3
9 Ferguson GR, Bacila IA, Swamy M. Does current provision of undergraduate education prepare UK medical students in ENT? A systematic literature review. *BMJ Open* 2016;**6**:e010054
10 Ijaz A, Sundar S, Zuberi S, Richards S. Online learning: an effective option for teaching ENT to medical students? *J Laryngol Otol* 2023;**137**:560–4
11 Chin RY-K, Tjahjono R, Rutledge MJR, Lambert T, Deboever N. The evaluation of e-learning resources as an adjunct to otolaryngology teaching: a pilot study. *BMC Med Educ* 2019;**19**:181
12 Radianti J, Majchrzak TA, Fromm J, Wohlgenannt I. A systematic review of immersive virtual reality applications for higher education: design elements, lessons learned, and research agenda. *Comput Educ* 2020;**147**:103778
13 Haowen J, Vimalesvaran S, Myint Kyaw B, Tudor Car L. Virtual reality in medical students' education: a scoping review protocol. *BMJ Open* 2021;**11**:e046986
14 Jensen LX, Konradsen F. A review of the use of virtual reality head-mounted displays in education and training. *Educ Inf Technol* 2018;**23**:1515–29
15 Venail F, Deveze A, Lallemant B, Guevara N, Mondain M. Enhancement of temporal bone anatomy learning with computer 3D rendered imaging software. *Med Teach* 2010;**32**:e282–8
16 Dharmawardana N, Ruthenbeck G, Woods C, Elmiyeh B, Diment L, Ooi EH, *et al*. Validation of virtual-reality-based simulations for endoscopic sinus surgery. *Clin Otolaryngol* 2015;**40**:569–79
17 Zhao YC, Kennedy G, Yukawa K, Pyman B, O'Leary S. Improving temporal bone dissection using self-directed virtual reality simulation: results of a randomized blinded control trial. *Otolaryngol Head Neck Surg* 2011;**144**:357–64
18 Copson B, Wijewickrema S, Zhou Y, Piromchai P, Briggs R, Bailey J, *et al*. Supporting skill acquisition in cochlear implant surgery through virtual reality simulation. *Cochlear Implants Int* 2017;**18**:89–96
19 Hardcastle T, Wood A. The utility of virtual reality surgical simulation in the undergraduate otorhinolaryngology curriculum. *J Laryngol Otol* 2018;**132**:1072–6
20 Course structure. In: https://warwick.ac.uk/fac/sci/med/study/ugr/why/courseinfo/structure/#y3 [20 December 2024]
21 Oh H, Son W. Cybersickness and Its severity arising from virtual reality content: a comprehensive study. *Sensors (Basel)* 2022;**22**:1314
22 McKinley DW, Norcini JJ. How to set standards on performance-based examinations: AMEE Guide No. 85. *Med Teach* 2014;**36**:97–110
23 Steensma H, Groeneveld K. Evaluating a training using the 'four levels model.' *J Workplace Learning* 2010;**22**:319–31
24 Marshall DC, Salciccioli JD, Walton S-J, Pitkin J, Shalhoub J, Malietzis G. Medical student experience in surgery influences their career choices: a systematic review of the literature. *J Surg Educ* 2015;**72**:438–45
25 Arora A, Lau LYM, Awad Z, Darzi A, Singh A, Tolley N. Virtual reality simulation training in otolaryngology. *Int J Surg* 2014;**12**:87–94
26. Farra SL, Gneuhs M, Hodgson E, Kawosa B, Miller ET, Simon A, *et al*. Comparative cost of virtual reality training and live exercises for training hospital workers for evacuation. *Comput Inform Nurs* 2019;**37**:446–54

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