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Research Article

VALIDATION OF HIGH-FIDELITY 3D-PRINTED HEAD AND NECK MODELS FOR TRAINING IN COMMON ENT EMERGENCIES

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Abstract

The goal of the study was to evaluate the usefulness of a tested 3D head and neck model for educating emergency medicine, primary care and allied health professionals in handling 10 typical ear, nose and throat (ENT) emergency cases. The research was performed during an ENT Emergencies training program in London. In total, 90 health professionals took part in the workshop. The group included 54 EM residents/trainees, 25 primary care residents/trainees, 4 ENT residents/trainees, 4 emergency nurse practitioners, 2 primary care attending physicians and 1 EM attending/consultant. There were 11 consultant ENT surgeons working on the faculty. During the course, the 3D models, printed using Fuesetec technology, were assessed to test their impact on how well participants could carry out ten common emergencies in ear, nose and throat medicine. In general, 86% (n=77) of individuals rated the models as highly or very useful in learning about ENT emergencies. The feedback systems were judged to mimic the real experience of patients' touch and palpation of tissues by the vast majority (64% for touch and 74% for texture). Using the practice models, over 70% of users were confident they could perform the 10 ENT procedures. Because they improved participants' performance in handling 10 emergency scenarios, the 3D models showed strong face validity, content validity and indirect validity. Using these models will make emergency ENT training easier for emergency departments.

Keywords: 3D-printed model, ENT emergencies, Simulation training, Emergency medicine education, Procedural confidence.

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INTRODUCTION

A large number of newly trained doctors lack confidence in caring for patients with ENT problems, largely because they receive little instruction on these matters in training programs. Simulation training reduces the risk of mistakes by letting doctors and nurses practice essential procedures without endangering patients.

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It has also been found that simulation leads to better learning than regular lectures in emergency medicine.7 As a result, medical simulation tools, especially 3D printed ones, are now used more widely to help train practitioners more efficiently. While using 3D models for technical training has gained a good response from trainees, they only demonstrate single procedural skills, leaving gaps in full ENT emergency teaching.8 Furthermore, these models have not fully proven their effectiveness on a regular basis or in real-life practice.8,10 Often such models are used for procedures

like tracheostomy, yet others such as managing quinsy or otitis externa, are hard to practice on these models. Because of this, a training tool must closely simulate real ailments, give realistic feel to the skin and provide detailed anatomy, but still keep patients safe and be cost-effective while using just a single model. The study hopes to achieve a detailed 3D printed head and neck model, designed to help teach emergency medicine physicians, primary care doctors and allied health professionals in the management of 10 frequent ENT emergencies.

METHODOLOGY

3D-printed simulation model design

I used a program called ZBrush from Pixologic, California which is a digital sculpting software, to design the head and neck models. The next step was to use Netfabb (Autodesk, California) to merge the individual body parts and improve their designs in preparation for fabrication (see figure 1A and B). To create the model, researchers turned the original strategy into a peritonsillar abscess model. In Blender (Blender Foundation, Netherlands), I changed the files to show a peritonsillar abscess and they were printed to replace the tonsils (figure 1B). The designs for the otological components came from applying a combination of the previously discussed methods (figure 1C). Images from an ear CT scan were imported into Mimics (Materialise NV, Belgium) to cut out the proper parts and any unclear areas were refined in ZBrush and joined to the ear model. Prints were produced by the Stratasys Digital Anatomical Printer (Stratasys, Minnesota, USA). The design included making use of digital resources for the different parts of the equipment. Graphical versions of the models and their endoscopic images are included in figure 2A–C and the appendixes of this paper.

ENT Emergencies Training Course

Models were put to the test at a breathing support course by running a validation study. Those taking part attended a workshop that covered the management of 10 typical ENT emergency cases. These emergencies involved clearing objects from the nose, caring for bloody noses, draining abscesses in the tonsils, reviewing stridor with flexible telescopes, treating patients with bleeding that followed tonsil removal, removing objects from the throat, inserting papoose^ {†} tubes and treating ears, removing objects from ears, draining hematomas after removing the thyroid and inserting tracheotomy tubes. Small group lectures, followed by hands-on work using printed models of the head and neck, were included in the one-day course. The educating team included ENT consultant surgeons and there were enough teachers to give each participant plenty of guidance during procedures. After finishing the theoretical part on treating emergencies in ENT, we performed simulation training using the 3D models. People participated in 10 station-based simulations, all starting with a clinical scenario that focused on the emergency procedure they were attempting. Afterwards, they worked at each station for 30 minutes, performing the particular procedure on the models while being overseen by ENT consultants, one after the next. There were common emergency department items at each station, for example, headlamps, tongue depressors, scalpels, syringes, needles, ribbon gauze and cautery devices. Otitis externa, Pope otowick and ear foreign body stations each had sturdy microscopes and stridor was accessed by using a flexible nasendoscope. At the completion of the course, everyone was given paper-based surveys to measure how they had interacted with the 3D models. All parts of the studies have shown their agreement to use their data for validating the 3D models.

Validation

A range of methods were used to validate the 3D models. To begin with, face validity was checked by having participants decide if the models could accurately represent what is done in ENT emergency situations. After that, we compared the listed ENT procedures with the relevant parts of the official postgraduate curricula for primary care and emergency medicine.11 12 We also had ENT specialist doctors provide feedback on the models considering the realism of commonly used ENT emergency treatments. We completed indirect criterion validity by recording each participant's degree of confidence in performing ENT emergency procedures after they used the 3D models.

RESULTS

Table 1: Realism rating of the 3D models course delegates.

Procedure/Assessment	Excellent	Above average	Average	Below average	Poor	N/A
A flexible nasal endoscopy and assessment of stridor are performed	39 (43%)	37 (41%)	11 (12%)	3 (3%)	0 (0%)	2 (2%)
Removal of a foreign body from the nose after assessing for it	34 (38%)	43 (48%)	9 (10%)	1 (1%)	0 (0%)	3 (3%)
Examining the ear for foreign bodies and removing them	48 (53%)	32 (35%)	8 (9%)	1 (1%)	0 (0%)	1 (1%)
Pope otowicks: a treatment option for otitis externa	42 (46%)	40 (44%)	7 (8%)	0 (0%)	0 (0%)	1 (1%)

Needlespiration for the treatment of peritonsillar abscesses	31 (34%)	37 (41%)	17 (19%)	3 (3%)	2 (2%)	0 (0%)
The assessment and removal of throat foreign bodies	41 (45%)	32 (35%)	10 (11%)	3 (3%)	1 (1%)	3 (3%)
Performing a tracheostomy*	38 (42%)	25 (28%)	1 (1%)	3 (3%)	0 (0%)	10 (11%)
The management of post-thyroidectomy haematomas	37 (41%)	34 (38%)	10 (11%)	0 (0%)	0 (0%)	9 (10%)
The management of epistaxis, including nasal packing and cautery	36 (40%)	35 (39%)	19 (21%)	0 (0%)	0 (0%)	0 (0%)
Managing a post-tonsillectomy bleed	35 (39%)	40 (44%)	6 (7%)	0 (0%)	0 (0%)	9 (10%)

Table 2: Realism rating of the 3D models course ENT consultants.

Procedure/Assessment	Excellent	Above average	Average	Below average	Poor	N/A
Perform a flexible nasal endoscopy and assess stridor	6 (55%)	4 (36%)	1 (9%)	0 (0%)	0 (0%)	0 (0%)
Examining the nose for foreign bodies and removing them	9 (82%)	2 (18%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Detecting and removing foreign bodies in the ear	5 (46%)	4 (36%)	2 (18%)	0 (0%)	0 (0%)	0 (0%)
Treatment of external otitis with Pope otowicks	7 (64%)	3 (27%)	1 (9%)	0 (0%)	0 (0%)	0 (0%)
Needlespiration for the treatment of peritonsillar abscesses	8 (73%)	2 (18%)	1 (9%)	0 (0%)	0 (0%)	0 (0%)
Identifying and removing throat foreign bodies	9 (82%)	1 (9%)	1 (9%)	0 (0%)	0 (0%)	0 (0%)
Tracheostomies	3 (27%)	4 (36%)	4 (36%)	0 (0%)	0 (0%)	0 (0%)
The management of post-thyroidectomy haematomas	5 (46%)	4 (36%)	1 (9%)	1 (9%)	0 (0%)	0 (0%)
Packing and cauterization in the treatment of epistaxis	3 (27%)	6 (55%)	2 (18%)	0 (0%)	0 (0%)	0 (0%)
Bleeding after a tonsillectomy	2 (18%)	6 (55%)	3 (27%)	0 (0%)	0 (0%)	0 (0%)

Table 3: Delegate confidence in managing common ENT emergencies following the use of 3D models.

Procedure	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not performed
A foreign body in the ear should be assessed and removed	54 (60%)	27 (30%)	6 (7%)	2 (2%)	1 (1%)	0
Acute and chronic otitis externa, including Pope's otitis	50 (56%)	24 (27%)	10 (11%)	3 (3%)	2 (2%)	0 (0%)
An effective method of treating a peritonsillar abscess	44 (49%)	22 (24%)	17 (19%)	3 (3%)	3 (3%)	0 (0%)
Identifying and removing throat foreign bodies	52 (58%)	21 (23%)	12 (13%)	1 (1%)	1 (1%)	2 (2%)
Tracheostomies	49 (54%)	23 (26%)	2 (2%)	3 (3%)	6 (7%)	8 (9%)
Bleeding after a tonsillectomy	56 (62%)	16 (18%)	10 (11%)	1 (1%)	3 (3%)	3 (3%)
Haematoma management after thyroidectomy	50 (56%)	30 (33%)	3 (3%)	4 (4%)	2 (2%)	0 (0%)
Packing and cauterization in the treatment of epistaxis	63 (69%)	21 (23%)	5 (5%)	1 (1%)	1 (1%)	0 (0%)

Examining the nose for foreign bodies and removing them	58 (64%)	25 (28%)	3 (3%)	1 (1%)	2 (2%)	1 (1%)
Conducting a flexible nasendoscopy and assessing stridor	36 (40%)	40 (44%)	10 (11%)	1 (1%)	2 (2%)	1 (1%)

Figure 1: 3D Models Course: Procedure Performance Radar

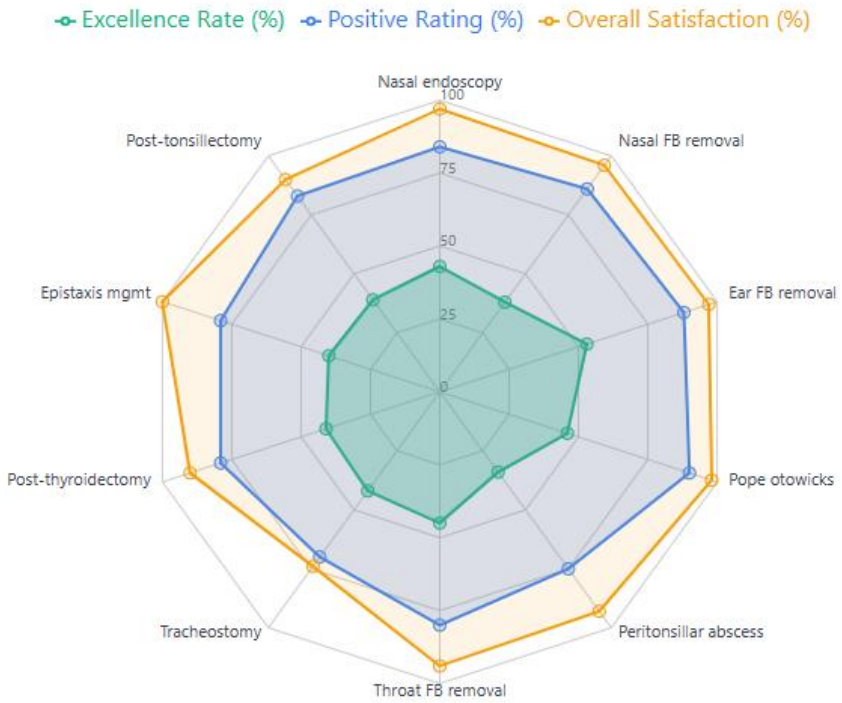


Figure 2: ENT Consultants' Assessment: 3D Models Realism Ratings, Expert consultant evaluation of procedure realism (n=11 consultants)

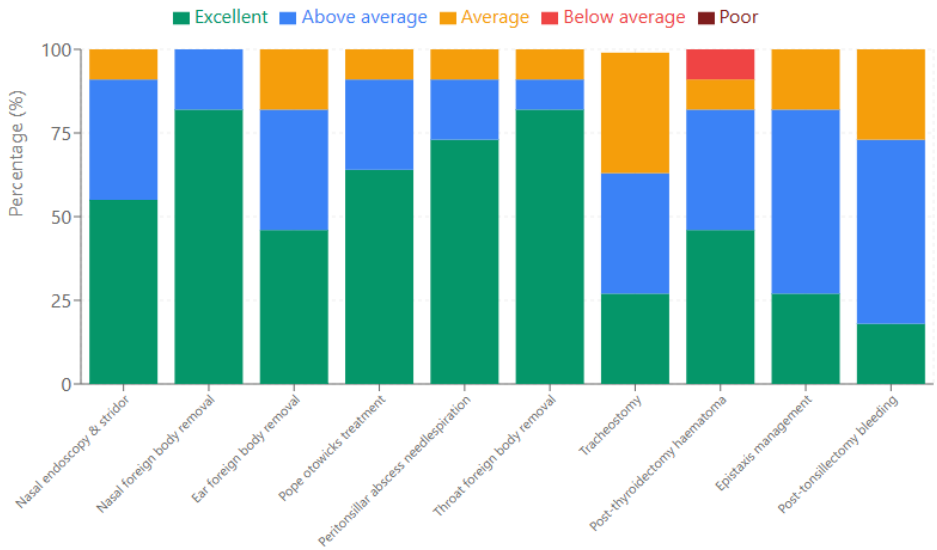
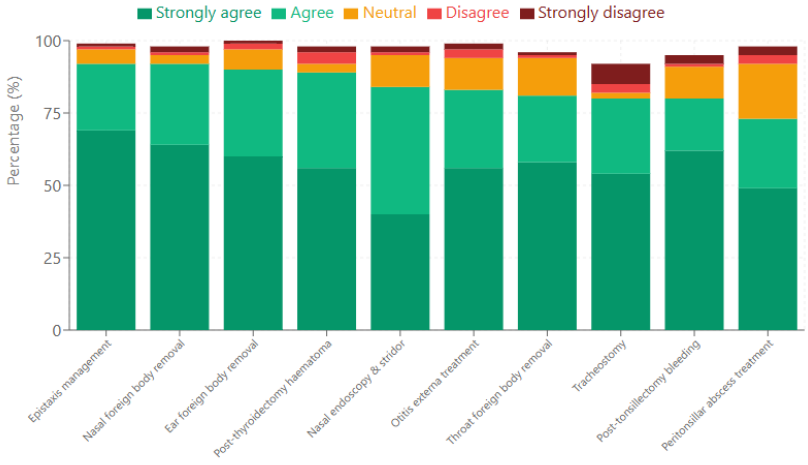


Figure 3: Delegate Confidence in Managing ENT Emergencies, Post-training confidence levels using 3D models (n=90 delegates)



Both course delegates and ENT consultants found that the 3D-printed models for the head and neck looked life-like and helped with training. Many of the models received high ratings in Table 1, with 75% or more often being given ratings of "Excellent" or "Above average" no matter the procedure. For both calculations, the models involved in checking and removing items from the ear and handling epistaxis including nasal packing and cautery got high "Excellent" and "Above average" ratings (88% and 79% respectively). Ten percent of participants felt that they didn't have enough time during the course to practice tracheostomy, giving it the lowest rating in realism among the procedures. The feedback from consultants (Table 2) showed that the simulated cases were quite realistic and were well-matched by what the delegates expected. While many rated laryngoscopy as "Excellent" or "Outstanding," tracheostomy got lower ratings, suggesting that as a somewhat more complex procedure, the model may not be as accurate. A great number of delegates said that they felt confident managing emergencies after using the models for training (Table 3). Managing epistaxis and removing foreign bodies from the nose were confidence-boosters, with most respondents (92% for both) agreeing, but the reverse was seen for tracheostomy (30% disagreed or were neutral). All in all, using the 3D models helps most doctors improve their skills and confidence in common ENT emergencies, though some refinement could be useful for more complex treatments such as tracheostomy.

DISCUSSION

Studies have revealed that ENT doctors do not always feel confident in dealing with emergency cases because of limited training. The overall results from the present study confirm that 3D-printed models shown to healthcare professionals are highly realistic. Also, several participants thought that the methods provided realistic touch feedback and simulated similar textures of actual tissue. Participants who used the 3D models became more confident in handling the 10 common ENT emergencies, confirming the study's strong indirect criterion validity.

Improving competence and confidence of emergency care providers

I found that within our group using 3D models helped the participants believe they could move forward and perform 10 common ENT emergency procedures more confidently. Doctors in emergency care and primary settings must be trained to respond effectively to ENT emergencies because dealing with these conditions quickly is important for patient safety.3 5 7 Proficiency in procedural actions is very important because evidence has shown that complications during procedures can be damaging to patients, often requiring extended stays in hospital. As many ENT centers depend on an emergency on-call rota, it is often someone from another specialty who steps in, so having specific training in ENT emergency procedures is extremely important for all emergency teams and having these models can support this.

Incorporating 3D models into local departments

Training with modern 3D models in the head and neck area has been linked to higher confidence in doing usual ENT procedures following only a day of learning. These models showed excellent results for face, content and indirect criterion validity. It was clear from the survey results that 98.4% of respondents wanted these models used in emergency departments and primary care centers to build trainees' confidence in handling ENT emergencies. A major challenge for using these models was that trained staff capable of delivering the training

were few in number. Learning from an expert instructor can provide instant feedback and chances to reflect after practicing simulations. However, prior studies suggest that some learners might prefer practicing with simulators by themselves. Likewise, the models allow for many repetitions, support skill growth and help learn by practicing procedures that infrequently occur clinically. Availability of these models close by encourages doctors to regularly practice emergency ENT procedures which reduces the risk of forgetting them.

CONCLUSION

The findings indicate that 3D-printed anatomic head and neck models are both realistic and effective for training in emergency medicine, primary care and for allied health professionals managing ENT emergencies. Training with these models raised participants' confidence and improved their skills, confirming robust face, content and indirect criterion validity. Using these models in local emergency and primary care contexts can help health workers prepare better, considering the inconsistent experience many have with some ENT emergencies and the limitations of standard teaching. Since faculty may not always be available, the programs make practice easier and allow people to learn on their own, helping skills stay fresh. These results back up the efforts to increase the use of 3D-printed simulation models for enhancing skills, confidence and ensuring patient safety in emergencies for ENT care.

REFERENCES

1. Ayub, S.M. (2022). "See one, do one, teach one": Balancing patient care and surgical training in an emergency trauma department. *J Glob Health*, 12, 03051.
2. Mk, G., Saldanha, M., Bhat, V.S. (2023). Simulation-based training in ear, nose and throat skills and emergencies. *Braz J Otorhinolaryngol*, 89, 144–151.
3. Doucet, G., Ryan, S., Bartellas, M. (2017). Modelling and manufacturing of a 3D printed trachea for cricothyroidotomy simulation. *Cureus*, 9, e1575.
4. Bhalla, S., O'Byrne, L., Beegun, I. (2021). "No drain, no gain": Validation of novel quinsy simulation model. *Laryngoscope InvestigOtolaryngol*, 6, 81–87.
5. Gao, R.W., Rooney, D., Harvey, R. (2022). To pack a nose: high-fidelity epistaxis simulation using 3D printing technology. *Laryngoscope*, 132, 747–753.
6. Royal College of General Practitioners (RCGP). (2024). GP Curriculum: Clinical Topic Guides. Available at: https://www.rcgp.org.uk/mrcgp-exams/gp-curriculum/clinical-topic-guides#ear.
7. Royal College of Emergency Medicine (RCEM). (2015). RCEM Curriculum. Available at: https://rcem.ac.uk/curriculum/.
8. Schonnop, R., Stauffer, B., Gauri, A. (2021). Procedural skills training in emergency medicine physicians within the Edmonton Zone: a needs assessment. *AEM Educ Train*, 5, e10495.
9. Whitcroft, K.L., Moss, B., McRae, A. (2016). ENT and airways in the emergency department: national survey of junior doctors' knowledge and skills. *J Laryngol Otol*, 130, 183–189.
10. Ericsson, A.K. (2008). Deliberate practice and acquisition of expert performance: a general overview. *Acad Emerg Med*, 15, 988–994.
11. Trehan, A., Barnett-Vanes, A., Carty, M.J. (2015). The impact of feedback of intraoperative technical performance in surgery: a systematic review. *BMJ Open*, 5, e006759.
12. Khunger, N., Kathuria, S. (2016). Mastering surgical skills through simulation-based learning: practice makes one perfect. *J Cutan Aesthet Surg*, 9, 27–31.
13. Suzuki, M., Miyaji, K., Watanabe, R. (2022). Repetitive simulation training with novel 3D-printed sinus models for functional endoscopic sinus surgeries. *Laryngoscope InvestigOtolaryngol*, 7, 943–954.

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