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Review

Virtual reality simulation training in Otolaryngology

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ABSTRACT

Objective: To conduct a systematic review of the validity data for the virtual reality surgical simulator platforms available in Otolaryngology.
Data sources: Ovid and Embase databases searched July 13, 2013.
Review methods: Four hundred and nine abstracts were independently reviewed by 2 authors. Thirty-six articles which fulfilled the search criteria were retrieved and viewed in full text. These articles were assessed for quantitative data on at least one aspect of face, content, construct or predictive validity. Papers were stratified by simulator, sub-specialty and further classified by the validation method used.
Results: There were 21 articles reporting applications for temporal bone surgery ($n = 12$), endoscopic sinus surgery ($n = 6$) and myringotomy ($n = 3$). Four different simulator platforms were validated for temporal bone surgery and two for each of the other surgical applications. Face/content validation represented the most frequent study type (9/21). Construct validation studies performed on temporal bone and endoscopic sinus surgery simulators showed that performance measures reliably discriminated between different experience levels. Simulation training improved cadaver temporal bone dissection skills and operating room performance in sinus surgery.
Conclusion: Several simulator platforms particularly in temporal bone surgery and endoscopic sinus surgery are worthy of incorporation into training programmes. Standardised metrics are necessary to guide curriculum development in Otolaryngology.

1. Introduction

Surgical trainees are required to achieve operative competency within a reduced period of clinical exposure compared to previous generations. Limited surgical exposure is compounded by the increasing workload of the trainer surgeon, the ethical and legal concerns over patient safety and the financial implications associated with accelerating the learning curve process[1–3]

In 2008, the Chief Medical Officer's annual report entitled 'Safer Medical Practice' advocated simulation-based surgical training in the UK.[4] The application of virtual reality (VR) simulation in surgical training was first proposed by Satava et al. in 1993 to deliver reproducible, consistent models which permit unlimited practice using standardised anatomy.[5] Training surgical tasks through repetitive, proctored sessions have been shown to improve the detection and analysis of surgical error.[6,7]

In the last decade, several VR simulators have been developed which produce a high fidelity representation of various operations in Otolaryngology. Three-dimensional projection, bimanual interaction and haptic (sensory) feedback are all features intended to enhance the user's experience. However, VR simulation is yet to be routinely incorporated into Otolaryngology training. In order for a simulator to be an effective training tool, it must include elements such as the ability for repetitive practice. Ideally it should be applicable for varying difficulty levels have established benchmarks and reliable outcome measures.[8] Robust validity data are essential to establish efficacy and guide application in surgical training.

The European Association for Endoscopic Surgery (EAES) guidelines outline the keystones of validation.[9] Face validity reflects the ability of a simulator to produce a realistic environment that resembles the actual surgical procedure. This is assessed using a trainer and trainee group using a structured questionnaire. Content validity is the assessment of the ability of the simulator to deliver what it is expected to achieve. This is demonstrated by satisfying

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pre-determined criteria that both groups agree upon. Construct validity confirms the simulator's ability to quantifiably differentiate between varying levels of expertise amongst participants or to test the ability of the model or tool to predict future performance (Predictive validity).

The objective of this review is to collect and critically analyse the evidence for VR simulation in Otolaryngology training and present a reference for program directors who are considering incorporating it into their training programs.

2. Methods

A systematic literature search was performed using Ovid Medline and Embase. Articles published until July 13, 2013 were included (Table 1). Fig. 1 summarises the search outcomes according to PRISMA guidelines.

2.1. Screening, eligibility and selection

Results from both databases produced a total of 432 citations. After removal of duplicates, 409 remained. Two independent reviewers (AA, LL) screened the citations based on title and abstract using the criteria outlined in Table 2 to determine relevance to Otolaryngology and postgraduate education and training. Thirty-six citations underwent full text review and references were hand searched for relevant studies. One additional paper (Fried et al., 2007) was included from reference searching. Each of these articles had quantitative data for at least one aspect of face, content, construct or predictive validity of the simulator.

2.2. Data extraction, analysis and outcomes

The author, date of publication, study design, and data from the eligible articles were tabulated in Microsoft Excel® (Microsoft Corporation, WA). Papers were stratified by simulator and sub-specialty type and further classified by validation method; Face, content, construct and predictive validity.

Table 1
Search strategies for Ovid Medline and Embase databases (Search July 13, 2013).

Ovid (Medline)	
1	exp Otolaryngology/
2	head/or ear/or mouth/or nose/or parotid region/or exp skull base/or exp larynx/or exp nose/or exp pharynx/or exp trachea/
3	exp Neck/
4	virtual reality.mp.
5	simulator*.mp.
6	patient simulation/
7	1 or 2 or 3
8	4 or 5 or 6
9	7 and 8
10	limit 9 to (english language and humans)
Ovid (Embase)	
1	exp otorhinolaryngology/
2	exp "face, nose and sinuses"/
3	exp ear/or exp nose/or exp throat/
4	exp ethmoid bone/or exp facial bone/or exp hyoid bone/or exp mastoid/or exp temporal bone/or exp turbinate/
5	exp simulator/
6	exp virtual reality/
7	1 or 2 or 3 or 4
8	5 or 6
9	7 and 8
10	limit 9 to (english language and humans)

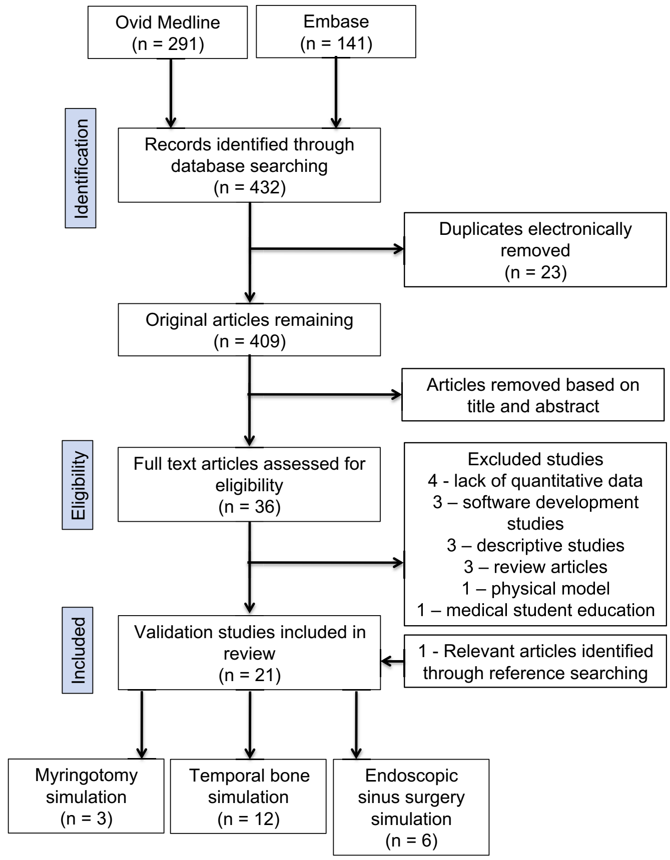

Fig. 1. Search outcomes of virtual reality surgical training simulation in Otolaryngology.

3. Results

There were 21 articles reporting on 3 main VR applications: temporal bone surgery, endoscopic sinus surgery and myringotomy (Table 3). A summary is shown in Table 4. There were 12 studies on temporal bone simulation using the Voxelman, Mediseus®, OSU (Ohio State University) or Stanford University platforms. Six studies were on endoscopic surgery simulation using the Endoscopic Sinus Surgery Simulator (ES3) or Dextroscope simulator. Three studies involved myringotomy simulation using the UWO (University of Western Ontario) haptics or optical tracker systems.

Other VR platforms were identified but articles describing these were excluded because they did not include quantitive or comparative data as outlined in the Method section (Table 5). The Mediseus is the only system with networking capability that allows a mentor to interactively guide the drilling process. The Voxelman is the only commercially available simulator at the present time.

3.1. Temporal bone surgery simulation

The Voxelman Temposurg, Mediseus®, OSU and Stanford platforms have all undergone validation studies with the aim of integration into postgraduate training programs in the UK, US and Australia (Table 4A).

3.1.1. Voxelman temporal bone simulator

Face validity was undecided although it was effective for training based on 20 respondents.[10] The largest evaluation of face and content validity was by Arora et al.[11] Eight-five participants were recruited comprising a trainer and trainee group. Although