The Journal of Laryngology & Otology (2018), ***132***, *133–137*.

doi:10.1017/S0022215117002183

MAIN ARTICLE

Training and assessment in functional endoscopic sinus surgery

M CHAN[1], S CARRIE[2]

[1]*ENT Department, Health Education North East, Newcastle Upon Tyne, and* [2]*ENT Department, Freeman Hospital, Newcastle Upon Tyne, UK*

Abstract

Background: Functional endoscopic sinus surgery is a common procedure performed within otolaryngology, but it carries potential for significant life-changing complications. It is therefore essential that trainees undergo adequate training. The European Working Time Directive has led to reduced operating time for the trainee surgeon. With variable access and the cost implications associated with cadaveric specimens, simulation can be an invaluable educational resource in surgical training. The current literature regarding the various simulation methodologies that have been used in functional endoscopic sinus surgery training is discussed.

Method: A literature search was conducted using the key words 'nasal', 'nasal polyps', 'endoscope', 'education and simulation', 'endoscopic sinus surgery' and 'training'.

Results: Twelve articles were identified; of these, eight trialled the use of simulators, two utilised ovine models and two used task trainers.

Conclusion: Simulation has shown benefit in functional endoscopic sinus surgery training; however, a robust platform accessible to ENT trainees is lacking.

Key words: Endoscopic Surgical Procedure; Nasal Surgery; Training Program; Nasal Procedure; Simulation Training; Education

Introduction

Functional endoscopic sinus surgery (FESS) is amongst the most common procedures performed by an otolaryngologist. It is the 'gold standard' option for the majority of nasal and sinus disorders, and is minimally invasive, with both diagnostic and therapeutic benefits.[1]

Endoscopic sinus surgery is performed in a small but complex anatomical space, in close proximity to important structures such as the orbit, optic nerve, internal carotid artery and other neurological structures.[2] As a result, there can be associated major complications such as cerebrospinal fluid leak, nasolacrimal duct damage, blindness, haemorrhage and meningitis.[2,3] Orbital and intracranial complications are amongst the most commonly reported complications in medicolegal cases.[4] Iatrogenic complications occur in 5–30 per cent of patients; therefore, appropriate training and operative experience are required to reduce the risk of surgical error.[5]

Otolaryngology trainees are expected to have detailed knowledge of the anatomy and physiology of the nose and paranasal sinuses. Approaching the sinuses endonasally through the nostrils can present the anatomy in an unfamiliar fashion.[6] By the time of training completion, UK trainees are expected to be at a surgical curriculum level 4 (able to perform procedures fluently without guidance) in several components of endoscopic nasal surgery, including middle meatal antrostomy, uncinectomy, nasal polypectomy and anterior ethmoidectomy.[7] A good grounding in the fundamentals of endoscopic nasal surgery provides a solid platform for any trainees wishing to pursue a special interest in advanced endonasal and skull base surgery.

For a trainee to be competent in a procedure, thorough operative experience in that technique is required. Skills in medicine, particularly in surgical practice, have traditionally been initiated and developed in patients undergoing surgery. The adage 'see one, do one, teach one' is no longer an appropriate model for medical education. Coupled with the increasing workload of a trainee surgeon and the European Working Time Directive, time in the operating theatre can be limited.[8,9] Simulation and courses offering cadaveric specimens can provide essential training to compensate for this.[8]

Medical simulation provides an educational, safe and realistic environment, where trainees can repeatedly

Accepted for publication 19 July 2017 First published online 16 January 2018

practice clinical scenarios or perform skill sets transferrable to real life.[10] Simulation can vary from simple trainers, designed to build on hand–eye co-ordination, haptic feedback and task exercises, to high-end workstations simulating whole procedures.[10] Simulation is already used in other surgical disciplines such as neurosurgery, ophthalmology, general surgery, obstetrics and gynaecology, and orthopaedics. Studies have already shown the benefits of surgical simulation, with a reduction in errors and improved surgical performance for trainees who had simulation experience.[11,12] A study published in 1998 recommended that cadaveric dissection be performed at an early stage, preferably before the trainee's first operation on a living patient.[6] However, the cost, limited availability and accessibility of cadaveric specimens necessitates other forms of training methodologies in FESS.

This article provides an overview into the current methodologies used to train novice surgeons in FESS, their effectiveness and what assessment tools are available.

Materials and methods

A literature search was conducted using the electronic databases Embase and Medline. Key terms used in the search included 'nasal', 'nasal polyps', 'endoscope', 'education and simulation', 'endoscopic sinus surgery' and 'training'.

A total of 32 articles were returned from the search. Conference abstracts, letters to editors, non-English language articles and those not relating to training were excluded. Other articles of interest were found through reference lists of included studies and were subsequently obtained through Open Athens.

The inclusion criteria for articles included: papers that investigated FESS training involving the use of virtual simulators, ovine models and task trainers. There were no restrictions on study population, trainee grade or publication year. A total of 12 studies were found: 2 involving simple task trainers, 8 using simulators and 2 using ovine models.

Results

The study publication dates ranged from 1998 to 2016. All 12 papers were published as full-text articles and in the English language. All studies were prospective, with candidates of varying medical experience ranging from medical students to expert sinus surgeons. Two studies assessed candidates with questionnaires, six studies involved task-related assessments, and four studies incorporated both questionnaire and task assessments.

Simulators

Eight studies were identified to have used a simulation platform for sinus surgery training.[2,13–19] Sample size varied from 5 to 111 participants, and studies consisted of participants with varying levels of experience, ranging from medical student to experienced surgeon.

Of the eight studies, six were virtual reality based and two were based on real anatomical models. Of the virtual reality simulators, three used the Endoscopic Sinus Surgery Simulator ('ES3'), one study involved validation of the McGill simulator for FESS and the remaining two used unspecified software.

The majority of the studies were validation studies assessing the simulators in terms of face, content and construct validity. Few of the studies assessed whether there was a correlation between performance on a simulator and level of experience in endoscopic nasal surgery. Five out of six of the studies assessed candidates on sinus surgery skills such as uncinectomy, maxillary antrostomy, and anterior and posterior ethmoidectomy in a simulated environment.[2,13,14,16,19] One study assessed the use of haptic feedback, with and without visual aids, in the development of transferrable skills for FESS.[18] One study assessed the correlation between results on the Endoscopic Sinus Surgery Simulator and the results from assessment of skills deemed necessary for the procedure, such as depth perception, spatial awareness and instrument handling.[2] One study assessed the role of operating performance simulation in junior residents on their first endoscopic nasal operation.[14]

Both studies investigating simulation on a real anatomical model used the Sinus Model Otorhino Neuro Trainer ('SIMONT').[15,17] One study assessed the benefit of this type of simulation on two groups of surgeons based on experience with sinus surgery.[17] The other looked at adapting the Sinus Model Otorhino Neuro Trainer into a more cost-effective trainer and considered what benefits this had on trainees.[15]

Two of the simulator studies utilised questionnaires, two used task-related assessments, and four combined both tasks and questionnaires as a means of assessing either candidate performance or the value of the simulator. Questionnaires were mainly based on Likert scales.

Overall, the studies showed a positive correlation between the level of experience of the surgeon and performance on a simulator.[13,16,19] For more junior trainees, repetition of tasks often led to an improvement in performance and decreased the task time in the simulator suggesting an increase in confidence.[17] Most junior trainees felt simulation was useful in demonstrating anatomy and in the development of transferrable skills, with one study positively showing that junior trainees who had prior simulation training performed better in their first endonasal sinus operation compared to trainees who had not.[13,14]

Task trainers

Two of the studies identified involved the use of task trainers.[20,21] Both studies utilised the same, self-constructed platform, but each study had different objectives. The task trainer was constructed out of synthetic and organic materials for under US$5.00.[22] The first study was a validation study assessing the task trainer

https://doi.org/10.1017/S0022215117002183 Published online by Cambridge University Press

in terms of realism.[21] Although it scored poorly in this domain, the task trainer was thought to be beneficial in developing hand–eye co-ordination and camera skills. The second study, using the same task trainer, observed candidate performance on the task trainer pre- and post-training.[20] It found significant improvement in performance with repeated practice, as measured in a procedural checklist. In addition, it suggested that combining an objective structured assessment of technical skills with the model could potentially determine competency outside the operating theatre.[20] The studies highlighted the benefits of a low-cost alternative for novice surgeons in the development of skills needed for FESS.[20,21]

Ovine models

Two of the studies identified used an animal model as a training tool, with both employing a sheep's head.[23,24] The models used in these studies allowed the participants to perform various sinus surgery techniques on the specimens. One study showed a positive correlation between experience and performance.[23] Both studies used task-related assessments in evaluating candidate performance. It was found that repeated practice led to shorter dissection times and that an ovine model would be useful in allowing early year trainees to acquire endoscopic skills.[25]

Discussion

This overview highlights the current types of training and assessment in FESS training, with 12 studies identified. Six of the 12 studies were based around virtual reality, with the most recognised simulator being the Endoscopic Sinus Surgery Simulator. Two of the 12 were based on real anatomical models (Sinus Model Otorhino Neuro Trainer), 2 studies used animal models and the final 2 used a task trainer. Simulation needs to produce a realistic environment that represents the actual surgical procedure (face validity). Furthermore, it needs to be able to deliver what it set out to achieve (content validity) and to be able to differentiate between varying levels of experience amongst candidates (construct validity).[25]

The Endoscopic Sinus Surgery Simulator was developed by the company Lockheed Martin between 1995 and 1998, in association with the University of Washington, Ohio State University and the Ohio Supercomputer Center. The Endoscopic Sinus Surgery Simulator utilises virtual instruments with haptic feedback, in a three-dimensional anatomical environment derived from computed tomography images. As the student advances through the training, they are given more complex tasks to perform.[26,27] The Endoscopic Sinus Surgery Simulator has been validated by several studies assessing performance on the simulator against visuospatial, depth perception and hand–eye co-ordination abilities.[2] It has been proven to demonstrate construct validity, with the simulator able to distinguish between three levels of experience in surgeons.[16] It is the only simulator that has been correlated with an improvement in surgical performance in the operating theatre, albeit with a small sample size.[14]

The McGill virtual simulator had some initial evidence supporting its use as an educational tool; it scored highly on realism, and can differentiate between senior and novice surgeons. It has not yet been as thoroughly validated as the Endoscopic Sinus Surgery Simulator. Other virtual reality simulators were often found to be more beneficial to junior trainees in developing anatomical knowledge or basic skills such as instrument handling.[13,18]

The Endoscopic Sinus Surgery Simulator is no longer in production. Newer simulators have been developed, but have not yet been validated or assessed for trainee benefit.[28] Use of the Sinus Model Otorhino Neuro Trainer anatomical model has been associated with an improvement in participants' surgical ability. The model can be adapted to individual needs. However, only one dissection can be performed before the model needs refurbishment. One study attempted to bypass these additional cost implications by adapting the model with the use of eggs as a cheaper alternative.[17,29]

Ovine models and task trainers are considered to be a cheaper alternative to simulators. Task trainers, though inexpensive, did not prove to be a realistic alternative, although they were useful in developing basic endoscopy skills. Ovine models, in particular a sheep's head, are not expensive models. However, the nasal anatomy of a sheep varies considerably from that of a human. Nevertheless, such models allow trainees to perform various surgical manoeuvres similar to those in real life. Some procedures, such as opening of the sphenoid sinus, could not be performed reliably, as the necessary anatomical landmarks are absent in the sheep. One study demonstrated construct validity using a sheep's head, by distinguishing between novice, intermediate and expert surgeons through comparing task-specific scores.[23]

Simulation was, on the whole, well received in all studies reviewed. The benefit appears to be most useful in junior trainees who have had little to no experience in endonasal sinus surgery, which was also demonstrated in studies when most complications were encountered.[19] The benefit of simulation appears to be less for more experienced surgeons when realism is more important. Besides the Endoscopic Sinus Surgery Simulator, the others did not have a progression element to the training, instead only offering a single training session. Studies that involved task repetition universally showed an improvement in performance and decreased task completion time when the initial and final attempt were compared.[16,17,21,24] Despite the use of task-related assessments and questionnaires, there was a lack of a standardised assessment for these simulators. Whilst simulation has been

https://doi.org/10.1017/S0022215117002183 Published online by Cambridge University Press

shown to improve surgical performance in other disciplines, this has yet to be replicated in FESS at a significant level.

- **There are few studies reviewing the general use of simulation in ENT as a whole**
- **No studies have reviewed use of simulation solely in functional endoscopic sinus surgery (FESS)**
- **Studies have proven the benefit of simulation in FESS training**
- **There is a lack of robust accessible platform for FESS training**

Simulation, whether virtual or anatomical, or animal models and task trainers, will form a more important aspect of surgical training in an ever-changing medical career. Time constraints in the operating theatre, which lead to diminished operating exposure, could be compensated by a face-, content- and construct-validated surgical trainer, with tasks varying in difficulty, feedback and out-of-hours accessibility. The use of inexpensive task trainers would allow the most junior trainees to practice instrument handling, depth perception and hand–eye co-ordination in a safe environment.

Conclusion

There are limited studies detailing training and assessment in FESS. Whilst all the studies identified showed a benefit to trainees, none of the simulators have been regularly incorporated into a training curriculum. The Endoscopic Sinus Surgery Simulator came closest to being part of resident education in North America; however, it is no longer in production and has limited availability. Simulation is an invaluable training tool for trainees, but at present there is no accessible and robust platform widely available for its integration into training programmes.

Acknowledgement

The authors would like to thank the Royal Victoria Infirmary Library Department for assistance with the literature search.

References

1 Luong A, Marple BF. Sinus surgery: indications and techniques. *Clin Rev Allergy Immunol* 2006;**30**:217–22
2 Arora H, Uribe J, Ralph W, Zeltsan M, Cuellar H, Gallagher A *et al*. Assessment of construct validity of the endoscopic sinus surgery simulator. *Arch Otolaryngol Head Neck Surg* 2005; **131**:217–21
3 Ramadan HH, Allen GC. Complications of endoscopic sinus surgery in a residency training program. *Laryngoscope* 1995; **105**:376–9
4 Patel AM, Still TE, Vaughan W. Medicolegal issues in endoscopic sinus surgery. *Otolaryngol Clin North Am* 2010;**43**: 905–14
5 Tan BK, Chandra RK. Postoperative prevention and treatment of complications after sinus surgery. *Otolaryngol Clin North Am* 2010;**43**:769–79
6 McFerran DJ, Grant HR, Ingrams DR, Fife DG. Endoscopic sinus surgery: are junior doctors being properly trained? *Ann R Coll Surg Engl* 1998;**80**:359–63
7 Otolaryngology. The Intercollegiate Surgical Curriculum. In: https://www.iscp.ac.uk/static/public/syllabus/syllabus_oto_2017 [10 October 2017]
8 Donaldson L. Safer medical practice: machines, manikins and polo mints. In: *150 Years of the Annual Report of the Chief Medical Officer: On the State of Public Health 2008*. London: Department of Health, 2009;49–55
9 Pothier DD, Toll EC, Grant DG, Giddings CE. Trends in operative training opportunities for junior and senior trainees in otolaryngology. *Clin Otolaryngol* 2009;**34**:179–84
10 Abou-Elhamd KE, Al-Sultan AI, Rashad UM. Simulation in ENT medical education. *J Laryngol Otol* 2010;**124**:237–41
11 Aggarwal R, Ward J, Balasundaram I, Sains P, Athanasiou T, Darzi A. Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery. *Ann Surg* 2007;**246**:771–9
12 Ahlberg G, Enochsson L, Gallagher AG, Hedman L, Hogman C, McClusky DA 3rd *et al*. Proficiency-based virtual reality training significantly reduces the error rate for residents during their first 10 laparoscopic cholecystectomies. *Am J Surg* 2007; **193**:797–804
13 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
14 Edmond CV Jr. Impact of the endoscopic sinus surgical simulator on operating room performance. *Laryngoscope* 2002;**112**: 1148–58
15 Fortes B, Balsalobre L, Weber R, Stamm R, Stamm A, Oto F *et al*. Endoscopic sinus surgery dissection courses using a real simulator: the benefits of this training. *Braz J Otorhinolaryngol* 2016; **82**:26–32
16 Fried MP, Sadoughi B, Weghorst SJ, Zeltsan M, Cuellar H, Uribe JI *et al*. Construct validity of the endoscopic sinus surgery simulator: II. Assessment of discriminant validity and expert benchmarking. *Arch Otolaryngol Head Neck Surg* 2007;**133**:350–7
17 Ogino-Nishimura E, Nakagawa T, Sakamoto T, Ito J. An endoscopic endonasal surgery training model using quail eggs. *Laryngoscope* 2012;**122**:2154–7
18 Rudman DT, Stredney D, Sessanna D, Yagel R, Crawfis R, Heskamp D *et al*. Functional endoscopic sinus surgery training simulator. *Laryngoscope* 1998;**108**:1643–7
19 Varshney R, Frenkiel S, Nguyen LH, Young M, Del Maestro R, Zeitouni A *et al*. The McGill simulator for endoscopic sinus surgery (MSESS): a validation study. *J Otolaryngol Head Neck Surg* 2014;**43**:40
20 Steehler MK, Chu EE, Na H, Pfisterer MJ, Hesham HN, Malekzadeh S. Teaching and assessing endoscopic sinus surgery skills on a validated low-cost task trainer. *Laryngoscope* 2013; **123**:841–4
21 Steehler MK, Pfisterer MJ, Na H, Hesham HN, Pehlivanova M, Malekzadeh S. Face, content, and construct validity of a low-cost sinus surgery task trainer. *Otolaryngol Head Neck Surg* 2012;**146**:504–9
22 Malekzadeh S, Pfisterer MJ, Wilson B, Na H, Steehler MK. A novel low-cost sinus surgery task trainer. *Otolaryngol Head Neck Surg* 2011;**145**:530–3
23 Awad Z, Taghi A, Sethukumar P, Tolley NS. Construct validity of the ovine model in endoscopic sinus surgery training. *Laryngoscope* 2015;**125**:539–43
24 Delgado-Vargas B, Romero-Salazar AL, Reyes Burneo PM, Vasquez Hincapie C, de Los Santos Granado G, Del Castillo Lopez R *et al*. Evaluation of resident's training for endoscopic sinus surgery using a sheep's head. *Eur Arch Otorhinolaryngol* 2016;**273**:2085–9
25 Arora A, Lau LY, Awad Z, Darzi A, Singh A, Tolley N. Virtual reality simulation training in otolaryngology. *Int J Surg* 2014; **12**:87–94
26 Fried MP, Satava R, Weghorst S, Gallagher A, Sasaki C, Ross D *et al*. The use of surgical simulators to reduce errors. In: Henriksen K, Battles JB, Marks ES, Lewin DI, eds. *Advances*

https://doi.org/10.1017/S0022215117002183 Published online by Cambridge University Press

in Patient Safety: From Research to Implementation (Volume 4: Programs, Tools, and Products). Rockville, MD: Agency for Healthcare Research and Quality (US), 2005;165–77
27 Wiet GJ, Stredney D, Wan D. Training and simulation in otolaryngology. *Otolaryngol Clin North Am* 2011;**44**:1333–50, viii–ix
28 Tolsdorff B, Pommert A, Hohne KH, Petersik A, Pflesser B, Tiede U *et al*. Virtual reality: a new paranasal sinus surgery simulator. *Laryngoscope* 2010;**120**:420–6
29 Nogueira JF, Stamm AC, Lyra M, Balieiro FO, Leao FS. Building a real endoscopic sinus and skull-base surgery simulator. *Otolaryngol Head Neck Surg* 2008;**139**:727–8

Address for correspondence:
Mr Michael Chan,
ENT department,
Freeman Hospital,
Newcastle upon Tyne NE7 7DN, UK

E-mail: Michaelchan@doctors.org.uk

Mr M Chan takes responsibility for the integrity of the content of the paper
Competing interests: None declared

https://doi.org/10.1017/S0022215117002183 Published online by Cambridge University Press