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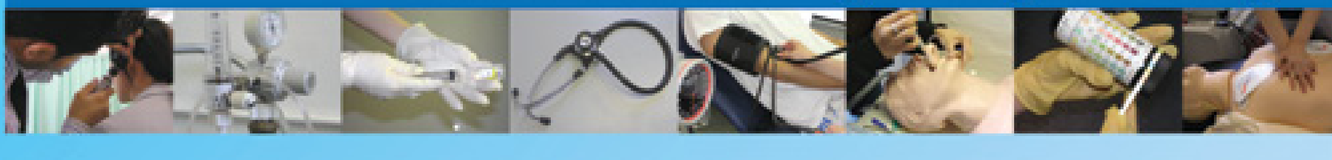
- 'docendo ac discendo' - 'by teaching and learning'



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Executive Board

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The International Journal of Clinical Skills looks forward to contributing positively towards the training of all members of the healthcare profession.

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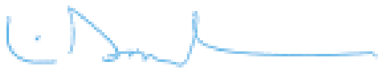
A Message from the Chief Medical Officer for England, United Kingdom

The systematic and safe acquisition of high quality clinical skills is an essential part of modern medical training as highlighted in my Annual Report published in March 2009. I wish the International Journal of Clinical Skills every success in highlighting research and knowledge in this important area.



Sir Liam Donaldson
The Chief Medical Officer for England

The ophthalmic surgical simulator: integrating virtual training into ophthalmic surgical skills tuition

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Abstract

Simulated surgical environments are increasingly being recognised as important complements to traditional theoretical and operating theatre tuition for surgeons. We report the introduction of a computer based surgical simulator to further integrate ophthalmic surgery into the training programme of the Royal College of Ophthalmologists (UK). The potential benefits of its use in training and as an assessment tool are discussed, together with caveats which must be considered. The integration with other teaching techniques, including existing skills centre training and e-learning are described.

Introduction

The ancient code of Hammurabi proscribed the punishment of hand amputation for practitioners unfortunate or careless enough to cause a patient to go blind following surgical intervention. Although the personal consequences to the modern day surgeon of human error are not so extreme, our patients still bear the legacy of any such failings for the rest of their lives. In an era of high patient expectations, open and public audit of surgical outcomes and omnipresent medico-legal surveillance of our practice, the need for robust and rigorous surgical training has never been greater. The days of 'see one, do one, teach one' are long gone. At the same time, service delivery targets, limits to junior doctors' hours and shortened fixed term training schemes which accompany "run through" training have imposed additional pressures on trainees and their seniors alike.

The delicate nature of ophthalmic surgery and the limits imposed simply by the small size of an eye, such that there can only be one surgeon operating on it at a time, have provided practical difficulties in training surgeons since eye surgery first began. In addition, however, the introduction of the binocular operating microscope into intraocular surgery as a routine practice from the 1970's onwards, required surgeons to master new skills of coordination and in turn pass these on to their trainees. Cataract surgery is now routinely undertaken under local anaesthetic, imposing further constraints on teaching. Perhaps for these reasons, ophthalmic surgeons embraced in-vitro training systems from an early stage. The vision of pioneers such as Larry Benjamin and Nigel Cox who started basic surgical training courses for fledgling ophthalmic surgeons in the 1980's established a firm ethos of training under simulated conditions at an early stage in the evolution of clinical skills training.

Recent developments in technology have allowed the development of virtual reality simulators to assist in the training and assessment of ophthalmic surgeons. This article reports the early experiences of the incorporation of the EYESi ophthalmic surgical simulator into training programmes at the UK's Royal College of Ophthalmologists.

The Simulator
The EYESi surgical simulator (VR magic) is a computer based simulator for intraocular surgical training, including cataract and vitreo-retinal procedures (Figure 1). During simulated surgery, the surgeon uses handheld instruments which are placed into

a model eye, from which a virtual image of the instruments' movements is generated through sensors which detect the manipulations made by the surgeon. These are projected to be viewed in three dimensions through the surgeon's binocular eyepieces, as would be the case in a real-life situation. In addition, the operation can be viewed by an observer on an adjacent monitor. The real strength of the system lies in the fact that the course of any procedure is not predefined, but determined by the surgeon's activity according to basic physical principles.

Figure 1: The EYESi simulator in use

Potentially there are no limits to the techniques that can be practised, but in the relative infancy of its introduction, the machine has to date been used mainly for training surgeons in vitreo-retinal manoeuvres and the basic steps of cataract surgery. One of the more challenging aspects of intraocular surgery to the complete novice is the development of the basic skill of manipulating instruments in three dimensions, without the benefit either of tactile feedback, or the ability to see his hands, which are outside the field of view of the viewing microscope. To this end, the simulator offers training modules to practise basic techniques such as picking up small cubes with forceps and then moving them into a position where they are released. Although this does not simulate any real surgical situation, it provides practise and enhances dexterity prior to attempting more complex tasks.

The simulator allows rehearsal of most of the steps of routine cataract surgery and as new software is written the menu of tasks that can be practised is increasing. In addition the software allows surgeons to alter the settings on a virtual phacoemulsification machine, which is the equipment used to deliver the ultrasonic emulsification of the crystalline lens in modern cataract surgery. As in many surgical procedures, an understanding of the technology that surgeons use is critical to successful outcomes, and the ability to experiment with different machine settings in the virtual environment rather than in the live operating theatre environment is an obvious benefit to patient safety.

Each task that the surgeon undertakes on the simulator is preceded by an on-screen explanation of what is required, together with a description of the medical context in which it is used. For example, the critical process of *capsulorhexis* (in which the surgeon makes a continuous 360 degree, 5 mm diameter circular tear in the delicate anterior capsule of the bag containing the crystalline lens) is key to the subsequent success of lens extraction. The simulator provides instruction on how to accomplish this procedure and at conclusion of the exercise provides a score out of 100, together with further analysis of any deficiencies in technique. These may include inadvertent touch of the cornea, which in real life is to be avoided at all costs or other instances of poor tissue or instrument handling. This system is invaluable in the teaching respect for delicate tissues, which can lapse when concentrating on challenging tasks. Success in a module can then be followed by an increase in the level of difficulty of the task, such as making the virtual lens capsule more fragile and liable to tear off in an unwanted direction.

The simulator also reproduces the foot controls used in ophthalmic surgery; the microscope controls for focus, zoom and X-Y shift, and the pedal controlling ultrasound power and aspiration and irrigation settings. Since understanding and control of these is an integral part of the surgical process, the ability to monitor a surgeon's performance in using them adds to the realism of the situation.

All simulations can be played back immediately after completion, so that the surgeon can view and learn from his errors. In particular, this is useful to highlight the aspects of surgery on which he may not have been concentrating in his eagerness to complete the task. As well as the issues of respect for tissues described above, this may include lack of awareness, for example, of focussing the microscope or other equipment issues, such as instrument settings.

In all, the simulator provides a comprehensively realistic environment, with the flexibility to develop individual programmes and monitor progress. The simulator was incorporated into training courses at the UK's Royal College of Ophthalmologists from October 2008 following its donation to the College by the London Deanery.

Incorporation in to the surgical skills faculty

The basic skills courses

A number of surgical training courses are provided for surgeons at all levels at the Royal College of Ophthalmologists. For the past ten years, attendance at a three day basic surgical skills course has been mandatory for all trainees prior to being allowed to undertake intraocular surgery. This course, developed from the original optional course of Benjamin and Cox, includes classroom based instruction in basic principles of wound construction, suturing, knot tying, needles and sutures, as well as phacoemulsification cataract surgery. In addition, the course provides intensive practice in these topics, using "skills boards" (Figure 2) which allow suture and knot tying practice, porcine eyelids to practise lid repairs, and skills centre practice using both porcine and prosthetic eyes. The skills centre (Figure 3) contains nine stations equipped with microscope and phacoemulsification machines on which trainees can familiarise themselves also with the operation of the hardware technology involved in modern cataract surgery.

Figure 2: The College "Skills Board"

Figure 3: The Royal College of Ophthalmologists Skills Centre

Course feedback from trainees has been encouraged since its inception, which has led to refinement and development of the curriculum covered. In the last twelve months, preparation for the course has been started prior to attendance via web based interactive e-learning, to maximise available practical time on the course and optimise learning outcomes. Similar blended learning strategies have previously been shown to improve cognition and performance, as well as training efficiency in the teaching of basic surgery [1]. Trainees now prepare for attendance online and their knowledge base is assessed at commencement of the course using an interactive audience participation system, whereby answers to questions can be projected via handheld remotes given to each delegate (Figure 4). This allows anonymous participation in the assessment, but facilitates feedback of scores both to the individual and a group analysis of the score for each topic. This in turn allows trainers to tailor the course to the appropriate level of knowledge.

Figure 4: Trainees using Q-Wizdom interactive audience participation system

The EYESi simulator is a natural partner to the facilities already available for skills training and not surprisingly was enthusiastically received by trainees who are generally highly skilled in IT, and often also adept at computer based simulations at a recreational level. The limiting factor of having only one simulator to be shared by up to 18 trainees over a three day period mandated that training on it was confined to relatively short periods. We therefore elected to train delegates on the courses two at a time, giving them instruction first in how to care for the very delicate equipment comprising the simulator, and then on how to access training modules themselves, followed by some free time to practice basic surgical manoeuvres. All trainees who have been trained have subsequently been allowed free access to use the simulator, by pre-booking a session either alone, or with colleagues or a trainer from their base hospital. Although the take up of this has been encouraging, there are clearly practical constraints for doctors working in units distant from the London base of the Royal College.

The simulator is very new technology and updates of the software are regular and ongoing. At present, although different levels of difficulty of individual components of surgery can be simulated, it is not possible to recreate complications, although with time it is likely that this facility will be available. Trainees obviously also continue to train in the traditional operating theatre setting and in other simulated environments. It is therefore difficult to quantify the value of the learning experience from the EYESi simulator on individuals, but anecdotal reports and feedback from trainees is positive. In particular it appears that it has given confidence to those commencing new steps in cataract surgery, the example of *capsulorhexis* described above being an often cited one.

Assessment and retraining

The difficulties in objectively evaluating surgical dexterity are well documented [2] and attempts to date have included complex systems using motion analysis based on multiple camera systems [3] or the use of labour intensive objective scoring criteria [4]. Most selection committees for ophthalmology trainees now include stations to assess candidates' potential surgical abilities, but these are fraught with inconsistencies and difficulties in comparing trainees at different levels of surgical maturity. The attractions of an objective and realistic analysis of ophthalmic surgical skills are therefore obvious, but any such data produced must be used with caution and interpreted in the context of the environment under which it is collected, previous experience with surgical simulators and past live surgery training. With more widespread use of computer based simulators and consequently a larger database of expected scores from trainees at any particular level, it is likely that the technology will have some role in assessment if sensitively used.

The obvious extrapolation of such inferences is that there may be a role for assessing or retraining failing surgeons or revalidating those in practice. The appetite from both within and outside the profession for a robust mechanism of validating current surgical practice has been recognised for some time [5] – once again, however, extreme caution is needed. Surgeons develop difficulties for many reasons and it is important to consider all of these. A score on a simulator alone in no way addresses all of these issues and in isolation is incapable of providing a robust analysis of a surgeon's abilities. It has however already provided support to surgeons experiencing difficulties as part of a rehabilitation programme. Those who, for whatever reason, have been out of clinical practice for some time have found the simulator to be a useful reintroduction to cataract surgery and we envisage this to be a developing role of the surgical simulator.

Discussion

The importance of using technology to simulate live surgical situations is now well recognised and indeed, was the focus of the most recent annual report by the Chief Medical Officer for England [6]. The Royal College of Ophthalmologists was eager to embrace such innovation and the EYESi surgical simulator has undoubtedly been welcomed by trainees and trainers alike. Initial experiences have been encouraging. They have also however highlighted the need for much more widespread dissemination of the technology before simulators can become a routine and effective mode of training. The availability of only four machines within the UK at the time of writing imposes severe restrictions on the access to simulator training. Work on it is tiring and requires enormous concentration, such that training is probably best accessed on a regular basis for relatively short periods. With such limited availability, this schedule is clearly only practical for a small minority of trainees at present. Ideally, a simulator should be available in at least every training region.

The simulator should be used as one of a number of aids to clinical skills tuition. Although it is superior to other existing facilities in teaching some tasks, skills boards are still better for training in suture placement and knotting. The skills centre, with artificial or porcine eyes and real microscopes and cataract machines, allows trainees to operate with exactly the same equipment as in real life and practise some manoeuvres which still remain beyond the scope of simulators at present. Its limitation is the ability of the materials available to be operated on to recreate real conditions. Clinical skills centres can be run with multiple stations, with a class all undertaking similar tasks under the supervision of a sole tutor, who is still able to monitor individual performances through video camera surveillance. The simulator however, lends itself either to one-to-one tuition or self-directed practice and is therefore better deployed by being widely disseminated geographically, such that all trainees can regularly practise without the need for distant travel. Whilst skills centre training can be occasional and grouped, we envisage that simulator training will develop in to a regular activity that surgeons partake in as part of continuing professional development. Colleges will have a role in developing training programmes and benchmarking standards which trainees at any particular level should aspire to.

The media often draw parallels between the training of pilots and surgeons. Although such comparisons can be illuminating, they can also be misleading. The ideal of being able to simulate every possible complication that a surgeon might face is likely to remain an aspiration. Even if software developments allow progress in this direction, the prospect of regular simulator assessments to revalidate surgeons is an unlikely one in the near future. Yet we should not fail to learn from the aviation industry that timely investment in simulators and serious commitment to risk reduction can pay dividends.

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Declaration of financial interest

The author has no financial interest in any of the products described in this paper.

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