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REVIEW

Trabeculectomy Training: Review of Current Teaching Strategies

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Andrew Walkden[1,2]
Leon Au[1,2]
Cecilia Fenerty[1,2]

[1]Manchester Royal Eye Hospital, Manchester University Foundation Trust, Manchester, UK; [2]Medical Academic Health Sciences Centre, University of Manchester, Manchester, UK

Abstract: The aim of this paper is to introduce readers to potential strategies available for teaching trabeculectomy surgery. Trainee surgical outcomes and various surgical simulation techniques are discussed, with suggestions on how to measure progress and consideration of relevant educational theories.

Keywords: trabeculectomy training, ophthalmic surgical skills training, simulated surgical training, simulated trabeculectomy training, trabeculectomy surgical training

Purpose

The aim of this paper is to present the current strategies available for teaching trabeculectomy surgery, with reference to the literature that surrounds this topic. A comprehensive review of the literature was perfomed using PubMed search terms; "Trabeculectomy and training", "trabeculectomy simulation", "glaucoma surgical training" and "teaching trabeculectomy surgery". A full systematic review of the literature using the PubMed database was conducted up until 1/05/19. The articles used were written in English, with all articles accessed in full. Both review articles and original articles were used for this review. Evidence from the literature was compiled in conjunction with anecdotal experience of the authors.

Introduction

Trabeculectomy remains the gold standard surgical intervention for lowering intraocular pressure (IOP). Despite the exciting developments involving minimally invasive glaucoma surgery, trabeculectomy is still required as part of a glaucoma surgeon's armamentarium. In the attempt to lower IOP, trabeculectomy historically has been the initial glaucoma operation of choice, with tube shunts reserved for refractory glaucomas.[1] Tube surgery has been reported to have lower complication rates, although large multicentre studies have shown the success rate of trabeculectomy to be significantly better than tube surgery in the first year when used as a primary procedure. Patients have also been shown to require less topical medications post trabeculectomy surgery.[2] More longer term data is expected to be produced from future large scale studies.[2]

Current trends towards subspecialisation, an increasingly litigious working environment, and European Working Time Directive obligations can make training opportunities difficult to find and can impact on a trainee's ability to undertake glaucoma surgery.[3] Availability of other surgical interventions may also play a role in decreasing numbers of trainee operations being performed.[4] Trabeculectomy surgery has been

Correspondence: Andrew Walkden
Manchester Royal Eye Hospital, Oxford Road, Manchester M13 9WL, UK
Tel +44 77 9215 3269
Email walkdenandrew@gmail.com

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suggested in the past as an ideal way to introduce trainees to intraocular surgery, as it provides the opportunity to learn basic tissue handling skills and suturing.[5] It also provides the platform to learn other similar techniques such as drainage device, non-penetrating, and iridocorneal angle surgery.

Modern ophthalmic surgical training programmes introduce trainees to intraocular surgery in the form of phaco-emulsification cataract surgery,[6] which means some of the more generic skills required for intraocular surgery such as conjunctival handling and suturing can be neglected. With the availability of different pharmaceutical classes of IOP lowering medication, trabeculectomy rates have been shown to decrease over the last decade.[7]

From a training perspective, modern surgical training has made attempts to move away from the Halstedian method of "see one, do one, teach one" when training surgical skills.[8] Many curricula now involve the use of simulation based training prior to undertaking live surgery on patients,[9,10] and this is likely to result in safer surgery and better patient outcomes.

Trainee Trabeculectomy Outcomes

Although trabeculectomy surgery has been shown to be safe and efficacious in terms of reducing IOP from large studies,[2,11,12] limited information exists with regards to trainee outcomes. One of the largest studies of trainee surgery from the UK analysed over three hundred cases, and found supervised trainee trabeculectomy outcomes to compare favourably with those of consultants in terms of qualified and unqualified success rates.[13] Of note, trainee outcomes were similar to those reported in large national landmark studies.[11,12] Other studies from the UK and the US reinforce the notion that acceptable supervised trainee surgical outcomes can be achieved.[5,14–17]

As would be expected, trainee groups have been reported to have significantly higher complication rates when compared with consultant cases, with bleb leaks and hypotony being the most frequent complications.[13,15] Bleb closure and suturing techniques have therefore been suggested as an area to be specifically targeted in terms of improving trainee outcomes, echoing previous suggestions from the literature that this may be a result of suturing skills being encountered less frequently in modern surgical training.[5,13,15]

It is difficult to directly compare the outcomes of these studies as different definitions of success are used in conjunction with varying lengths of follow up data and trainee surgical experience. It must also be stressed that trainees are more likely to undertake less complicated "training cases" which makes direct comparison with consultant outcomes difficult. Nevertheless, the current evidence available from the literature does reassure us that safe outcomes can be achieved with appropriate case selection. It also allows us to reassure patients that successful outcomes can be achieved if cases are being performed by trainee surgeons. It does however remain intuitive that high-quality senior supervision is fundamental to successful trainee outcomes.

Simulated Surgical Training

The use of surgical simulators for training and assessment has been used successfully by different medical training bodies. A variety of techniques have been employed to aid clinical and surgical skills training, assessment and clinical scenario management.[18] Simulation provides educators with the freedom of focused training in a more controlled environment without risking harm to patients. From a trainee perspective, it allows the chance to practice the skills required of a modern surgeon to achieve proficiency at their own pace, becoming comfortable with the basic steps of certain techniques before entering the potentially stressful learning environment of the operating theatre. The greatest advantage of virtual reality medical simulation is the opportunity to try and fail without consequence for the patient.[19] More recently, surgical simulation has been formally integrated into training programme curriculae, with institutions acknowledging the importance of providing these opportunites at any early stage in training.[9]

High-fidelity, interactive, virtual reality computer based simulation techniques have been employed successfully in ophthalmic training for teaching basic phacoemulsification skills. The Eyesi™ (VR MAGIC),[20] allows many aspects of the operation to be recreated, including an adjustable operating table, foot pedals and surgical instruments that are inserted through "incisions/ports" on a model "eye". The surgeon sits in the usual position looking through an operating microscope whilst instrument interaction with the tissue and ocular structure is simulated in real time. It has been shown to improve trainee cataract surgical outcomes, with the ability to target more difficult steps in surgery if required.[21–24] To the best of our knowledge, no dedicated trabeculectomy virtual reality simulators exist. This is likely to be a result of supply and demand, given the subspecialist nature of the surgery, the cost of developing the technology and subsequent purchase of the equipment by educational institutions. It is easier to justify the cost effectiveness of

virtual reality simulators for commonly performed procedures, such as phacoemulsification surgery. However a newer vitreoretinal module now exists, so there may be further developments in subspecialist glaucoma surgery in the future.

Cadaver/Porcine Models

The lack of virtual reality simulation techniques is not an issue with the other methods available. Given the tissue handling and suture techniques involved in trabeculectomy surgery, animal and simulated models lend themselves well to refining these techniques.

Human cadaver models using high-molecular weight osmotic material to dehydrate specimes have been described by authors within the literature. Globe-holding devices can also be employed.[25] Porcine models have been suggested as a cheaper and more readily accessible training tissue. It is important to consider that these methods require access to a dedicated training space with microscopes and sterilisable equipment. Preparation of autopsy globes requires specific care as formalin and Karnovsky solution fixatives are used, therefore requiring protective eye wear. Eyes obtained from eye banks for non-transplantation usage may not always have been tested for infectious diseases, with costs varying markedly. Despite the potential educational benefits, the use of such specimens present their own challenges which can be potentially off putting.

Synthetic simulation models provide the opportunity to bypass these issues, and they do not require the use of sterilised equipment. A variety of models can be found,[26,27] varying from eyes with and without conjunctiva or rectus muscles. There are significant advantages to using such synthetic models, but critics will argue that the fidelity of human tissues are extremely difficult to replicate. A lower cost alternative using apples to practice creating a scleral flap has been described, with apparently good effect.[28]

Why Does It Work?

To the best of our knowledge there is no available peer reviewed evidence to suggest a superior approach to training trabeculectomy surgery via simulation methods. The authors have direct experience of using such models and have found them useful for teaching the basics of trabeculectomy surgery. They certainly offer the ability to become comfortable with critical steps prior to performing them live on patients. It is obvious that simulation methods should not, and will never replace the educational benefit of time spent in theatre by trainee surgeons, but can be used as a highly effective adjunct.

When considering educational learning methodology, in particular Kolb's theory,[29,30] it is easy to argue how simulation techniques can improve practical skills. Kolb states "learning is the process whereby knowledge is created through the transformation of experience".[30] He suggests that concrete experiences are required initially in order to allow time for reflection and abstract thinking to occur, so that we can actively experiment with concepts.[30] Just like practicing any skill, repetitive practice allows students to enter this learning cycle and consequently improve their technique. This enables a constructivist approach to learning.[31] Active learning is facilitated, whilst reflection can occur during periods of non-use. Repetition of scenarios then allows the learner to build upon "real life" concrete experiences,[31] and amalgamate these experiences with those encountered during practise, and vice versa. The trainee can revisit difficult surgical steps in a simulated setting prior to returning to a real life environment, for example conjunctival closure, which has been suggested as an area to be targeted in order to improve trainee outcomes.[13,15] This creates a "hybrid" of real life and virtual experience, which summate to a stronger learning experience. It must be noted that for this to occur, the virtual reality experience needs to be accurate enough to recreate real life surgical scenarios, which these methods certainly do.

Assessing Proficiency

In general, assessment of surgical skill is often based on subjective measures and measured by complication rates and successful outcomes. Additionally, live surgical cases do not offer the same consistent environment often required for assessment. The simulation methods mentioned above provide the trainee and assessor with the ability to replicate and repeat surgical scenarios with consistency in order to assess improvement and aid skill acquisition. These tools are valuable for surgical education, especially in the earliest stages of training as it allows the opportunity to give constructive feedback based on performance in a non clinical environment away from the operating theatre. Operating theatres are associated with additional factors that can affect learning in the earliest stages of training, whether it be time stressors, complex cases and patient expectations. From our experience and those of others, it can be highly beneficial for the

rudimentary phases of surgical procedures to be practiced using simulation techniques prior to entering this potentially difficult environment.[21] This allows the basic steps to be acquired before attempting live surgery, potentially improving patient outcomes and maximizing the time available in theatre for more advanced learning and skill acquisition.

In recent decades, there has been an increasing trend toward assessing competence of practical skills using specific competency based systems also known as Ophthalmology Surgical Competency Assessment Rubrics (OSCARS), and these have been successfully incorporated into various ophthalmic training curriculae around the world[6,32,33] These rubrics often deconstruct an entire procedure into individual steps that can then be individually analysed and measured, creating a score that can then be compared against future assessments. A description of the performance necessary to achieve each grade in each step is given. These rubrics are available for many ophthalmic procedures, such as ECCE, phacoemulsifcxation and strabismus surgery. One rubric for assessing trabeculectomy performance has been described in great detail by authors within the literature after collating opinions from surgeons around the world and has since been accredited by the International Council of Ophthalmology.[34] The authors opted to apply the Dreyfus model[35] in order to design their assessment tool, taking into account the expected stages of skill acquisition.[34] This OSCAR allows reliability, validity and feasibility, which have been described as the prerequisite markers of a successful assessment tool[34] Although it is intended to be used to assess live surgery, there is potential for certain aspects of the assessment to be used with simulation models, as has been suggested by other colleagues.[26] The authors themselves highlight the fact that the length and detail of the tool may act as a disincentive for its use, although they claim in practice assessments can be completed in a few minutes. In addition there is the suggestion that the prior experience of the trainee is relevant, as a junior trainee being assessed at a novice level could be deemed acceptable, but the same performance in an advanced trainee would be a cause for concern. One potential pitfall for this approach could be differing levels of ability being deemed acceptable. It may be more useful to define a strict standard for what is deemed "surgical competence" in trabeculectomy surgery, so that this benchmark can be aimed for by all trainee surgeons irrelevant of prior experience and stage of training. Another perceived difficulty for a trainee may be the variations in surgical technique that different trainers may employ, for example different antimetabolite use or use of an anterior chamber maintainer. In reality, these variations are likely not to be relevant when considering the greater picture of developing competency in a surgical technique. In fact, trainee surgeons are often in the privileged position of being able to witness a variety of different techniques and approaches to the same surgical procedure by different surgeons. This allows the opportunity to develop and refine their own "optimal" individual surgical technique.

Which Technique?

Given the effectiveness and popularity of trabeculectomy surgery, it will be of no surprise that there are a plethora of variations in terms of approach and technique, much of which is a result of surgeon preference and experience.[36,37] Modern-style trabeculectomy incorporates safety features such as a fornix-based conjunctival flap, buried releasable sutures, water-tight conjunctival closure and varying antimetabolite usage. As previously discussed, experiencing a variety of approaches can be advantageous for trainees developing their surgical skills. Although there is no substitute for time spent observing and being guided by senior surgeons, it can be useful to be aware of the basic steps and techniques required, with much of this information available in various text books and online videos. Although different institutions and surgeons are likely to have their own preferences, we recommend the Moorfields Safer Surgery System[38,39] as a comprehensive guide for deconstructing and understanding trabeculectomy surgery. This paper describes in detail each step, offering advantages and disadvantages of technique variations, for example different sizes and shapes of scleral flaps and antimetabolite usage. Using the techniques described, the authors report an excellent success rate of 96.7% at 3 years in a complex case mix.[40]

Conclusion

We have discussed the available literature on trainee surgical outcomes and provided insight into how modern training techniques can be adopted to learn trabeculectomy surgery. Experienced surgeons will no doubt have their own approach to teaching these skills but we hope this offers a summary of the strategies available that can be adopted by trainers and trainees alike to augment learning and help to improve the outcomes of future glaucoma surgeons. It is worth mentioning at this point that higher degrees in education can be undertaken by trainees and educators alike in order to improve teaching and training

skills. Courses such as the "Train the Trainer" course[41] also offer the opportunity to refine individual training skills. Although it is important that trainees take responsibility for their own learning using the methods detailed above, it is the authors' belief that the quality of teaching and training is often determined by the surgical opportunities made available to students by their teachers. This may require surgical trainers specifically investing in their own professional development, whether in the form of higher qualifications or time allocated during the working week specifically dedicated to training. The authors feel that this would improve glaucoma surgical training and therefore patient outcomes both today and in the future.

Disclosure

The authors report no conflicts of interest in this work.

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