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ORIGINAL ARTICLE

Use of the Eyesi virtual reality simulator during and after the COVID-19 pandemic and its relevance to phaco-emulsification surgery future training planning

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Abstract

Background: This study aimed to a find a consensus on the validity of a new hybrid surgical training scheme at times of pandemics and post-pandemics including: (1) identifying a minimum number of surgical sessions sufficient for steady surgical progression using the Eyesi virtual reality (VR) simulator alone during the pandemic, and live surgery sessions alone or in combination with the Eyesi VR simulator in the post-pandemic phase; and (2) predicting surgical performance and progression using the Eyesi VR simulator inbuilt modular reports and their role and validity as alternatives to surgical supervisor reports during pandemics. **Method:** A prospective study using a tailored, structured anonymized questionnaire of the mixed open questions and closed questions type was carried out over two years from March 2020 to March 2022. **Results:** Fifty-eight responses favoured one surgical session as sufficient to maintain and improve surgical performance using the Eyesi VR simulator alone or live surgery alone or combination of both; fifty responses favoured two surgical sessions. In all 108 responses, participants indicated that a combination of practice on the Eyesi VR simulator and live surgery is advantageous in improving surgical skills versus live surgery practice only. Additionally, 79 responded that practice on the Eyesi VR simulator alone might enhance the acquisition of surgical skills and improve performance, which can predict in parallel an improved surgical performance on live cases, but 29 responses did not support this notion. **Conclusions:** A dedicated 1–2 sessions of practice on a surgical Eyesi VR simulator alone during pandemics, or a combination of the Eyesi VR simulator and live surgical cases or sole live surgery during post-pandemic times, might be an integral part of the training curriculum to ensure a steady improvement in the acquisition of surgical skills. The use of the Eyesi VR simulator modular reports might be helpful as an alternative to surgical supervisor reports at times of pandemics or in conjunction with these at post-pandemic times.

Keywords: *simulator; virtual reality; training; assessment; operating room; posterior capsular rupture*

Introduction

There is a worldwide recognized increased need to address ophthalmic surgical learning in general and phaco-emulsification in particular.[1] There is also a rising need to estimate, predict and measure this learning process from the early stages up to senior levels via regular supervisors' reports and simulation platform reports.[2] Different types of simulation have been tried as part of this learning process, many of them proving to be integral for learning.[3]

The demand to monitor and improve the phaco-emulsification learning process among different grades of eye surgeons alongside the increased need for simulated surgical learning became more evident during the COVID-19 pandemic, and the position of simulation has been well recognized during a time of staggered surgical training.[4]

The popularity of the use of surgical Eyesi VR simulators in general and the Eyesi simulation platform specifically increased during the COVID-19 pandemic.[5] There is unequivocal evidence in the literature that training on the Eyesi virtual reality (VR) simulator is essential for the progression of surgical skills. This progress can be measured using well-defined computer software via sequential score-based modules.[6–10] The scores in each module on an eye surgery Eyesi

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VR simulator in the early stages of a residency program may help to predict a resident's future performance in the operating room. It was found that these scores may allow early identification in an objective way of junior surgeons who might need supplemental training in cataract surgery.[6] Also, it has been noticed that proficiency-based training on an Eyesi VR simulator using its different modules can improve clinically relevant cataract surgical skills. Junior surgeons and surgeons of an intermediate level of experience showed progression in their operating room performance score.[7]

Additionally, Thomsen et al. concluded that performance on the Eyesi simulator as matched to real-life surgical performance can be significantly and closely correlated. However, it is recommended that data from multiple sources should be used to make performance and proficiency assessments.[8] Moreover, the results of a study by Solverson et al. showed that the performance of experienced surgeons can be quantified and monitored by the Eyesi VR simulator, and this simulator can also be a valid individualized task training platform that may help improve junior surgeons' dexterity to expert surgeon level.[9]

The Royal College of Ophthalmologists in London, UK, in its report from another study, came to the conclusion that the rates of unadjusted posterior capsular rupture (PCR) in the first and second years of ophthalmology training have decreased since 2009. This has significant benefits for patients undergoing cataract surgery, and this 38% reduction in complication rates aligns with the introduction of Eyesi VR simulator training.[10]

Materials and methods

The questions in this questionnaire were informed by searching peer-reviewed journals on online sources like PubMed, Google Scholar, and Embase using the search key words: phacoemulsification, simulation, Eyesi, COVID-19, training, learning. A mixed open questions and closed questions type of questionnaire was used in this study in a prospective way. Each respondent was given at least 24 h to read, understand and complete the questionnaire. The questionnaire was answered in an anonymized way whereby the names of respondents were removed but members of each of the three groups were given a code to identify their group.

The study was multicentre, with an equal number of questionnaires allocated to each group of surgeons.

Participants

A total of 108 ophthalmic surgeons of varying grades of experience in phaco-emulsification completed the questionnaire. There were 36 ophthalmology consultants, 36 middle grade surgeons and 36 ophthalmology junior surgeons. All of these surgeons were involved in simulation training during the COVID-19 pandemic period using the Eyesi VR simulator but to a variable level, and were involved in a combination of live surgery and VR simulation in the post-COVID-19 phase.

The duration of each training session on the Eyesi VR simulator and the number of cases/tasks were perceptually and practically matched to the duration of a standard teaching phaco-emulsification theatre list. Each session was for approximately 3 h including training on modular tasks that included: injection of viscoelastics, capsulorrhexis, hydrodissection, phaco-chop or divide and conquer, irrigation and aspiration, and intra-ocular lens (IOL) implantation. The participants were required to include simulator or live surgery sessions that were of similar duration, or to add up shorter sessions to make up one session of 3 h duration.

For the steps that did not feature in the Eyesi VR simulator like making corneal incisions and side ports, time could be compensated for by repeating some other tasks to match the same total amount of time for each session.

Main outcome measure

Direct questionnaires were completed during the period March 2020–March 2022 by ophthalmic surgeons of various levels of phaco-emulsification experience. The responses to these questions were based on each surgeon's own personal qualitative assessment based on the Eyesi simulator's inbuilt modular reports of progression and their personal surgical supervisors' reports and phaco-emulsification surgical audit, and each surgeon's own comparison of Eyesi VR simulator-based phaco-emulsification training alone during the COVID-19 pandemic compared with a combination of Eyesi VR simulator/real surgery training or predominantly real surgery on live patients during the post-COVID-19 phase. Each participant completed one questionnaire only. Bias was minimized by using questions that were checked against basic linguistic standards, and using simple, self-explanatory questions.

Statistical design and analysis

In this study, we used a purposive type of sampling with a mixture of critical case sampling, where participants are likely to provide important and specific answers to the research question, and maximum variation sampling, where the selected participants represent the whole range of a spectrum of eye surgeons whereby we could capture a full picture of different practices related to phaco-emulsification training from the responses in the questionnaire.

The sample size was calculated using the Survey Monkey Calculator. The sample size used at a 95% confidence interval was associated with a 5% margin of error for the study. The choice of 36 candidates in each response group was calculated using a two-tailed test based on power $(1 - \beta) = 0.80$ and $\alpha = 0.05$. The confidence interval was calculated by adding and subtracting the margin of error from the sample mean with the aid of a statistician. The *P*-value was calculated from the *t*-distribution table.

The chi-squared test, using the SPSS package, was used for analysis of the responses to define the level of significance. We used the chi-squared test because we mainly tested categorical variables in this study, with questionnaire answers of the yes/no type, or answers that returned percentages or counts.

Ethics and consent

Ethical approval was not required as the study did not involve patients or volunteers. All live surgery sessions were done as part of planned routine practice rather than as part of the study. All participants in the questionnaire survey have consented to the publication of the analysis of results.

Results

Responses received from all 108 participants indicated that a combination of practice on the Eyesi VR simulator and live surgery is predicted to have more benefit in improving surgical skills compared with live cases practice only. Additionally, 79 (73.1%) participants indicated that practice on the Eyesi VR simulator alone might enhance the acquisition of surgical skills with improved performance that can predict in parallel an improved surgical performance on live cases. These responses came from 24 consultants, 33 middle grade surgeons and 22 junior surgeons. Twenty-nine participants (26.9%) did not think that practice on the Eyesi VR simulator alone could predict surgical skills as reflective of real surgery practice. Of these, 12 were consultants, three were middle-grade surgeons and 14 were junior grade surgeons (Table 1). On the other hand, 58 responses (53.7%) thought that one surgical session of surgical Eyesi VR simulator training with or without live surgical training, or live surgery only may be sufficient to maintain and improve surgical performance, while 50 participants (46.3%) favoured two surgical sessions. The differences between these responses are statistically significant: the *P*-value is 0.00301 and after Yates correction the *P*-value of 0.004722 is also significant. Of these 58 responses, the grades of surgeons that favoured one session were 24 consultant surgeons, 18 middle grade surgeons and only 14 junior surgeons. Conversely the responses that indicated the need for two surgical sessions as a minimum comprised 12 from consultants, 18 from middle-grade surgeons and 22 from junior surgeons (Table 2).

Table 1. Questionnaire responses regarding Eyesi simulator predictiveness of real surgery skills and performance

Surgeon grade ($n = 108$)	Eyesi simulator can predict real surgery skills and performance	Eyesi simulator cannot predict real surgery skills and performance
Consultant ($n = 36$)	24	12
Middle grade ($n = 36$)	33	3
Junior grade ($n = 36$)	22	14

$P = 0.004722$ at 95% confidence interval.

Table 2. Responses from different grades of surgeon regarding number of surgical practice sessions required to maintain and improve phaco-emulsification skills

Surgeon's grade ($n = 108$)	Responses favouring 1 surgical session	Responses favouring 2 surgical sessions
Consultant ($n = 36$)	24	12
Middle grade ($n = 36$)	18	18
Junior grade ($n = 36$)	14	22

The responses in Table 2 are based on a perceived practically matched duration of session of training on the Eyesi VR simulator to the duration in the live operating room (OR) environment. The duration per session was 3 h, doing 4–5 cases, whereas in a standard teaching phaco-emulsification theatre list the number of cases ranges from 4 to 6. Also, the responses showed that 70% of consultants had 70% access to an Eyesi VR simulator during the COVID-19 pandemic, 40% access in the immediate 3 months post-COVID-19 pandemic, and 80% access to live surgery during the same post-COVID-19 phase. On the other hand, the responses showed that middle grade surgeons had 40% access to an Eyesi VR simulator during the COVID-19 pandemic, 45% access in the immediate 3 months post-COVID-19 pandemic and 55% access to live surgery during the same post-COVID-19 phase.

Junior surgeons had 95% access to an Eyesi VR simulator during the COVID-19 pandemic, 80% access in the immediate 3 months post-COVID-19 pandemic and 70% access to live surgery during the same post-COVID-19 phase (Table 3).

Table 3. Access to an Eyesi surgical simulator versus live surgery access among different surgeon grades

Surgeon grade	Simulation access during COVID-19 pandemic	Live surgery access during COVID-19 pandemic	Simulation access in 3 months post-COVID-19 pandemic	Live surgery access in 3 months post-COVID-19 pandemic
Consultant	70%	0%	40%	80%
Middle grade	40%	0%	45%	55%
Junior grade	95%	0%	80%	70%

Comparison between access to live surgery and simulated surgery is based on approximately 3 h sessions.

Discussion

This study tried to address an unmet demand to identify alternative designs of a training program for phaco-emulsification at times when there is suboptimal exposure to live surgery or when exposure is not possible at all.[11] The use of various types of surgical simulation was not only found to address this demand, but was also found to improve performance in certain surgical steps and decrease the rate of intra-operative complications.[12,13] The current study used a questionnaire that is specifically designed with a purposive selection method to include responses from eye surgeons of different grades of proficiency in phaco-emulsification surgery.

We found in this study that 73.1% of the respondents supported the view that training on the Eyesi VR simulator can improve surgical performance in vitro which can help to predict a similar performance on live cases. Findings from other studies have also supported the strong correlation between performance on the surgical Eyesi VR simulator and predictiveness of performance on live surgical cases and that actually improvement in performance on the Eyesi VR simulator reflects a similar improvement on surgical cases.[6–10]

Starting at junior level, Lucas et al. concluded that use of the Eyesi VR simulator has significantly lowered the rate of intra-operative complications performed by an individual for the first 10 phaco-emulsification operations.[14] Rothschild et al. concluded in their systematic review that there is good evidence that Eyesi VR simulator training was useful specifically to decrease the rate of intra-operative posterior capsular rupture and out-running capsulorrhexis, but found limited evidence in respect of other complications.[15] The Eyesi VR simulator was also found to be useful in assessing surgeons' dexterity in order to assist tailoring specific individual needs while designing training programs.[16]

Another finding from our study is that the Eyesi VR simulator modular reports can be used to certify an individual surgeon's progress and could be used as an alternative to supervisor surgical reports. In order to draw this conclusion, each surgeon response was perceptually based on exposure to a similar environment to match a training session on the Eyesi VR simulator with a live theatre session in terms of the total time allowed per session and the number of cases or tasks completed.

The well-structured modular assessment software of the Eyesi VR simulator was found to have a pivotal role in surgical skills acquisition. It helps classify surgical experience levels and improve performance on live cases.[17,18]

Also, another finding from our study is that 53.7% of responses supported the view that one surgical session of dedicated Eyesi VR simulator training or combined Eyesi VR simulator and live cases training per week may be accepted as a minimum sufficient number to allow the steady acquisition and improvement of surgical skills. This in practice will invariably mean less time in dedicated surgical sessions is needed for training.

Laurell et al. supported a similar view in their study when they concluded that, in addition to decreasing complications rates and maintaining surgical skills, Eyesi VR simulator training may shorten training time.[19] Daly et al. also concluded that the time spent to pass Eyesi VR simulator modules is predictive of performance and the time needed in the theatre.[20] Moreover, Belyea et al. concluded that junior surgeons who trained and completed Eyesi VR simulator modules were more efficient in using the phaco power, having fewer complications and shorter learning curves.[21] Furthermore, Chun Ng et al. concluded that trainee surgeons who completed all Eyesi VR simulator modules were more capable and confident to successfully complete the most challenging tasks of phaco-emulsification.[22]

Conclusion

This study attempted to provide focused answers towards addressing an increasing need to tailor an ophthalmology surgical training scheme at times of lack of exposure or suboptimal exposure to live surgical training and practice as in the COVID-19 pandemic and in the post-pandemic phase.

The study concluded that 1–2 sessions of dedicated Eyesi simulation practice alone or combined with live surgical practice is an appropriate starting point for such a scheme.

Furthermore, the study concluded that the Eyesi VR simulator system generated modular reports for each individual surgeon that might be used as a valid alternative to surgical supervisor reports at times of pandemics or similar crises.

Moreover, this arrangement might successfully be extended to post-crisis times as the study concluded that these Eyesi reports can successfully predict a surgeon's performance in live cases surgery.

However, further targeted research with a larger study sample size and more objectively structured questionnaires is recommended.

Also, this study has limitations in that the respondents to the questionnaire in this study are not of the same grade. Also, there needs to be more structured session matching in terms of documenting difficulties and complications encountered, and the appropriateness of the length of each session.

A future study should also take the difference in stress levels between live surgery practice and practice on the Eyesi VR simulator into consideration.

It might be more useful to perform a further study with similar questionnaires targeted at a specific group of surgeons with a junior level of phaco-emulsification experience, and another separate one with surgeons at a senior level.

Conflict of interest

None to declare.

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Data availability

The data supporting the findings of this article are available from the corresponding author on request.

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