

Efficacy of Eyesi[®] surgical simulator training in improving high-tension capsules capsulorhexis performance

Eficácia do treinamento com simulador cirúrgico Eyesi[®] em melhorar a capsulorrexe em cápsulas de alta tensão

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ABSTRACT

Purpose: To evaluate if Eyesi[®] cataract surgical simulator training using its standard course curriculum is effective in improving performance of cataract surgery trainees on creating capsulorhexis on high-tension capsules on the simulator. **Methods:** We retrospectively analyzed training reports of ophthalmic surgery trainees (2nd and 3rd year residents and cataract fellowship trainees) that have accomplished the standard Eyesi[®] cataract surgery simulator training course version 2.1 between May 2012 and August 2013 at Instituto de Diagnóstico e Terapia Ocular, Rio de Janeiro, Brazil. We compared the mean score (from 0 to 100) attributed by the simulator on performing the same task, a capsulorhexis on a high-tension capsule, on the surgical simulator “before training” (during beginning of the course) and “after training” (at later stages of the course). **Results:** Thirty-seven trainees’ reports were analyzed. Mean and standard deviation “before training” high-tension capsulorhexis score was 41.73 ± 27.08 points and the mean “after training” score was 72.55 ± 16.40 points, a difference of +30.82 points (p value <0.001 on Paired t test), representing a 73% improvement on performance. **Conclusions:** Eyesi[®] surgical simulator training on course version 2.1 curriculum was effective in improving performance of cataract surgery trainees on creating capsulorhexis on high-tension capsules.

Keywords: Capsulorhexis; Cataract extraction; Medical education; Phacoemulsification; Virtual systems

RESUMO

Objetivos: Avaliar se o treinamento realizado com o simulador cirúrgico de catarata Eyesi[®] e o seu currículo de exercícios padrão são efetivos em melhorar o desempenho de cirurgiões de catarata em formação na confecção de capsulorrexe em cápsulas de alta tensão realizadas no simulador. **Métodos:** Analisamos retrospectivamente relatórios de treinamento de residentes de 2^o e 3^o ano e fellows de catarata que realizaram o curso versão 2.1 de treinamento com o simulador cirúrgico de catarata Eyesi[®] no período de maio de 2012 a agosto de 2013 no Instituto de Diagnóstico e Terapia Ocular, Rio de Janeiro, Brasil. Comparamos o escore médio (de 0 a 100 pontos) atribuído na confecção de capsulorrexe em cápsula de alta tensão no simulador “antes do treinamento” (durante início do curso) e “depois do treinamento” (nos estágios finais do curso). **Resultados:** Trinta e sete relatórios de cirurgiões em treinamento foram analisados. O escore médio e desvio padrão da capsulorrexe em cápsula de alta tensão “antes do treinamento” foi de $41,73 \pm 27,08$ pontos e “depois do treinamento” de $72,55 \pm 16,40$ pontos, uma diferença de +30,82 pontos ($p < 0,001$ no teste t pareado), representando uma melhora de 73% no desempenho. **Conclusão:** O treinamento realizado com o simulador cirúrgico de catarata Eyesi[®] seguindo o currículo do curso versão 2.1 foi eficaz em melhorar o desempenho de cirurgiões em treinamento na confecção de capsulorrexe em cápsulas de alta tensão.

Descritores: Capsulorrexe; Extração de catarata; Educação médica; Facoemulsificação; Sistemas virtuais

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INTRODUCTION

Modern cataract surgery requires high skill levels to be performed with safety and reproducibility. Capsulorhexis is a critical step that can be challenging on situations such as high-tension capsules, even for experienced surgeons.

Formation of new surgeons is an issue on medical education as patient demands are rising and complications during surgical learning curve are usually more frequent. Surgical judgment and manual dexterity need to be improved with frequent practice and performance feedback on surgery learning process.

Cataract surgery training on virtual reality surgical simulators has become an effective tool in education of ophthalmology residents⁽¹⁻³⁾. Simulators have also been useful on developing new surgical techniques⁽⁴⁻⁵⁾, evaluation of the impact of stereo acuity, distraction and sleep deprivation on cataract surgeons performance⁽⁶⁻⁹⁾ and even in certification of surgeon abilities, without exposing patients to risk^(10,11). Eyesi® surgical simulator (VRMagic, Germany) is a high-fidelity virtual reality device developed for intraocular surgery training, including cataract and vitreoretinal procedures (Figure 1). It has also been validated as a model for capsulorhexis training^(12,13) and its use as a training tool by ophthalmology residents is associated with a shorter and safer learning curve on cataract surgery⁽¹⁾.

The simulator software evaluates surgeon's performance in each particular task considering objective aspects, like completion of the given task, time for doing it, extension of movement of instrument inside the eye, positioning of the globe, handling of the instruments and intraocular tissue damage during the training procedure⁽¹²⁾. As a virtual reality computer based simulator, it offers the possibility of developing different tasks for manual abilities training and a curriculum of activities with an educational structure.

The purpose of this study is to evaluate if Eyesi® cataract surgical simulator training using its standard course curriculum is effective in improving performance of cataract surgery trainees on creating capsulorhexis on high-tension capsules.



Figure 1: Eyesi cataract surgical simulator

METHODS

Eyesi® cataract surgery simulator 2.1 course consists of a standardized training curriculum with 100 different tasks divided in 4 phases with progressive levels of difficulty and complexity: CAT A (Introduction), CAT B (Beginner), CAT C (Intermediate) and CAT D (Advanced). Progression throughout the training curriculum requires that the trainee reaches a minimum required score (50 points on CAT A, 60 on CAT B and 70 on CAT C) for three times consecutively at each given task.

On CAT A, virtual tasks with small spheres and squares make the trainee adapted to intraocular surgery, microscope use, anterior and posterior chamber dimensions. The trainee also practices bimanual tasks, anti-tremor exercises and starts manipulating cataract surgery instruments inside the eye.

On CAT B phase, the cataract surgery steps are introduced, starting with lower levels of complexity and difficulty, as low-tension capsulorhexis (with a 5mm diameter guiding circle with anterior chamber permanent viscoelastic fill; clockwise and counterclockwise), hydrodissection (with good red reflex and low nuclear-cortex adherence), emulsification of soft nucleus, chopping training exercises and cortex aspiration.

As the trainee completes CAT A and starts CAT B, after every hour of training the simulator presents a cataract "Challenge Course". It consists of a sequence of four surgical steps tasks: capsulorhexis on a high tension capsule, hydrodissection, divide and conquer nucleus emulsification and aspiration of cortex. After completing the Challenge Course, the trainee returns to his training curriculum tasks.

On CAT C, the curriculum adds difficulty to the given tasks, including medium and high tension capsulorhexis, with and without guiding circle, chopping techniques, hard nucleus emulsification and more difficult cortex aspiration. The capsulorhexis on high-tension capsule without guiding circle was the one evaluated in this study.

On CAT D, the trainee practice in some difficult situations such as rescuing a capsulorhexis in the presence of an errant tear and zonular dehiscence.

All tasks completed by the trainee are automatically saved by Eyesi software and listed on a training report, with scores, date and time of each exercise performed. Each task has a score that varies from zero to 100. For capsulorhexis scoring the simulator software considers the following criteria: centration, roundness, diameter, time for accomplishing, tissue treatment (touching the cornea or iris) and position of the eye during the procedure (loss of red reflex). This scoring system has already been validated on previous study⁽¹²⁾.

We retrospectively analyzed all training reports of ophthalmic surgery trainees (2nd and 3rd year residents and cataract fellowship trainees from different ophthalmology residency institutions in Brazil) that have accomplished Eyesi® cataract surgery simulator training course version 2.1 between May 2012 and August 2013 at *Instituto de Diagnostico e Terapia Ocular*, Rio de Janeiro, Brazil. Were included trainees that accomplished Eyesi® cataract training course 2.1 and completed CAT A, B and C modules. We excluded trainees that did not have done at least 2 Challenge Course exercises, because they would not have the capsulorhexis on high-tension capsules without guiding elements during CAT B training for comparison.

To access the efficacy of Eyesi simulator 2.1 course training on improving the performance at high-tension capsule capsulorhexis we compared the same task (capsulorhexis – high-

tension capsule without guiding elements) score performed in 2 different moments of training: an initial evaluation of performance (“before training” score) and a second evaluation (“after training” score). The “before training” score was calculated by the mean score of the first 2 capsulorhexis on high-tension capsule without guiding elements that were performed during the “Challenge Course”, executed by the trainee during the first 2 hours of CAT B training. The “after training” score was the mean score of the first 2 capsulorhexis on high-tension capsule without guiding elements performed during CAT C phase. At this point (CAT C) of Eyesi course 2.1 curriculum the trainee has already completed at least 13 different capsulorhexis exercises of rising levels of difficulty, for at least 3 times each, totalizing at least 39 capsulorhexis with progressive levels of difficulty. We also analyzed total number of tasks accomplished during the whole course training and total time of training (in hours) on the simulator.

Participants authorized training data report analysis and the study followed the tenets of the Declaration of Helsinki.

A level of significance of 0.05 was considered for statistical analysis.

RESULTS

Forty trainees have completed CAT A, CAT B and CAT C Eyesi simulator training between May 2012 and August 2013. Three of them were excluded because did not have two capsulorhexis on high-tension capsules exercises during CAT B for comparison, resulting in 37 trainees for analysis.

The mean score \pm standard deviation was 41.73 ± 27.08 points on “before training” and 72.55 ± 16.40 points on “after training” high-tension capsule capsulorhexis, a difference of +30.82 points between “before” and “after” scores (p value <0.001 on Paired t test), representing a 73% improvement from before to after training performance (Table 1).

Table 1
Comparison of “before training” and “after training” high-tension capsule capsulorhexis score

	“Before training” (n=37)	“After training” (n=37)	Difference (%)	p value*
Mean score (\pm SD)	41.73 (± 27.08)	72.55 (± 16.40)	30.82 (73%)	<0.001

SD: standard deviation; (*) Paired t test

The mean number of total tasks \pm standard deviation performed by trainees during the simulator training course was 451.73 ± 102.57 tasks and mean total training time on the simulator \pm standard deviation was 9.53 ± 2.02 hours.

For analyzing if there is an effect of hours of training and number of tasks accomplished on capsulorhexis score improvement, we stratified the sample into two groups: group A (who had an improvement of less than 32 points of score) and group B (improvement of more than 32 points of score). We found no statistical difference on total time of training and total number of tasks between trainees that had less than 32 points of improvement in score versus those that had more than 32 points of improvement (Table 2).

Table 2
Comparison of total hours of training and total number of tasks accomplished during training with improvement in high-tension capsule capsulorhexis score

	Group A (<32 points improvement)	Group B (>32 points improvement)	p value*
Mean total hours of training (\pm SD)	9.55 (± 1.80)	9.52 (± 2.26)	0.96
Mean total number of tasks (\pm SD)	447.17 (± 83.74)	456.05 (± 119.91)	0.79

SD: standard deviation; * Unpaired t test

DISCUSSION

The construction validity of the Eyesi® cataract surgical simulator capsulorhexis exercise has already been demonstrated, representing that its scoring system can effectively discriminate between a high skilled surgeon and a low skilled one^(11,12), as well as the positive repercussion of simulator training on cataract surgery learning curve of ophthalmology residents^(1,14) and on wet lab performance⁽²⁾. On the present paper, we evaluated if the standard training course curriculum of exercises offered by Eyesi cataract simulator, on version 2.1, was effective in improving the surgical abilities of novice surgeons on a specific high difficult task such as performing a capsulorhexis on a high-tension capsule.

Our findings have demonstrated an improvement in surgical abilities of trainees with simulator practice within its standard curriculum, as we observed a significant score rising of 73% with training, reaching a mean high score capsulorhexis (72.55 points), that means a good, round and centered capsulorhexis. Indeed we observed a reduction in standard deviation (SD) of the sample mean score between initial and final evaluation (before training SD ± 27.08 versus ± 16.40 after training), suggesting a trend to standardization of abilities in capsulorhexis among these novice surgeons.

The total number of tasks performed and total hours of training vary among trainees (mean number of tasks 451.73 ± 102.57 , and mean total training time 9.53 ± 2.02 hours), however there was no significant difference on these criteria between the group that had more (>32 points) and the one that had less absolute score improvement (<32 points). Considering that trainees had different initial skills, with an initial low mean score (41.73 points) and higher standard deviation (± 27.08), the “after training” evaluation showed a more homogenous group with a mean score of 72.55 points and a lower standard deviation (± 16.40 points). That is, with similar training time, the training curriculum could improve more the abilities of the less skilled trainees than those of the more skilled ones. This finding emphasizes the usefulness of the simulator in surgical training of the beginner surgeons, usually less skilled, who have the longest learning curve ahead and would most benefit from simulator training.

The formation of an ophthalmic surgeon requires a comprehensive approach that should include knowledge about anatomy and surgical techniques, surgical judgment and developing of manual abilities. This last requisite can only be achieved with practice of movements and maneuvers, with better results if performed at a controlled environment, with evaluation

and correction of errors between tasks repetitions. That leads to better skills and self-confidence. However, this is something not easy to offer to training surgeons on real human surgery on a traditional master-apprentice model, because a real eye and patient are there, depending on the result of the surgery to see better or not. Even on wet labs, where we do not have a live patient under the microscope, the conditions are not excellent, the dimensions of anterior chamber of animal eyes, transparency of the cornea, thickness and elasticity of the capsule and density of the nucleus are far away from what we found in senile cataracts, and therefore cannot simulate real surgery.

Virtual reality surgical simulators help fill this gap in surgeons training, offering a reproducible scenario for safe repeated practice, adding the evaluation feedback for performance correction and a possibility of creation of structured curriculum of exercises for standardized training.

We have been using simulator training as an auxiliary surgery-teaching device in Rio de Janeiro since 2012⁽¹⁵⁾ with a very positive feedback from surgeons in training and their assistant teachers, and as far as we know, this is the first report of the results of cataract surgical virtual reality simulator training in Brazil.

In summary, we conclude that Eyesi® cataract surgical simulator training course version 2.1 is effective in improving surgical performance of trainees on capsulorhexis of high-tension capsules.

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