Construct validity of a surgical simulator as a valid model for capsulorhexis training

Brian Privett, MD, Emily Greenlee, MD, Gina Rogers, MD, Thomas A. Oetting, MS, MD

PURPOSE: To compare the performance on the EYESi surgical simulator capsulorhexis training module between medical students and residents and experienced cataract surgeons.

SETTING: Department of Ophthalmology, University of Iowa, Iowa City, Iowa, USA.

DESIGN: Comparative case series.

METHODS: The study comprised medical students and residents at the University of Iowa and experienced cataract surgeons. Neither group had experience with the simulator. Each participant completed 4 trials on the capsulorhexis module.

RESULTS: The 7 experienced surgeons achieved statistically significantly better total scores than the 16 medical students and residents on the easy level and the medium level of the capsulorhexis module ($P = .004$ and $P = .000007$, respectively). Experienced surgeons achieved significantly better scores in all parameters at the medium level, with better centering ($P = .001$), less corneal injury ($P = .02$), fewer spikes ($P = .03$), less time operating without a red reflex ($P = .0005$), better roundness of the capsulorhexis ($P = .003$), and less time completing tasks ($P = .008$).

CONCLUSION: The surgical simulator capsulorhexis module showed significant construct validity ($P<.05$).

Financial Disclosure: No author has a financial or proprietary interest in any material or method mentioned.

J Cataract Refract Surg 2010; 36:1835–1838 © 2010 ASCRS and ESCRS

Online Video

One of the more difficult tasks for beginning cataract surgeons is creating the curvilinear capsulorhexis.[1] Traditionally, residents use animal models, often pig eyes, in a wet lab to learn how to perform this maneuver. Although pig eyes closely resemble human eyes, the elasticity of the porcine anterior capsule makes capsulorhexis creation much different from that in a senile human eye. The need for new tissue and for setup time in the wet lab limits the ability to repeat specific tasks, such as creating a capsulorhexis multiple times.

Advances in computer technology have led to increasingly sophisticated virtual-reality simulators for many types of surgery. There are currently 2 commercially available ophthalmic simulators. One is PhacoVision (Melerit Medical). The other, the EYESi (VRmagic Holding AG), was purchased by our program at the University of Iowa several years ago. We have found it to be useful in helping our residents learn how to create a capsulorhexis and to develop skills to keep the eye centered during surgery. The purpose of this study was to evaluate the construct validity of the capsulorhexis module of the simulator. Construct validity has been shown for the vitreoretinal, anterior segment forceps, and anti-tremor modules of the simulator.[2,3] Feudner et al.[4] recently found that the structured capsulorhexis training module of the simulator significantly improved capsulorhexis performance in pig eyes in the wet lab. However, we believe that this

Submitted: February 22, 2010.
Final revision submitted: May 4, 2010.
Accepted: May 7, 2010.

From the Department of Ophthalmology (Privett, Greenlee, Rogers, Oetting), University of Iowa Hospitals and Clinics, and the Veterans Affairs Medical Center (Greenlee, Oetting), Iowa City, Iowa, USA.

Corresponding author: Thomas A. Oetting, MS, MD, University of Iowa Hospitals and Clinics, Department of Ophthalmology, 200 Hawkins Drive PFP, Iowa City, Iowa 52242-1091, USA. E-mail: thomas-oetting@uiowa.edu.

Published by Elsevier Inc.

0886-3350/$—see front matter
doi:10.1016/j.jcrs.2010.05.020

study is the first to show construct validity of the capsulorhexis module.

MATERIALS AND METHODS

Study Group and Protocol

Two groups were selected to establish construct validity. Group 1 comprised medical students and first-year ophthalmology residents at the University of Iowa who had never performed cataract surgery or used a practice laboratory. Group 2 comprised practicing cataract surgeons who had performed at least 200 cases. None of the participants had experience using any module of the surgical simulator. Participants were all volunteers interested in trying out the simulator and participating in the project. Members of the 2 groups had similar experience with video games.

Apparatus

The study was performed using the EYESi simulator with software version 2.5.1. The simulator has a virtual operating microscope to simulate stereoscopic images. Handheld probes simulate virtual instruments when inserted in a virtual eye (Figure 1). Multiple tasks on the simulator can be performed while the instructor monitors them on a viewing panel. The participants were tested on the capsulorhexis module on the easy level and the medium level.

Procedure

Group 1 participants were given a 5-minute talk on the purpose of creating a capsulorhexis and the principles behind creating a curvilinear capsulorhexis. A brief orientation to the simulator was given, including a live demonstration of the medium level. The participants then did a trial run on the easy level (Video, available at http://jcrsjournal.org). This trial run was not scored and allowed the virtual microscope zoom and focus to be permanently adjusted to the setting used for subsequent tasks.

Each participant then completed 2 trials on the easy level and on the medium level. On the easy level, the capsulorhexis flap was already started, with a low likelihood that the tear would extend radially. The participants had to enter the eye with the virtual capsulorhexis forceps and complete the tear. Participants could choose whether they

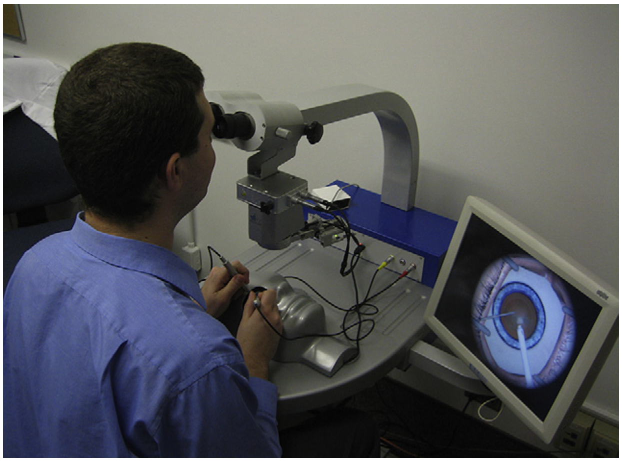


Figure 1. A surgeon using the surgical simulator.

wanted to make a clockwise or counterclockwise capsulorhexis based on handedness or preference. After completing 2 trials on the easy level, the participants performed 2 trials on the medium level. On this level, the flap had not been started and there was an intermediate likelihood of extending the tear radially. The participants had to fill the anterior chamber with an ophthalmic viscosurgical device, start a flap with a cystotome, and complete the flap with the capsulorhexis forceps. Each module provided a virtual guideline of a 6.0 mm capsulorhexis for participants to follow.

Group 2 participants had the same instruction and procedure except that the explanation of the purpose of the capsulorhexis was omitted based on their experience. The same investigator (B.K.P) supervised all tasks. Group 1 performed 64 trials and Group 2, 28 trials.

At the end of each task, the simulator scored the participant on multiple criteria. These scores were saved into the database of simulator, and the investigator accessed the database to monitor the progress of trainees.

The overall maximum score was 1000. This score was based on multiple criteria recorded by the software program. The collected data were analyzed using the Student *t* test.

Table 1. Results on easy level of capsulorhexis module, in which the flap was already started.

	Mean ± SD		
Parameter	Medical Students and Residents (n = 32)	Experienced Surgeons (n = 14)	*P* Value
Overall score (out of 1000)	259.375 ± 293.806	527.857 ± 305.241	.003598†
Centering* (mm)	0.381 ± 0.253	0.280 ± 0.208	.098741
Injured cornea area (mm^2)	4.623 ± 5.074	1.245 ± 1.355	.009421†
Local irregularity of capsulorhexis (spikes)	0.344 ± 0.701	0.071 ± 0.267	.083836
Operating without red reflex (min:s)	00:53 ± 00:54	00:12 ± 00:13	.004243†
Roundness	0.430 ± 0.378	0.502 ± 0.374	.277370
Time (min:s)	02:07 ± 00:48	1:24 ± 00:28	.001573†

*Distance from capsulorhexis center to center of the eye
†Statistically significant difference ($P < .05$)

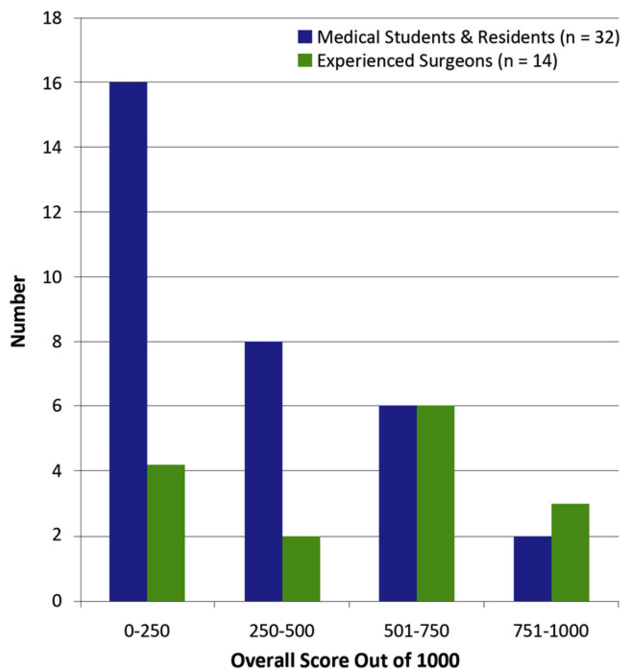


Figure 2. Overall scores of all trials at the easy level.

RESULTS

Group 1 comprised 16 medical students and first-year ophthalmology residents. Group 2 was comprised of 7 practicing cataract surgeons.

Table 1 shows the data collected from the easy level of the module. On that level, the experienced cataract surgeons outperformed the medical students and residents in multiple parameters, including overall score ($P = .004$), amount of corneal injury ($P = .009$), and time taken to perform the task ($P = .01$). Experienced surgeons also spent less time operating without a red reflex ($P = .004$), meaning they completed the task without decentering the virtual globe as often. The overall score (maximum score 1000) was 259 in Group 1 and 528 in Group 2. Figure 2 shows the distribution of the overall score for the 2 groups on the easy level.

Table 2 shows the data collected from the medium level of the module. Experienced surgeons outperformed the medical students and residents in all parameters. The overall mean score in Group 2 was better than in Group 1, and the difference was highly statistically significant ($P = .000007$). Group 2 did a better job centering the capsulorhexis ($P = .001$) and creating a more round capsulorhexis ($P = .003$), spent less time operating without a red reflex ($P = .0005$), spent less time completing the task ($P = .008$), and caused less corneal injury ($P = .02$). Figure 3 shows the distribution of the overall score in the 2 groups on the medium level.

DISCUSSION

As residency programs look to invest in educational tools, such as surgical simulators, it is important to know whether the money and time spent using it is a valid model for real-life cataract surgery.[5,6] We compared the performance of medical students and residents with no intraocular surgical experience with that of experienced cataract surgeons (>200 cases) on the capsulorhexis module of the EYESi ophthalmic surgery simulator. The comparison experienced cataract surgeons and medical students and residents showed the capsulorhexis module has significant construct validity ($P < .5$). The difference was greater at the medium level, in which participants had to create the capsulorhexis from start to finish.

All participants said they believed the simulator would be a useful training tool for beginning cataract surgeons. The use of the virtual capsulorhexis forceps was tricky for some experienced cataract surgeons because the handheld probes require using a footpedal to open and close the virtual forceps. The most current version of the simulator includes a forceps that is

Table 2. Results on medium level of capsulorhexis module, in which the participants began the capsulorhexis themselves.

Parameter	Mean ± SD: Medical Students & Residents (n = 32)	Mean ± SD: Experienced Surgeons (n = 14)	*P* Value
Overall Score (out of 1000)	201.250 ± 266.613	605.714 ± 233.459	.000007†
Centering* (mm)	0.523 ± 0.354	0.206 ± 0.074	.000977†
Injured cornea area (mm^2)	2.200 ± 2.745	0.552 ± 1.453	.020256†
Local irregularity of capsulorhexis (spikes)	1.031 ± 1.892	0.071 ± 0.267	.033488†
Operating without red reflex (min:s)	00:52 ± 00:37	00:14 ± 00:15	.000537†
Roundness	0.278 ± 0.327	0.585 ± 0.321	.002582†
Time (min:s)	03:22 ± 00:49	02:41 ± 00:58	.008149†

*Distance from capsulorhexis center to center of the eye
†Statistically significant difference ($P < .05$)

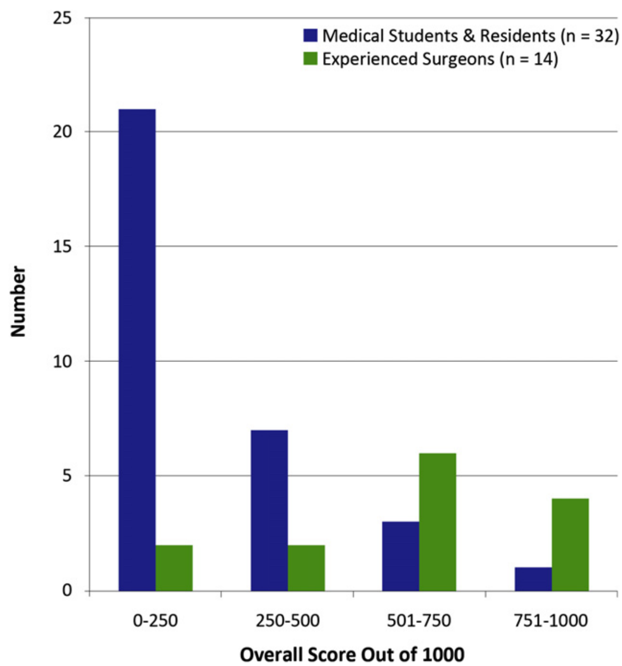


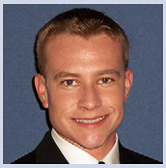
Figure 3. Overall scores of all trials at the medium level.

closed with the hand rather than with the footpedal, which may address this concern. Another concern raised by some experienced surgeons was that the anterior capsule beneath an overlying flap is too easy to accidentally grab, which could lead to a radial tear and result in a lower score for some experienced cataract surgeons.

The capsulorhexis module of the simulator allows repetitive and measured completion of a capsulorhexis. Rogers et al.[7] showed that the use of this simulator, along with a structured wet lab, formative feedback, backing in of cases, and deliberate practice, reduced the incidence of surgical complications by residents. As the use of accommodating intraocular lenses increases, it is becoming more important to create a consistent capsulorhexis. The capsulorhexis module and other modules have now been shown to have significant construct validity; therefore, training programs should consider using the simulator for training future cataract surgeons.

REFERENCES

1. Prakash G, Jhanji V, Sharma N, Gupta K, Titiyal JS, Vajpayee RB. Assessment of perceived difficulties by residents in performing routine steps in phacoemulsification surgery and in managing complications. Can J Ophthalmol 2009; 44:284–287. Available at: http://article.pubs.nrc-cnrc.gc.ca/RPAS/rpv?hm=HInit&calyLang=eng&journal=cjo&volume=44&afpf=i09-051.pdf. Accessed June 25, 2010
2. Rossi JV, Verma D, Fujii GY, Lakhanpal RR, Wu SL, Humayun MS, de Juan E Jr. Virtual vitreoretinal surgical simulator as a training tool. Retina 2004; 24:231–236
3. Mahr MA, Hodge DO. Construct validity of anterior segment antitremor and forceps surgical simulator training modules; attending versus resident surgeon performance. J Cataract Refract Surg 2008; 34:980–985
4. Feudner EM, Engel C, Neuhann IM, Petermeier K, Bartz-Schmidt K-U, Szurman P. Virtual reality training improves wet-lab performance of capsulorhexis: results of a randomized, controlled study. Graefes Arch Clin Exp Ophthalmol 2009; 247:955–963
5. Lee A. Teaching and assessing surgical competency in ophthalmology [letter]. Ophthalmology 2006; 113:2380–2381. Available at: http://download.journals.elsevierhealth.com/pdfs/journals/0161-6420/PIIS0161642006011237.pdf. Accessed June 25, 2010
6. Downing SM. Validity: on meaningful interpretation of assessment data. Med Educ 2003; 37:830–837
7. Rogers GM, Oetting TA, Lee AG, Grignon C, Greenlee E, Johnson AT, Beaver HA, Carter K. Impact of a structured surgical curriculum on ophthalmic resident cataract surgery complication rates. J Cataract Refract Surg 2009; 35:1956–1960



First author:
Brian Privett, MD

Department of Ophthalmology, University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA