Surgical simulator training reduces operative times in resident surgeons learning phacoemulsification cataract surgery

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A B S T R A C T

Purpose: To compare the surgical duration for routine phacoemulsification surgeries in residents with and without virtual simulator training.

Methods: Retrospective cohort study of operative times of routine phacoemulsification cataract surgeries performed by 29 different third-year residents rotating at one academic institution. One group underwent mandatory virtual cataract surgery simulator training (SIM) in their second year of residency before starting surgeries while the other group did not undergo any simulator training (NOSIM). Outcomes measured were comparative surgical times and vitreous loss rates between groups in their third year of residency.

Results: 722 surgeries were included. Surgeries in the SIM group were on average 6.7 min (min) shorter compared to the NOSIM group (P = 0.0001). Although both groups required less time for surgery over the course of the academic year, regression analysis showed that NOSIM group residents overall required 17% longer time for an uncomplicated clear corneal phacoemulsification surgery (incidence rate ratio 1.17; p = 0.0001). In the final month of their residency residents in the SIM group (32.2 ± 3 min) were 9 min faster than NOSIM peers (41.2 ± 3 min mean ± SE; p = 0.02). Vitreous loss rates were 1.4% in the SIM group and 3.6% in the NOSIM group (p = 0.06).

Conclusion and Importance: Early and continuous implementation of mandatory virtual simulator surgical training before starting intraocular surgeries significantly decreases operative times in third year residents learning phacoemulsification compared to non-simulator trained peers.

1. Introduction

In recent years virtual cataract surgery simulators have become available providing the beginning surgeon with a realistic training environment that allows the trainee to develop fine motor control movements, practice all the steps of phacoemulsification cataract surgery, and also to remediate weak points of past surgical cases during their surgical rotations. Previous reports have shown that virtual cataract surgery simulator training for beginning surgeons reduced phacoemulsification times and complication rates during cataract surgery.1–3 In a recent study operating room performance after proficiency-based simulator training improved significantly in beginning (32%) and intermediate surgeons (38%).4 While surgical quality and safety are essential in surgical education, operating room efficiency is also a key element for successful surgeons. Previously, a time-based study of the first fifty surgical cases in simulator and non-simulator groups showed that time was not significantly affected by simulator training in beginning and intermediate surgeons, although a difference was noted after 25 surgeries.5 The goal of this study was to investigate surgical time length in simulator and non-simulator-trained surgeons in their final year of residency. As we will describe in the following, we find significant improvement in surgical times from simulator training.

2. Methods

The Institutional Review Board approved this retrospective cohort study at our institution. Each group consisted of third year ophthalmology residents (PGY4) in their final year of residency, who rotated through our institution as second year residents (PGY3) and returned for another rotation in their final year (PGY4). All routine cataract surgeries were performed with a clear corneal incision technique with the divide and conquer phacoemulsification approach. All residents received supplementary cataract surgery training consisting of a wet-lab at the beginning of each academic year, weekly lectures during the 3-month rotation at our institution on surgical technique and management of complications of phacoemulsification. Second year resident surgical times were not included because a scleral tunnel surgical wound technique was used in those surgeries and comparison of surgical times was therefore not possible.

Surgeries were divided into two groups: 1. No simulator group...
clear corneal incision technique surgeries is shown in Fig. 2. Regression analysis of surgical time over the academic year showed that third year residents in the NOSIM group needed 17% longer for an uncomplicated, clear corneal incision phacoemulsification than the SIM group ($r = 0.15$ SE 0.02, IRR 1:17, 95% CI 0.1–0.19; $p = 0.0001$).

The incidence of posterior capsular tear with vitreous loss was lower in the SIM group ($n = 5; 1.4\%$) compared to the NOSIM group ($n = 13; 3.6\%$), but the difference did not reach statistical significance ($p = 0.06$). Duration of complicated surgeries with vitreous loss was not different between groups ($p = 0.3$).

5. Discussion

To our knowledge, this study is the first to demonstrate a significant reduction in surgical time during uncomplicated routine cataract surgery in simulator trained ophthalmology residents. Previously, Pokroy described that surgical length and posterior capsule ruptures in the first 50 surgeries were not significantly affected by simulator training although times were shorter after the first 25 cases. This observation could be explained by initial adaptation of novice surgeons to the surgical environment and involvement of the attending surgeon completing parts of the procedure. In addition, our study starts with third year residents, who typically have the experience of 20 surgeries at the start of their senior year, and more experience compared to Pokroy's study. Analysis of surgical time by month showed that while both groups made progress in completing the surgery in less time, simulator-trained third year residents had consistently shorter surgical times compared to non-simulator trained peers (Figs. 1 and 2). Although third year residents start the academic year with an experience of approximately 20 cataract surgeries, they begin to perform three to four cases per week and quickly accumulate experience, but have similar numbers throughout the academic year. There is variability with surgical skill levels, but in our study residents rotated every 3 months and the present study includes data from 29 different surgeons. We observed a lower incidence of vitreous loss in simulator-trained residents, but because of the small sample size this difference did not reach statistical significance ($p = 0.06$). However, a recent larger study including 265 surgeons described a 38% reduction in posterior capsular rupture (PCR) rates (from 4.2% in 2009 to 2.6% in 2015) in first and second year British ophthalmology residents with access to a surgical simulator versus a 3% reduction of PCR rates in non-simulator trained surgeons.

These data suggest that simulator training may be beneficial to reduce complication rates in phacoemulsification.

Limitations of our study include its retrospective design with an historical (NOSIM) control group. However, other than the simulator training the surgical curriculum was identical between groups; all residents received the same didactic training, had the same experienced surgical mentors, and the same phacoemulsification platform and instruments. The goal of this study was to compare total surgical times and the retrospective design of the study did not allow us to correlate individual surgical times or specific surgical steps with simulator training times to account for the possibility of more talented surgeons or to compare the module training to surgical step training. We included 29 consecutive residents independently of their surgical adeptness and all 15 residents in the simulator group completed an average of 333 min of training, which would allow for less talented surgeons to increase their skills. In addition, we observed a low vitreous loss rate in both groups indicating a balanced surgical talent pool in both groups. We found that mandatory simulator training implementation in the second year of residency resulted in significantly shorter surgical times compared to non-simulator trained senior residents. This advantage could be explained by the improved ability to handle instruments intraoperatively, the insight to target areas of experienced surgical problems during simulator training and therefore improve the overall efficiency in live surgery. Further studies are needed to correlate each surgical step with corresponding surgical simulator module training.
times and to analyze its effect on the efficiency of the management of surgical complications. Teaching cataract surgery is a balance between patient safety, meeting the demands of academic curricula and operating room efficiency. Our data shows that mandatory virtual cataract surgery simulator training can help increase surgical efficiency and safety in senior resident surgeons. An additional benefit of reduced surgical time is greater accessibility to cataract surgery for patients and residents.

Patient consent

This study was IRB approved by our institution and a patient consent waiver was granted. The study complies with HIPPA rules of private health information. This report does not contain any personal information that could lead to the identification of the patient.

Funding

No funding.

Authorship

All authors attest that they meet the current ICMJE criteria for authorship.

Declaration of competing interest

The following authors have nothing to disclose: CL, GS, SS, TM.

Acknowledgements

The authors would like to thank Mr. Ali Fokar, MPh for his help with the statistical data analysis.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajoc.2019.100576.

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Table 1

| N   | Number of Surgeries | SIM group (mean ± SE) | NOSIM group (mean ± SE) | Time difference (minutes) | P*     |
|-----|---------------------|-----------------------|-------------------------|---------------------------|--------|
| Total (n = 722) | 43.4 ± 0.8 (n = 358) | 50.1 ± 0.9 (n = 364) | 6.7 | 0.0001 |
| Uncomplicated (n = 704) | 41.6 ± 0.8 (n = 353) | 47.7 ± 0.8 (n = 351) | 6.1 | 0.0001 |

Unpaired T-test. *P < 0.05 considered statistically significant. N = number of surgeries. Uncomplicated surgeries exclude vitreous loss. Surgical simulator training was started one year prior to third year of residency.