

Learning curves for strabismus surgery in two ophthalmologists

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Purpose: To identify the average turning point by comparing the learning curves of two surgeons learning to perform strabismus surgery. **Materials and Methods:** Patients who underwent procedures to correct exotropia between January 2010 and December 2014 followed for at least 3 months were retrospectively assessed. The first 70 patients on whom each of two ophthalmologists (A and B) performed surgery to treat strabismus were divided into 7 cohorts comprising 10 patients each based on the chronological order of the surgery. Factors, including patient age, preoperative angle of deviation, operative time, and success or failure of the operation, were compared between the two surgeons. Learning curves were calculated based on changes in operative time and operation success rate. Operation success was determined by measuring the angle of deviation at a distance of 5 m 3 months after the operation. **Results:** A turning point was observed after 40 cases for Surgeon A and 50 cases for Surgeon B based on the operative time learning curve. No turning point was observed in the operation success rate learning curve based on the absence of a specific trend. Success rate by cohort was not significantly different between the two surgeons ($P > 0.05$). Surgeon B had a significantly longer mean operative time than Surgeon A ($P = 0.045$). **Conclusions:** Approximately 50 cases are required for an ophthalmologist to reach a turning point in strabismus surgery. This outcome can be used as a guideline when training surgeons to perform strabismus surgery.

Key words: Learning curve, ophthalmology, strabismus surgery, surgical training

Strabismus surgery is performed to achieve normal ocular alignment, and to improve eyesight and appearance. The primary purpose of strabismus surgery is to achieve orthophoria through minimally invasive procedures. Since 1839, when Dieffenbach performed the first surgery to correct strabismus, other surgeons have continued to improve the procedure and guidelines have been established to suggest the best approach depending on the angle of deviation.^[1] As a number of factors influence the outcome of the operation, however postoperative correctional benefits may vary and surgical intervention can result in over- or under-correction. Such uncertainty in the outcome makes surgeons performing strabismus surgery for the first time uneasy, which is why most of these operations are performed by highly experienced ophthalmologists.

A search of the literature indicates that there have been no studies conducted on the learning curve for performing strabismus surgery. Therefore, this study evaluated the learning curves of two ophthalmologists performing strabismus surgery based on the operation duration and operation success rate in the first 70 patients of each physician. Based on a comparison of the two groups of outcomes, we

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estimated the amount of training required for a surgeon to exhibit constant and stable performance in strabismus surgery.

Materials and Methods

The first Surgeon A specialized in the retina and had experience performing vitrectomy and cataract operations, but not strabismus correction surgery. The second Surgeon B specialized in ophthalmic plastic surgery and had performed ophthalmic plastic operations but not strabismus correction surgery. We enrolled and retrospectively analyzed those patients on whom these two ophthalmologists had performed strabismus correction surgery between January 2010 and December 2014 and had been followed for at least 3 months. The Institutional Review Board of the hospitals in which each surgeon performed the surgeries approved the study. The first 70 patients on whom each of the two ophthalmologists (A and B) performed the strabismus correction surgery were, respectively, divided into seven cohorts comprising 10 patients each based on the chronological order of the surgery (i.e. patients 1–10 in cohort 1, patients 11–20 in cohort 2, etc.). Those patients with esotropia, vertical strabismus, large-angle exotropia >50 prism diopters (PD), previous strabismus surgery history, or concomitant organic ocular disease were excluded from the study.

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In most cases, general anesthesia was used but local anesthesia was applied in those patients who rejected general anesthesia or others who would be put at a high risk from general anesthesia. For local anesthesia, 0.5% proparacaine hydrochloride (Alcaine®, Alcon) was preoperatively applied to the eye. At the start of the operation, 2% lidocaine (0.5 ml) was administered through the sub conjunctiva of the muscle on which the operation was to be performed. If the patient complained of pain during the operation, 4% lidocaine was injected. Following the anesthetic injection, the surgery was performed according to the preoperative plan through the incision of the conjunctival fornix, which was made inferior temporally of the lateral rectus and inferior nasally of the medial rectus. As for the type of surgery, nondominant eye medial rectus resection and lateral rectus recession, or bilateral lateral rectus recession were performed depending on patient features. Angle of deviation was measured at every visit, prior to the operation, and at 1 month and 3 months after the operation. As part of the preoperative tests, angle of deviation was measured at a distance of 5 m using the alternating prism cover when the patient could cooperate. The Krimsky test was used in cases when the patient could not cooperate and in cases of sensory exotropia. The extent of the adjustment of the angle during the operation was determined based on the angle of deviation measured at least twice before the operation, as suggested by Parks and Mitchell.^[2] Measurement of the angle of deviation was performed using the same approach preoperatively and postoperatively. Referring to the classification suggested by Kim *et al.*,^[3] operation success was defined as achieving a postoperative angle of deviation between approximately -10 PD and + 10 PD at 5 m 3 months after surgery. Operative time was defined as the amount of time from the beginning of the conjunctival incision to the completion of the conjunctival suturing. Age and sex of the patients who underwent operation, preoperative angle of deviation, operative time, and operation outcome were compared between the groups of patients operated on by Surgeon A and Surgeon B. Learning curves were identified based on the changes in operative time and operation success rate.

SPSS version 14.0 (SPSS Inc., Chicago, IL, USA) was used to perform the statistical analysis and the significance level was set at ≤ 0.05 . An independent *t*-test was conducted to determine whether the two groups differed in terms of patient age, mean follow-up duration, preoperative angle of deviation, or operative time. In addition, the Chi-square test was used to compare categorical variables such as sex distribution, preoperative diagnosis, operation type, and operation outcome (success or failure). Learning curves were obtained by drawing graphs to represent changes in operative time and the operation success rate by chronological order and surgeon. The turning point was defined as the point where the trend of declining operative time stopped or the operation success rate increased.

Results

Mean patient age, sex, and preoperative angle of deviation did not differ significantly between groups. Operation success rate for the first 70 cases did not differ significantly between groups. Mean operation time was significantly longer for Surgeon B than Surgeon A [Table 1].

Table 1: Characteristics of patients stratified by surgeon, ophthalmologist A and B

	A	B	P
Number of patients	70	70	-
Age at surgery (years)	36.07±24.88	14.46±17.29	0.001*
Gender (male:female)	33:37	38:32	0.398†
Follow-up duration (months)	5.75±1.43	11.75±2.71	0.014*
Preoperative diagnosis			
Intermittent exotropia	45	9	0.000†
Sensory exotropia	25	61	
Preoperative exodeviation (PD)	33.14±7.08	31.29±8.15	0.157*
Type of surgery			
LROU Rec.	42	5	0.000†
R and R	28	65	
Operative time (min)	54.84±11.64	60.63±11.32	0.045*
Result of surgery (success/failure)	60/10	58/12	0.642†

Values are presented as mean±SD. *Analyzed with independent *t*-test, †Analyzed with Chi-square test. PD: Prism diopter, LROU Rec.: Bilateral lateral rectus recession, R and R: Lateral rectus recession and medial rectus resection, SD: Standard deviation

For Surgeon A, 25 of the first 70 cases had sensory exotropia and the remaining 45 had intermittent exotropia. Surgeon A performed unilateral medial rectus resection and lateral rectus recession in 28 cases and bilateral lateral rectus recession in 42 cases. Postoperative adverse events included one case of retinal tear plus vitreous hemorrhage resulting from perioperative scleral perforation, which occurred in the left eye of a patient who underwent bilateral lateral rectus recession to correct exotropia of 40 PD. In this patient, barrier laser photocoagulation was performed on the lesion suspected of having a retinal tear and the final visual acuity measured 1 week after the operation was 20/25 and exotropia of 20 PD persisted.

Surgeon B had 9 cases of sensory exotropia and 61 cases of intermittent exotropia. Surgeon B performed unilateral medial rectus resection and lateral rectus recession in 65 cases and bilateral lateral rectus recession in 5 cases. Postoperative adverse events included one case of impaired eye movement resulting from an adhesion on the operative site, which was found 3 months after medial rectus resection and lateral rectus recession in the right eye of a patient with exotropia of 25 PD. The patient had postoperative esotropia of 10 PD, diplopia, and abduction of the right eye. At 7 months after the operation, medial rectus recession (4 mm) was performed in the right eye to treat the diplopia, but the abduction of the right eye persisted.

Analysis of the learning curves based on operative time for each surgeon indicated that Surgeon A had a turning point after 40 cases while Surgeon B had a turning point after 50 cases [Fig. 1]. Both surgeons became experienced after 40–50 cases and this trend was confirmed by checking the first 100 cases of Surgeon A, who had more cases. With regard to the learning curve based on operation success rate, there was no turning point observed as there was no general trend for either of the two surgeons [Fig. 2].

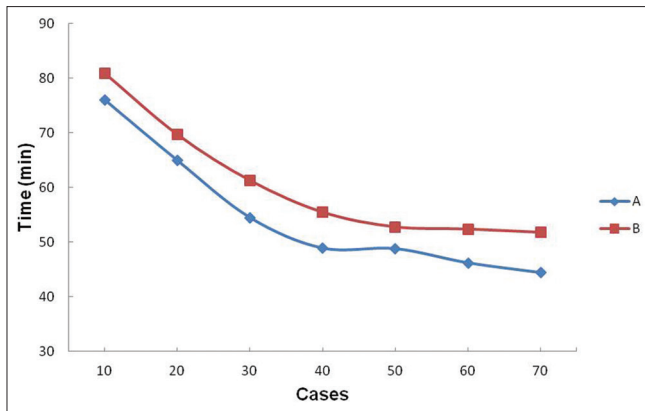


Figure 1: Learning curves of operative time for ophthalmologists A and B. A turning point is observed after 40 cases in ophthalmologist A. A turning point is observed after 50 cases in ophthalmologist B

Discussion

Strabismus surgery can improve eye function, including eye motility, visual acuity, acquisition of binocular vision, and visual field enhancement.^[4] Left untreated, strabismus can cause deteriorating stereoscopic vision, amblyopia, diplopia, or progression of exotropia. These potential consequences emphasize the importance of timely corrective surgery. Strabismus surgery differs from other ophthalmologic operations in that the same operational procedure does not always achieve the same outcome. Outcomes may differ depending on the patient's genetic makeup, age at time of surgery, presence of a high accommodative convergence to accommodation ratio, refractive error, and other factors.^[5] As for exotropia surgery, it remains controversial whether it is better to overcorrect the angle of deviation as measured right after surgery and many factors affect the success rate of the operation, hence the same operational procedure is reported to have different success rates depending on the surgeon and center at which surgery is performed. In addition, even a fully experienced surgeon does not always obtain a successful result, indicating that experience alone does not determine a successful outcome. Taking all these features of strabismus surgery into account, however, the experience of the surgeon remains an important factor that can lead to a higher success rate and fewer complications. An understanding of the learning curve will help to establish guidelines regarding the amount of training (minimum number of operations) a surgeon require to gain acceptable proficiency in strabismus surgery. A survey of literature revealed no studies examining the learning curve for strabismus surgery. The present study compared two groups of patients who underwent operations performed by two surgeons to obtain comprehensive results.

The mean operative time was significantly longer for Surgeon B than for Surgeon A. The difference might be accounted for by the fact that Surgeon B performed unilateral medial rectus resection and lateral rectus recession significantly more often than Surgeon A. Therefore, comparison of the operative time between the two surgeons is meaningless. Overall, operative time for the strabismus surgery is affected not only by the surgeon's skill level, but also the status of adhesion with the conjunctiva, Tenon's capsule,

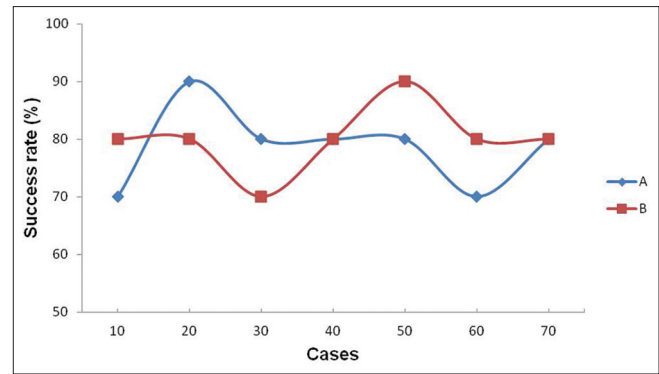


Figure 2: Learning curves of success rate for ophthalmologists A and B. A turning point is not observed in ophthalmologists A or B

or extraocular muscle. This study excluded those patients with a history of previous strabismus surgery in an attempt to eliminate the effect of these other factors. Such exclusion ensures that the trend of declining operative time on the learning curve was mainly due to the increase in experience.

Analysis of the operation success rate also showed no meaningful pattern or trend based on the success rate of each 10-case cohort. No turning point was identified with regard to operation success rate. One limitation of this study was the 3-month follow-up period, which is shorter than that in other studies. In intermittent exotropia surgery, exodeviation increases over time after surgery, while success rates decline. This suggests that a longer follow-up period is likely to reveal different success rates.

Other factors that could influence the operative time and operation success rate include anesthesia approach and skill level of the assistant in the operating room. Basically, general anesthesia was given to all but those patients who rejected general anesthesia. No description is provided here on the relationship between anesthesia type and learning curve as there seemed to be no correlation. The assistant likely had minimal impact on the learning curve because the same 1st year resident was present in the operating room assisting the procedure for each surgeon.

The small number of cases included in the study was another limitation of this study. The postoperative follow-up period was only 3 months. In addition, both surgeons were highly experienced in other ophthalmologic operations before they started to perform strabismus surgery, suggesting that they were in a better position to learn a new type of surgery than surgeons with less operative experience.

Conclusion

Findings of this study suggest that a surgeon who is experienced with other ophthalmic operations should practice performing more than 50 cases of strabismus surgeries to obtain the skills required to stably perform exotropia surgery. This finding can be used to determine an appropriate training period for surgeons performing strabismus surgery. Additional studies on other factors that may affect the learning curve will help to establish a more precise learning curve for surgeons performing strabismus surgery.

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Conflicts of interest

There are no conflicts of interest.

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