Efficiency in skill development of pterygium excision with amniotic membrane transplantation among the 1st year ophthalmology residents at Thammasat Eye Center

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Purpose: To evaluate the learning curve of pterygium excision with amniotic membrane transplantation among the 1st year ophthalmology residents.

Methods: Prospective comparative study. Four first year ophthalmology residents were monitored for operating time and recurrence rate on all their cases of pterygium excision with amniotic membrane transplantation throughout one year. Data for baseline characteristic of patients with continuous data were analyzed for differences among residents using one-way ANOVA. Proportional data such as age, gender, laterality and recurrence rate were analyzed for differences among residents using Fisher's exact test. Average predicted operating time with consecutive cases were analyzed using linear regression. Operating time stabilization with consecutive cases was visualized by a Locally Weighted Scatterplot Smoothing (LOWESS) and Quadratic best fit lines.

Results: A total of 159 eyes (159 patients) with primary pterygium excision were performed with sutured amniotic membrane transplantation. All cases were attributed to four ophthalmology residents composed of 40, 41, 42 and 36 patients. The average operating time was 50.38 ± 13.92 minutes, with a range of 28 to 100 minutes. The operating time declined in proportion to the number of patients and stabilized after 38 cases (average time 43.33 ± 18.93 minutes). The recurrence rate of pterygium found in this study was 11.94%

Conclusions: Pterygium excision with sutured amniotic membrane transplantation is considered as appropriate training procedure for ophthalmology residency training due to less duration needed to reach the learning curve. Additionally, the rate of recurrence among residents is comparable to that of other similar studies.

Keywords: learning curve, operating time, pterygium excision, amniotic membrane transplantation, recurrent pterygium

Ethics: This study was approved for ethical research in human with the human research ethics committee of Thammasat University, Thailand (Research ID: MTU-EC-OP-0-105/56)

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Introduction

Pterygium is a degenerative disease of the ocular surface tissue. Many mechanisms have been proposed such as proinflammatory cytokines[1], immunological mechanism,

many of which are significantly driven by ultraviolet light and some suggested involvement of genetic factors. [2,3,4] Its prevalence is high in the tropical area near the equator with significantly more sunlight exposure.[5-8] Local climate and weather with windy, dusty, and smoky environments are also associated with higher prevalence for pterygium occurrence.[5] Some reported the influence of age resulting in younger patients being more likely to experience a recurrence.[8] Other factors such as gender are not found to be statistically proven.[9] One important part in managing patients with pterygium is the avoidance of predisposing factors such as ultraviolet from sunlight and wind exposure. In the past, bare sclera technique with or without adjunctive treatment such as β- radiation or MMC (Mitomycin C) was frequently performed in routine service. [10] However, later studies found the recurrence rate to be up to 50%.[11-13] In current practice, after pterygium excision, the bare sclera is covered by either a conjunctival graft (CAG)[10-11,14-17] or amniotic membrane transplantation (AMT)[16-18] resulting in a lower recurrence rate of approximately 5-10%. Conjunctival graft has more appealing cosmetic result in exchange for the loss of normal conjunctival tissue which might be needed for future glaucoma surgery.[11] Amniotic membrane does not require the use of the patient's normal conjunctiva. Some studies still report a higher recurrence rate by amniotic membrane compared to conjunctival graft.[9] Pterygium excision with amniotic membrane transplantation is limited by the varied availability of amniotic membrane. Surgeons place the amniotic membrane onto the sclera using either sutures or fibrin glue. Both techniques are still widely used. No reports are found to give differences to outcome.[21] Comparing both techniques that fibrin glue requires less time and a relatively flatter learning curve than the sutured technique.[19-21] Pterygium is the second most common eye disease requiring surgical treatment (second only to cataracts).[22] Pterygium excision operation is popularly used for resident training due to its complexity and less debilitating complications compared to cataract surgery in most ophthalmology residency training centers.[23] Therefore pterygium excision is an essential part of ophthalmology residency programs. It is necessary to study various factors associated between the learning curve and proficiency development of surgical procedures by residents for improving ophthalmology residency programs.

Materials and methods

One hundred and fifty-nine patients with pterygium (total of 159 eyes) were enrolled in the study. All pterygium cases in this study were screened by ophthalmologists for indication of surgery. Four first year residents were chosen to participate in this study. All procedures were conducted during October 2014 to July 2015 at Thammasat eye center. Prior to surgery patients were interviewed and underwent complete ocular examinations. All pterygium excisions were performed with sutured amniotic membrane graft in this study.

Patient selection

Inclusion criteria

1.Eye diagnosed with primary pterygium by a consultant level ophthalmologist.
2.Patients aged between 20 to 70 years old.
3.Pterygium with cornea invasion ≥ 2 mm.
4.Patients informed and consented to surgery.
5.Patients able to attend follow-up at least 6 months postoperatively.

Exclusion criteria

1.Patients with multiple pterygium heads in one eye.
2.Eyes with history of prior ocular surgery, active ocular inflammation,

infection, preexisting glaucoma or any other severe ocular disease. 3.Patients with underlying disease contraindicating for surgery such as recent onset heart attack, cerebrovascular disease. 4.Patients unable to cooperate during surgery. 5.Patients unable to consent for follow according to study protocol.

Pre-operative care

The patient history was fully taken especially on the patient occupation, UV exposure behavior (indoor and outdoor), duration and onset of pterygium, prior ocular surgery or ocular accident. Full ocular examination was performed such as visual acuity assessment, intraocular pressure measurement, complete fundus examination and slit lamp biomicroscopy to evaluate the appearance and size of pterygium on the cornea in millimeters.

Surgical technique

First the eyelid was painted with 5% povidone-iodine solution which was also used for eye irrigation. The patient's eye was draped and prepared by sterile technique. Draping was done to reduce the non-surgical exposure area. Anesthetic technique consisted of topical 0.5% tetracaine hydrochloride eye drop together with subconjunctival 2% xylocaine without adrenaline injection under the pterygium body. The pterygium head was excised from the cornea. Bleeding point was checked and stopped with cotton bud tip or by bipolar coagulator. Bare sclera was measured to tailor the size of the amniotic membrane graft. The graft was placed on bare sclera also with epithelium facing upward only. Single suture by 8-0 or 10-0 nylon was firstly done at the four corners of the amniotic membrane graft fixing to the sclera followed by continuous sutures all along graft margins. Operating time was recorded in minutes, starting from subconjunctival xylocaine injection to the last nylon suture. Cases which any intraoperative complications have occurred were thoroughly recorded.

Post-operative care and follow-up

Patients were routinely follow-up appointments on the first day, week 1, month 1, month 3 and month 6 after pterygium surgery respectively. All received topical steroid and antibiotic eye drops and eye ointments. Drug administration and dose adjustment depended on the inflammation of the eye postoperatively. Patients were advised to avoid from wind, dust and sunlight by wearing sunglasses all the time. Visual acuity assessment, intraocular pressure measurement was done together with slit lamp biomicroscopy was performed to detect inflammation and infection of the amniotic membrane in addition to recurrence of pterygium at each follow-up visit.

Statistical analysis

Prospective comparative study. Four first year ophthalmology residents were monitored for operating time and recurrence rate throughout one academic year. Data for baseline characteristic of patients with continuous data was analyzed for differences among residents using one-way ANOVA. Proportional data such as gender and recurrence rate were analyzed for differences among residents using Chi-squared test. Average predicted operating time with consecutive cases was analyzed by linear regression. Operating time stabilization with consecutive cases was visualized by a Locally Weighted Scatterplot Smoothing (LOWESS) and Quadratic best fit lines.

Results

All four residents were divided into groups A, B, C, and D as shown in table 1. All performed pterygium excision with sutured amniotic membrane transplantation in patients who were qualified by the inclusion criteria. Patients who did not

meet the criteria were excluded from the study. The surgery took place between October 2014 and July 2015. The number of patients in each group was 40, 41, 42 and 36 respectively. The average age of patient was 57.32 ± 13.15 years old. Of the 159 patients, 68 patients (42.76%) were male and 91 patients (57.23%) were female. The site of pterygium occurred was 83 (52.21%) on the right and 76 (47.79%) on the left respectively. Overall the information on number of patients, gender and laterality distribution did not show statistical differences. The shortest duration from onset of pterygium to surgery day was 6 months and the longest duration was 11 years. 10-0 nylon were mostly used for suturing in 147 patients (92.50%) while the rest 12 patients (7.55%) were sutured by 8-0 nylon. Recurrent pterygium within 6 months was found in 19 patients (11.94%). The average operating time was 50.38 ± 13.92 minutes with a range of 28 minutes to 100 minutes.

In figure 1 The LOWESS (Locally Weighted Scatterplot Smoothing) best fit line showed decreasing operating time for pterygium surgery in correspondence to the increasing number of cases. The incline of the best fit line gradually stabilized. The operating time appeared to stabilize on 40 minutes at about 38 cases visually extrapolating from this graph.

In an alternate attempt to model the learning curve from Figure 2 (Quadratic prediction model), the standard deviation of operating time represented on the vertical bars. The average operating time of all resident's first case was 75.00 ± 10.80 minutes. The operating time became gradually shorter by each consecutive case. Visually extrapolating from the Quadratic prediction model the operating time appeared to stabilize on 43 minutes at about 38 cases.

Comparing both attempts to model the learning curve at which the operating time stabilized, we found that both models are relatively consistent. Visual extrapolation of the LOWESS and Quadratic model both suggested operating time stabilization at the 38th case with operating time of about 40 and 43 minutes respectively. This was also consistent with raw data analysis and the average of the 38th case for all 4 surgeons was 43.33 ± 18.93 minutes.

In an attempt to model the progression of operating time among residents using generalized linear regression model in figure 3A,3B,3C,3D, we found that each resident spent less time

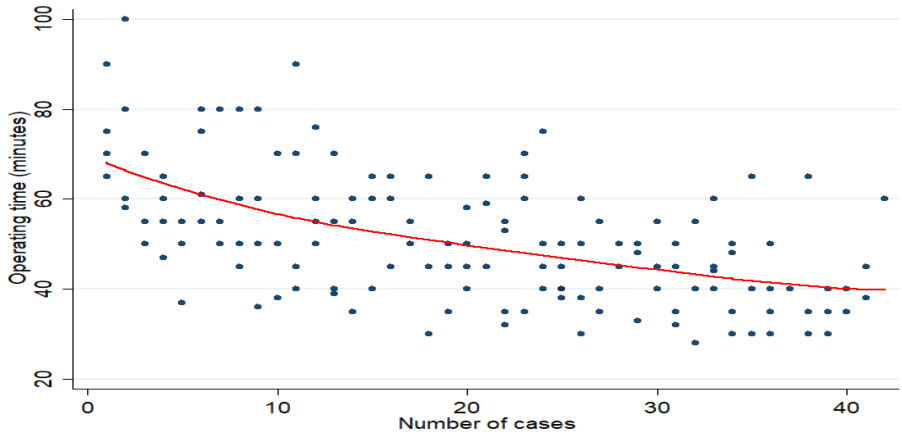

Figure 1: Operating time of pterygium excision with increasing number of cases, with LOWESS (Locally Weighted Scatterplot Smoothing) best fit line.

Table 1: Descriptive statistics in demographic data between the groups.

	A	B	C	D	Total	*P*
Number	40	41	42	36	159	0.885
Age (years old)	52.30±12.86	55.75±13.56	59.09±13.37	62.77±10.46	57.32±13.15	0.004
Affected eye						
OD	21 (52.50%)	19 (46.34%)	23 (54.76%)	20 (55.55%)	83 (52.21%)	0.763
OS	19 (47.50%)	22 (53.66%)	19 (45.24%)	16 (44.45%)	76 (47.79%)	
Gender						
Male	19 (47.50%)	17 (41.46%)	17 (40.47%)	15 (41.67%)	68 (42.76%)	0.922
Female	21 (52.50%)	24 (58.54%)	25 (59.53%)	21 (58.33%)	91 (57.23%)	
Operating time (minutes)	49.07±14.68	51.96±12.81	54.90±13.29	44.80±13.32	50.38±13.92	0.010
Suture						
10-0	40 (100.0%)	41 (100.0%)	38 (90.47%)	28 (77.78%)	147 (92.45%)	0.000
8-0	0 (0.00%)	0 (0.00%)	4 (9.53%)	8 (22.22%)	12 (7.54%)	
Number of recurrent pterygium	8 (20.00%)	4 (9.75%)	3 (7.10%)	4 (11.11%)	19 (11.94%)	0.348

according to the number of surgeries.

Graph in figure 5 was a linear regression model stratifying the number of cases into strata of 3 cases for visualization. By comparing the reduced operating time taken by each resident in the same graph shown in figure 4 and 5 (linear regression and standard error bars), all residents could be divided into 2 groups based on their similarity upon comparison of operating time (B, D and A, C). Group B and D appeared similar in operating time within the first 6 cases by faster than that of group A and C. Operating time was similarly comparable reduced in all 4 residents after the 6th case of onwards.

Of 159 eyes, 19 eyes were found to have recurrence (11.94%). The recurrence rate of each resident A, B, C, and D was 20.00 %, 9.75 %, 7.14 % and 11.11% respectively shown in table 2. Other complications noted in this study are shown in table 3 such as Dellen 1 patient (0.63%), Tenon prolapse 1 patient (0.63%), Corneal scar 6 patients (3.77%), Graft retraction 1 patient (0.63%), Epithelial cyst 1 patient (0.63%), and Pterygium granuloma 1 patient (0.63%).

Discussion

This study on surgical skill development of ophthalmology residents focused in pterygium excision with amniotic membrane transplantation is evaluated by operating time. Several studies were conducted on this topic. A study from Ramsay et al. (2001), Cook et al. (2004) had concluded various statistical methods used for learning effects in health technology.[24-25] The common term used was the relationship between the decreasing rate of operating time together with the occurrence rate of the complication. With regards to this study, the complication of interest is the recurrence rate of the pterygium after surgery. However due to the natural pathophysiology of this disease, there are

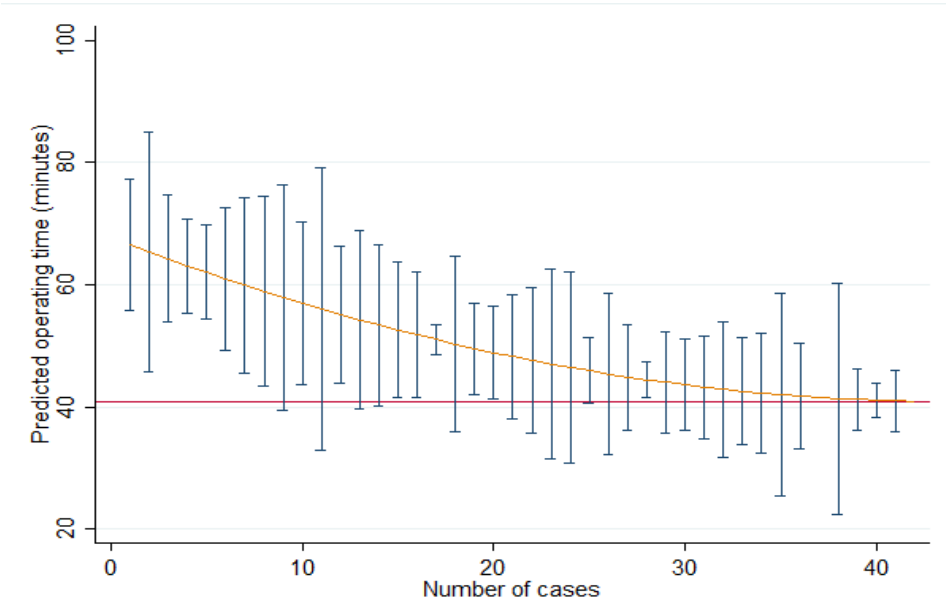

Figure 2: Predicted operating time with increasing number of cases, with Quadratic prediction model. Vertical bars represent standard deviation of operating time.

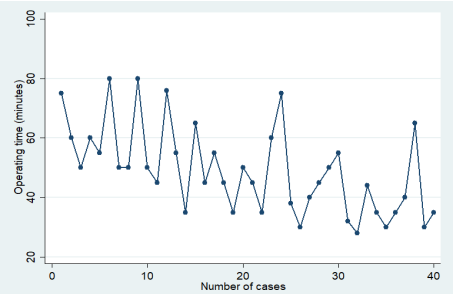

Figure 3A: Pterygium excision operating time with increasing number of cases, Surgeon A.

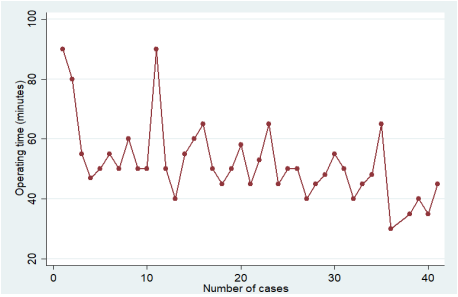

Figure 3B: Pterygium excision operating time with increasing number of cases, Surgeon B.

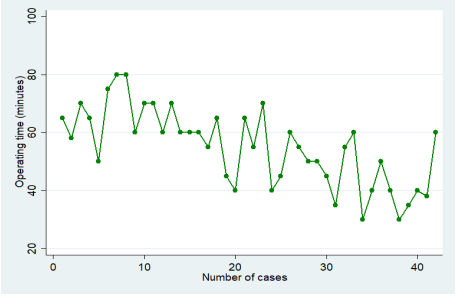

Figure 3C: Pterygium excision operating time with increasing number of cases, Surgeon C.

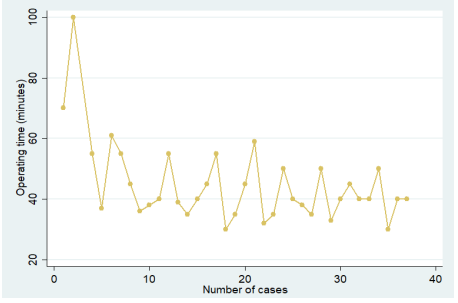

Figure 3D: Pterygium excision operating time with increasing number of cases, Surgeon D.

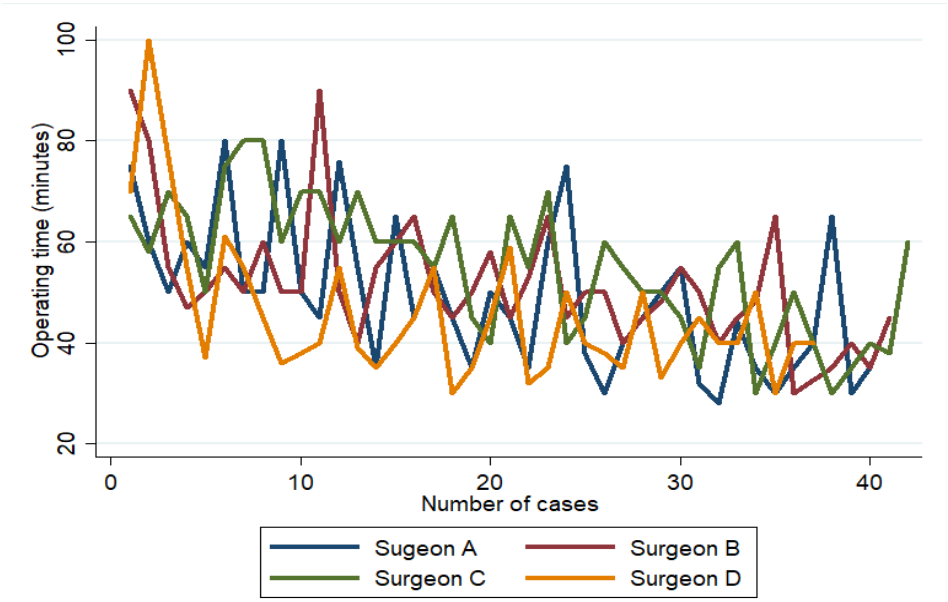

Figure 4: Pterygium excision operating time with increasing number of cases, separated by 4 surgeons.

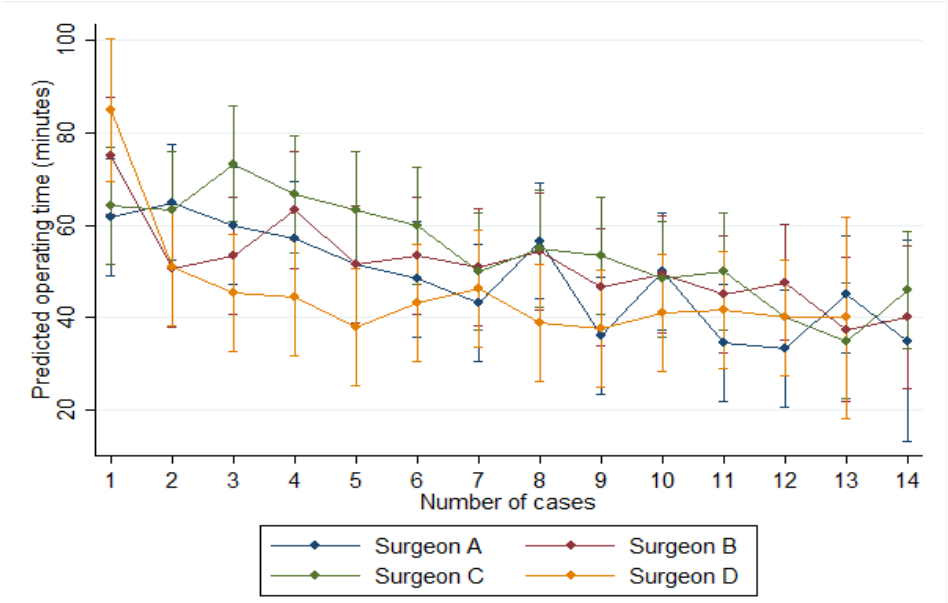

Figure 5: Predicted operating time with increasing number of cases, (in strata of 3) with linear regression and standard error bars.

multifactorial etiologies involving the recurrence rate.[26] The recurrence rate may not be the best surrogate marker for skill development in pterygium surgery during residency program training. The surgeon's expertise is one of many factors determining the learning curve. If we ignore confounding factors as complication rates and variations in intrinsic difficulties of each case ranging from anatomical to cooperative factors, the learning curve of pterygium surgery can only be followed by the decreased in operating time alone.[24]

Statistical methods to model the learning curve in studies widely used for the decreased operating time analysis was Wright and Logarithmic curve fitting of operating time data.[24] The rate of decrease in operating time during the initial phase could determine the learning curve. Wright's learning percentage was popularly used to analyze the efficacy of work in manufacturing industry which used a value as high as 80-90%.[24] However the average operating time also reflect the personal character of surgeon more than the difficulty of the surgical method.

Koranyi G. et al. observed 120 cases of pterygium surgery with the cut and paste method and quantified outcomes of learning curve development by measuring operating time and recurrence rate.[27] The study found that in surgeons with no prior experience in pterygium surgery under the microscope had the learning curve for achieving stability around 40 cases. The steepness of the learning curve for the cut and paste method was not clinically different from the surgeons experienced in cataract surgery under the microscope previously.

The objective in our project is to study the relationship between the decreasing rate of operating time and the number of surgical cases need to reach the learning curve that representing skill development in inexperienced ophthalmology resident. In figure 1 we plotted the graph by using the LOWESS (Locally Weighted Scatterplot Smoothing) best fit line to visualize the average operating time by the four ophthalmology residents. The average operating time in the first case of each resident was approximately 75.00 ± 10.80 minutes. This operating time decreased until the 38th consecutive cases and thereafter the average operating time had stabilized.

We then later plotted another graph (figure 2) using Quadratic prediction model to alternately visualize the operating time in relation to the number of consecutive cases. Visual extrapolation of both models showed that the average operating time by the ophthalmology resident was around 40 and 43 minutes respectively at the 38th case and was maintained stable even after consecutive cases. This leads to the understanding of the resident's learning curve used for pterygium excision with amniotic membrane transplantation was after 38 cases onwards. This result was similarly to the study from Koranyi G. et al. which reported the learning curve needed at 40 cases.[27] In our study the pterygium cases per each resident that can operate upon is around 36 to 42 cases which is insufficient to clearly assess the resident's skill development. But we can monitor and predict operating time from the graph trend statistically. For further studies this limitation may continue to be resolved by collecting more samples.

Figure 4 and 5 showed operating time comparison between the four residents. We found that surgeon B, D had a faster learning curve than surgeon A, C (although this was only observation in the first 6 cases). Suggesting that learning curve is a combination of various factors surrounding the experience of surgery, there are also factors that fluctuate between the surgeons themselves. The variable between the surgeons appear impactful only at the beginning of the training. When the ophthalmology resident has experienced a

Table 2: Show the recurrence of pterygium, describing the incidence and the chronological case number of which it occurred, and the proportion of recurrences that occurred in the first 10 cases for each surgeon.

Resident	Number of pterygium recurrence	Chronological case number of pterygium recurrence	Number of pterygium recurrence in the first 10 cases
A	8 (20.00%)	2,3,6,8,10,15,21,25	5 (62.5%)
B	4 (9.75%)	3,4,6,30	3 (75.0%)
C	3 (7.14%)	5,8,22	2 (66.6%)
D	4 (11.11%)	4,6,9,10	4 (100.0%)

Table 3: Surgical complications among 4 residents.

Complication	A (n=40)	B (n=41)	C (n=42)	D (n=36)	Total (n=159)
Recurrence	8 (20.00%)	4 (9.75%)	3 (7.14%)	4 (11.11%)	19 (11.94%)
Dellen	-	-	1 (2.38%)	-	1 (0.63%)
Tenon prolapse	-	1 (2.43%)	-	-	1 (0.63%)
Corneal scar	2 (5.00%)	1 (2.43%)	2 (4.76%)	1 (2.77%)	6 (3.77%)
Graft retraction	1 (2.50%)	-	-	-	1 (0.63%)
Epithelial cyst	1 (2.50%)	-	-	-	1 (0.63%)
Pterygium granuloma	-	-	1 (2.38%)	-	1 (0.63%)

considerable amount of surgery, the variable factors between the surgeons will reduce thereafter.

The skill development of pterygium surgery may be assessed by monitoring recurrent pterygium as mentioned previously. The decreased operating time as the number of patients indicate increased skills in surgery. The incidence of recurrent pterygium can result in the quality of the operation based on this experience. However this complication may not be the only surrogate marker for skill development of the surgery due to many confounding factors. Whether it is patient related factors such as the age of the patient, ethnicity or even the status of the pterygium preoperatively (size, amount, inflamed severity) as well as the behavior of daily UV light exposure. In addition the recurrent pterygium may be caused by the surgeon who performed the surgery owing to variation in surgical experience and surgical technique.

Farrah et al. found recurrent pterygium following primary pterygium excision with conjunctival autograft transplantation (CAG) performed by trainees and consultants 19.4% and 6.8% respectively.[28] Also Kositpipat K. et al. published a prospective study reporting recurrent pterygium after primary pterygium excision with conjunctival autograft transplantation 9.7% and 4.8% respectively.[29] The following study showed the lower incidence rate of recurrence in experienced surgeons. By the way there were no significantly difference between two groups in some studies.

Chalioulias et al. found no different results for primary pterygium removal with CAG of those performed by the consultants and trainees (26.3 and 24.3 %, respectively).[30] In our study the participating residents are considered as inexperienced surgeons with a recurrence rate of pterygium excision with amniotic membrane transplantation approximately 11.94%. All of which occur within the first 6 months after pterygium surgery. Previous study as mentioned above conducted about the rate of recurrent pterygium by conjunctival graft comparing to amniotic membrane transplantation had result similarly to our study. By analyzing the sequence of recurrent pterygium patients for each resident (the average amount of pterygium case per each resident is 37.75), most recurrent pterygium occurs within the first 10 patients from each ophthalmology resident. As the number of cases increase so does the decline in recurrent rate reflecting the affect to learning curve to the surgeon experience.

Our study was prospectively designed to minimize confounding factors. The result is then evaluated by the author as an independent observer. This study is a part of routine to research and it can further be used to develop ophthalmology residency training programs. The improvement point of this research is that the number of patients of each resident should be increased to obtain an average operating time at a more stable level and it will represent precise learning curve and skill development bestowing confidence about the accuracy in assessment of the surgical skill development in ophthalmology residents.

Conclusion

Most ophthalmologists perform a lot of pterygium surgeries in clinical practice. Its frequency is the second only to cataract surgery. Due to the straight-forward nature of the surgery method combined with the complexity of hand-skills required, pterygium excision is widely used for residency training as a basic procedure for microsurgery. The learning curve requires an achievable amount of time suitable for skill development within a training program. Possible complications such as recurrent pterygium is also acceptable for an inexperienced surgeon. Re-operation causes considerably less morbidity compared to other eye surgeries. Overall pterygium excision is suitable for ophthalmology residency training, but nevertheless the surgery should be conducted and monitored by experienced ophthalmologist to minimize the risk to the patients.

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Reference

1.Di Girolamo N, Chui J, Coroneo MT, et al. Pathogenesis of pterygia: role of cytokines, growth factors, ad matrix metalloproteinases. Prog Retin Eye Res. 2004;23:195–228.

2.Taylor HR, West SK, Rosenthal FS, et al. Corneal changes associated with chronic UV irradiation. Arch Ophthalmol. 1989;107:1481–4.

3.Moran DJ, Hollows FC. Pterygium and ultraviolet radiation: a positive correlation. Br J Ophthalmol. 1984;68:343–6.

4.Coroneo MT, Di Girolamo N, Wakefield D. The pathogenesis of pterygia. Curr Opin Ophthalmol. 1999;10:282–8.

5.McCarty CA, Fu CL, Taylor HR. Epidemiology of pterygium in Victoria, Australia. Br J Ophthalmol. 2000;84:289–92.

6.Gazzard G, Saw SM, Farook M, Koh D, Widjaja D, Chia SE et al. Pterygium in Indonesia: prevalence, severity and risk factors. Br J Ophthalmol. 2002;86:1341–6.

7.Wong TY, Foster PJ, Johnson GJ, Seah SK, Tan DT. The prevalence and risk factors for pterygium in an adult Chinese population in Singapore: the Tanjong Pagar survey. Am J Ophthalmol. 2001;131:176–83.
8.Lewallen S. A randomized trial of conjunctival autografting for pterygium in the tropics. Ophthalmology. 1989;96:1612–4.
9.Rosen R. Amniotic Membrane Grafts to Reduce Pterygium Recurrence. Cornea. 2018;37(2):189-93.
10.Tan DT, Chee SP, Dear KB, Lim AS. Effect of pterygium morphology on pterygium recurrence in a controlled trial comparing conjunctival autografting with bare sclera excision. Arch Ophthalmol. 1997;115:1235–40.
11.Hirst LW. The treatment of pterygium. Surv Ophthalmol. 2003;48:145–80.
12.Ti SE, Tan DT. Tectonic corneal lamellar grafting for severe scleral melting after pterygium surgery. Ophthalmology. 2003;110:1126–36.
13.Tarr KH, Constable IJ. Late complications of pterygium treatment. Br J Ophthalmol. 1980;64:496–505.
14.Kenyon KR, Wagoner MD, Hettinger ME. Conjunctival autograft transplantation for advanced and recurrent pterygium. Ophthalmology. 1985;92:1461–70.
15.Ma DH, See LC, Liau SB, Tsai RJ. Amniotic membrane graft for primary pterygium: comparison with conjunctival autograft and topical mitomycin C treatment. Br J Ophthalmol. 2000;84:973–78.
16.Prabhasawat P, Barton K, Burkett G, Tseng SC. Comparison of conjunctival autografts, amniotic membrane grafts, and primary closure for pterygium excision. Ophthalmology. 1997;104:974–85.
17.Luanratanakorn P, Ratanapakorn T, Suwan-Apichon O, Chuck RS. Randomised controlled study of conjunctival autograft versus amniotic membrane graft in pterygium excision. Br J Ophthalmol. 2006;90:1476–80.
18.Tananuvat N, Martin T. The results of amniotic membrane transplantation for primary pterygium compared with conjunctival autograft. Cornea. 2004;23:458–63.
19.Koranyi G, Seregard S, Kopp ED. Cut and paste: a no suture, small incision approach to pterygium surgery. Br J Ophthalmol. 2004;88:911–4.
20.Koranyi G, Seregard S, Kopp ED. The cut-and-paste method for primary pterygium surgery: long-term follow-up. Acta Ophthalmol Scand. 2005;83:298–301.
21.Por YM, Tan DT. Assessment of fibrin glue in pterygium surgery. Cornea. 2010;29:1–4.
22.Gogate P, Deshpande M, Dharmadhikari S. Which is the best method to learn ophthalmology? Resident doctors' perspective of ophthalmology training. Indian J Ophthalmol. 2008;56:409-12.
23.Le K, Bursztyn L, Rootman D, Harissi Dagher M. National survey of Canadian ophthalmology residency education. Can J Ophthalmol. 2016;51:219-25.
24.Ramsay CR, Grant AM, Wallace SA et al. Statistical assessment of the learning curves of health technologies. Health Technol Assess. 2001;5:1–79.
25.Cook JA, Ramsay CR & Fayers P. Statistical evaluation of learning curve effects in surgical trials. Clin Trials. 2004;1:421–7.
26.Deusinger SS. Analyzing errors in practice. A vehicle for assessing and enhancing the quality of care. Int J Technol Assess Health Care. 1992;8:62–75.
27.Koranyi G, Artzen D, Wijk T. Learning curve in the Cut and Paste method for surgery of primary pterygium. Acta Ophthalmol. 2013;91:463–8.
28.Farrah JJ, Lee GA, Greenrod E, et al. Outcomes of autoconjunctival grafting for primary pterygia when performed by consultant compared with trainee ophthalmologists. Clin Experiment

Ophthalmol. 2006;34:857–60.
29.Kositphipat K, Tananuvat N, Choovuthayakorn J. Results of pterygium excision adjunct with conjunctival autograft transplantation for primary pterygium by ophthalmology trainees. Int Ophthalmol. 2016;36:615–21.
30.Chalioulias K, Dwarika D, Thakur S. Pterygium excision with conjunctival autograft: consultant versus trainee. Clin Exp Ophthalmol. 2007;35:396.