• Clinical Research •

Intermittent sliding-lock-knot suture for limbal conjunctival autograft fixation in pterygium surgery: a technique note

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Abstract

● **AIM:** To report a technique used with intermittent sliding-lock-knot (ISLK) fixation for limbal conjunctival autografts in pterygium surgery and compared with those of routine intermittent (RI) fixation.

● **METHODS:** Consecutive patients with primary pterygium who had undergone pterygium excision combined with limbal conjunctival autograft transplantation between March 2021 and March 2022 at our institute were retrospectively analyzed. Primary outcome measures were mean duration of surgery and suture removal, degree of conjunctival hyperemia on postoperative day 1, pain score at suture removal, postoperative symptoms at 6mo, including conjunctival hyperemia, foreign body sensation, and graft stability.

● **RESULTS:** Ninety-eight patients underwent monocular surgery and were divided into ISLK (51 eyes) and RI (47 eyes) groups according to the type of conjunctiva autograft fixation method planned. There was no significant difference in mean duration of surgery between the two groups (18.59±2.39min *vs* 18.15±2.20min, *P*=0.417); however, compared to the RI group, shorter suture removal times were observed in the ISLK group [0.58min (0.42-0.87) *vs* 3.00min (2.21-4.15), *P*<0.001]. The degree of conjunctival hyperemia on postoperative day 1 was milder in the ISLK group (*P*<0.001). Pain scores at suture removal were lower in the ISLK group than in RI group [1 (0-3) *vs* 2 (1-4), *P*<0.001]. Postoperative symptoms at 6mo were comparable between the groups (*P*=0.487), with no recurrence.

● **CONCLUSION:** ISLK is an innovative method for limbal conjunctival autograft fixation after pterygium excision. Compared to RI fixation, ISLK facilitates suture removal and reduces discomfort, with comparable surgery duration and less conjunctival hyperemia.

● **KEYWORDS:** intermittent sliding-lock-knot fixation; pterygium; suture removal

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INTRODUCTION

Pterygium is a common ocular surface disease characterized by the invasion of fibrovascular tissue from the bulbar conjunctiva into the cornea, leading to corneal astigmatism, malcosmetic, and even loss of vision[1]. It is important to differentiate it from pseudopterygium[2]. Currently, the most commonly employed and effective surgical approach for pterygium treatment involves excision combined with limbal conjunctival autograft transplantation[3-4]. To date, limbal conjunctival autografts, following excision of the pterygium, have been reported to be the optimal approach to prevent recurrence[5-6]. Autologous conjunctiva can be fixed at the graft site by suture, fibrin glue, or autologous blood. Among these methods, routine intermittent (RI) fixation is preferred by various ophthalmologists because of its low incidence of graft displacement and low cost[6-7]. However, when the RI suture is used to secure the limbal conjunctival autograft, it often induces an obvious inflammatory reaction and significant symptoms of irritation, including pain and foreign body sensation[5,8]. Therefore, we propose an intermittent sliding-

lock-knot (ISLK) fixation technique of limbal conjunctival autograft to optimize the current suture method and compare the clinical outcomes of this method with that of RI fixation.

SUBJECTS AND METHODS

Ethical Approval This study was approved by the Research Ethics Committee of the Second Affiliated Hospital of Fujian Medical University on July 20, 2021 (No.XJS2021031) and was conducted according to the Declaration of Helsinki. Written informed consent was obtained from all patients prior to study initiation.

General Information We retrospectively analyzed consecutive patients with primary pterygium who had undergone surgery between March 2021 and March 2022 at the Second Affiliated Hospital of Fujian Medical University, China.

Inclusion criteria were primary pterygium on the nasal side and extending at least 2 mm from the limbus. The exclusion criteria were as follows: 1) patients with recurrent pterygium or temporal pterygium, a history of previous eye surgery, other ocular disorders, including lack of limbal stem cells, trichiasis, abnormal eyelids, glaucoma, and uveitis; 2) patients with systemic diseases, including severe hepatic and renal dysfunction, coagulopathies, and Sjögren's syndrome; 3) patients on anticoagulation therapy.

During the initial 6mo (March 2021 to September 2021) of the study period, we primarily employed the RI suture technique to fix the graft. However, due to notable drawbacks observed in practical application, such as pronounced inflammation and irritation following RI suturing[8-9], we proposed interrupted ISLK sutures. This method was employed in the latter half of the study period (September 2021 to March 2022). Eligible patients, who met the inclusion criteria, were allocated to either the ISLK or RI group, based on the method of conjunctiva autograft fixation technique. Data regarding the mean duration of surgery and suture removal, degree of conjunctival hyperemia on postoperative day 1, patients' pain scores during the suture removal procedure, and the postoperative symptoms at 6mo, including conjunctival hyperemia, foreign body sensation, and graft stability, were collected and evaluated. Detailed demographic and clinical data of the patients, including sex, age, and other systemic diseases, including hypertension and diabetes, were obtained from their medical records.

Perioperative Medication All patients were treated with tobramycin eye drops preoperatively (Tobrex Alcon-Couvreur, Belgium) for *q2h* before they went to bed on the day prior to surgery. From postoperative day 1, both groups were treated with tobramycin eye drops and 1% prednisolone acetate ophthalmic suspension (Pred Forte, Ireland) that was administered four times a day, for 1wk. Tobramycin dexamethasone eye ointment (TobraDex, Alcon Cusi, Spain) was also applied once at night for 1wk.

Surgical Procedures All surgical procedures were performed by a senior ophthalmologist under microscope (Carl Zeiss, VISU210). After topical anesthesia was achieved with the instillation of three drops of 0.5% tetracaine hydrochloride eye drops at intervals of 5min, a lid speculum was applied to open the eyelid during operation. The local anesthetic, lidocaine (HCl 20 mg/mL plus epinephrine 0.0125 mg/mL; 0.5 mL), was then injected under the pterygium body using a 25-gauge needle; the pterygium was seized with forceps at the neck and then cut from the body of tissue. The fascia tissue underneath was removed, the apex of the pterygium was held, and the pterygium was then peeled off the cornea using a pair of Wescot scissors. Minimal cauterization of the bleeding vessels was applied. After the conjunctival defect was measured, a free limbal conjunctival autograft was harvested from the superior bulbar conjunctiva of the same eye. During harvesting of the conjunctival autograft, efforts were made to minimize the removal of subconjunctival tenon's tissue. The free graft was then transposed and positioned with the same orientation as the limbal. The conjunctival defect where the graft was harvested was left unsutured. Five sutures were used per technique with a 10/0 nylon thread (EH210 V002, USA), two of which were secured at the limbus, and three at the opposite edge of the graft to attach it to the adjacent conjunctiva and sclera.

Different fixation methods were adopted in the two groups: the ISLK group underwent ISLK fixation with 10/0 nylon thread, and the RI group underwent RI fixation with 10/0 nylon thread. After passing through the bulbar conjunctiva, the episclera, and the conjunctival graft, the sutures were then tightened and cut short. After surgery, the conjunctival sac was coated with tobramycin dexamethasone eye ointment, and the monocular eye pad was bandaged. The surgery was video-recorded, and the duration of surgery was noted. The duration of surgery was calculated from the administration of anesthetics to the removal of the lid speculum. The ISLK fixation method is illustrated in Figure 1 and Video 1 (online supplementary).

Quantification of the Degree of Conjunctival Hyperemia on the Postoperative Day 1 The degree of conjunctival hyperemia refer to Srinivasan *et al*[10]. A degree of conjunctival hyperemia less than or equal to level II was considered mild to moderate conjunctival hyperemia, and a degree greater than level II was considered as severe conjunctival hyperemia.

Removal of Suture and Pain Assessment The sutures in both groups were removed on postoperative day 7, and the procedure was performed under topical anesthesia. Suture removal in the ISLK group was performed as follows: the eyelid was pushed by the fingers on the left hand to expose the conjunctiva graft, and the suture was removed by pulling the end with a micro tweezer under the slit lamp (Video 2, online supplementary). Suture removal in the RI group was performed

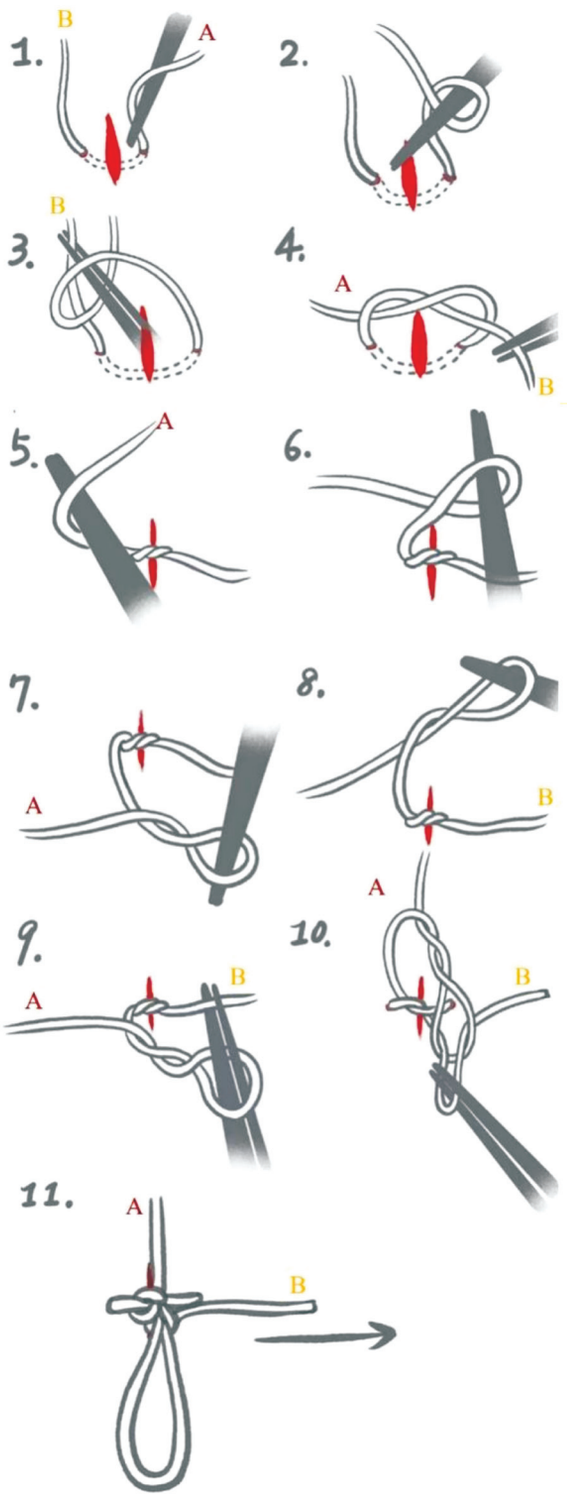

Figure 1 A schematic diagram of ISLK fixation End A refers to the suture with the attached needle, while end B designates the free end of the suture. The needle holder makes a circle around ending A (1, 2), end B was grasped with the needle holder (3). The needle holder was pulled and pushed to lay the first knot (4). The same steps are repeated to make a circle around end A (5, 6). The needle holder was twisted once to make an entanglement (7, 8), then end B was grasped with the needle holder (9). The needle holder was pulled to lay the second knot (10). For suture removal, a piece of micro tweezers was used to pull end B, thereby opening the ISLK (11). Suture can then be pulled off easily. ISLK: Intermittent sliding-lock-knot.

as follows: A lid speculum was used to open the eye, the micro tweezers were used to grasp the end of the suture, and a 1 mL injection needle was used to cut off the sutures. Thereafter, the duration of suture removal was recorded, and pain during suture removal was scored.

The pain during suture removal was graded using a five-point scale[5,8,11-12]. The 0 represented no pain, 1 meant the pain could be tolerated, 2 meant the pain was quite uncomfortable, 3 meant it hurt very much, and 4 meant it was unbearable and the procedure needed to be stopped to relieve pain.

Postoperative Follow-up Patients were followed up at 6mo after surgery. The postoperative symptoms were assessed after completion of a preformed questionnaire that included grading of conjunctival hyperemia, foreign body sensation, and graft stability[10,13]. Each of the three outcomes was scored on a scale ranging from 0 to 4 (Table 1). The most appropriate grade was selected from the three evaluation indexes, and the sum of the corresponding scores constituted the final follow-up result. Zero meant no discomfort at all, 1-3 indicated mild discomfort, 4-6 represented moderate discomfort, 7-9 denoted significant discomfort, and 10-12 signified severe discomfort.

Statistical Analysis The data were statistically analyzed using SPSS 25.0 (Chicago, Armonk, NY, USA). Age, surgery duration, suture removal duration, and pain score were analyzed using the Shapiro-Wilk test for normality and Levene's test for homogeneity of variance. Age and surgery duration, which were normally distributed, were expressed as mean±standard deviation (SD) [95% confidence interval (CI)]. These parameters were then compared using compared with Student's *t*-test. However, the degree of conjunctival hyperemia, the suture removal duration, pain score and followed-up evaluation did not conform to the normal distribution which were expressed as the median (min-max) and compared using the Mann-Whitney *U* test. Statistical significance was defined as a P-value<0.05.

RESULTS

A total of 98 eyes were included in the study, of whom 51 and 47 were allocated to the ISLK and RI groups, respectively. All patients underwent ocular examination, including standard slit-lamp examination, visual acuity testing, optometry, intraocular pressure, and fundus photography. The demographic and clinical characteristics of both groups are shown in Table 2 and Figure 2. No recurrence was observed in both groups for 6mo after surgery. The mean surgery duration in ISLK group was 18.59±2.39min (95%CI: 17.91-19.28min), whilst that in the RI group was 18.15±2.20min (95%CI: 17.61-18.90min). There was no significant difference observed in the mean surgery duration between the two groups (P=0.417).

Regarding the degree of conjunctival hyperemia on postoperative day 1, 24 patients in the ISLK group exhibited a degree less

Table 1 Follow-up outcome evaluation at 6mo after pterygium surgery

Follow-up evaluation	Scoring parameters
Conjunctival hyperemia	0=None
	1=Mild hyperemia of bulbar conjunctiva
	2=Moderate hyperemia of bulbar conjunctiva, no eyelid swelling
	3=Significant bulbar conjunctival hyperemia, with eyelid swelling
	4=Significant bulbar conjunctival hyperemia, with high eyelid swelling, small palpebral fissure
Foreign body sensation	0=None
	1=Presence of foreign body sensation but easily tolerated
	2=Presence of foreign body sensation causing some discomfort
	3=Presence of foreign body sensation causing discomfort that interferes with usual activity or sleep, lacrimation is obvious
	4=Presence of foreign body sensation that completely interferes with usual activity or sleep
Graft stability	0=All four sides of the graft margin are well apposed
	1=Gaping/displacement of one side of the graft-bed junction
	2=Gaping/displacement of two sides of the graft-bed junction
	3=Gaping/displacement of three sides of the graft-bed junction
	4=Graft completely displaced from the bed

Table 2 Comparison of characters and main outcomes between ISLK and RI fixation

Parameters	Total (*n*=98)	ISLK (*n*=51)	RI (*n*=47)	*P*
Sex, female, *n* (%)	64 (65.3)	37 (72.5)	27 (57.4)	0.166
Age, y, mean (SD)	61.65 (10.20)	62.65 (10.03)	60.52 (10.59)	0.247
Surgery duration, min, mean (SD)	18.37 (2.30)	18.59 (2.39)	18.15 (2.20)	0.417
Conjunctiva hyperemia, *n* (%)				<0.001
≤II	34 (34.7)	24 (47.1)	10 (21.3)	
>II	64 (65.3)	27 (52.9)	37 (78.7)	
SRD, min, median (range)	0.77 (0.42-4.43)	0.58 (0.42-0.87)	3.00 (2.57-4.43)	<0.001
Pain score, point, median (range)	2 (0-4)	1 (0-3)	2 (1-4)	<0.001
Postoperative outcome score, point, median (range)	0 (0-2)	0 (0-1)	0 (0-2)	0.487

ISLK: Intermittent sliding-lock-knot; SRD: Suture removal duration; SD: Standard deviation; RI: Routine intermittent.

than or equal to II, and 27 patients had a degree greater than II. In the RI group, 10 patients were less than or equal to II, and 37 patients had a degree greater than II. Overall, the degree of conjunctival hyperemia in the ISLK group was milder than that in the RI group (P<0.001).

The suture removal duration in the ISLK group (0.58min, 0.42-0.87; median, min-max) was significantly less than that in the RI group (3.00min, 2.57-4.43; P<0.001).

The pain score during the suture removal procedure in ISLK patients ranged from 0-1, with a median (min-max) overall pain score of 1 (0-3). In the RI group, the patients experienced more pain and discomfort, with a score ranging from 1 to 3, and the overall pain score was 2 (1-4), The difference between the two groups was significant (P<0.001).

A total of 98 cases were followed up at 6mo, of which three cases were lost to follow-up (two patients in the ISLK group and one in the RI group). The sum of the scores for each of the three outcomes (conjunctival hyperemia, foreign body sensation and graft stability) were as follows: in the ISLK group, 6 and 43 patients had a score of 1 and 0 respectively, whilst in RI group, 5 patients had a score of 1, 1 patient a score of 2 and 39 patients exhibited a score of 0. There was no significant difference detected in conjunctival hyperemia, foreign body sensation and graft stability at 6mo after surgery between the two groups (P=0.487).

DISCUSSION

Although recent studies have reported the mechanism and diagnosis of pterygium, surgical suture modalities remain to be further explored[14-15]. Currently, limbal conjunctival autograft is considered the gold standard for the management of primary pterygium owing to its reduced recurrence rate and fewer complications[16-19]. Various methods have been reported to fix the limbal conjunctival autograft, including routine sutures, autologous serum adhesion, fibrin glue, biological glue and corneal bandage lenses[18,20-23]. At present, whether fibrin glue should be used remains controversial[22]. Elwan[24] reported that the use of fibrin glue instead of suture in pterygium surgery can effectively reduce postoperative ocular discomfort and avoid removing the suture. However, fibrin glue as a heterologous substance has the risk of cross infection and allergic reaction,

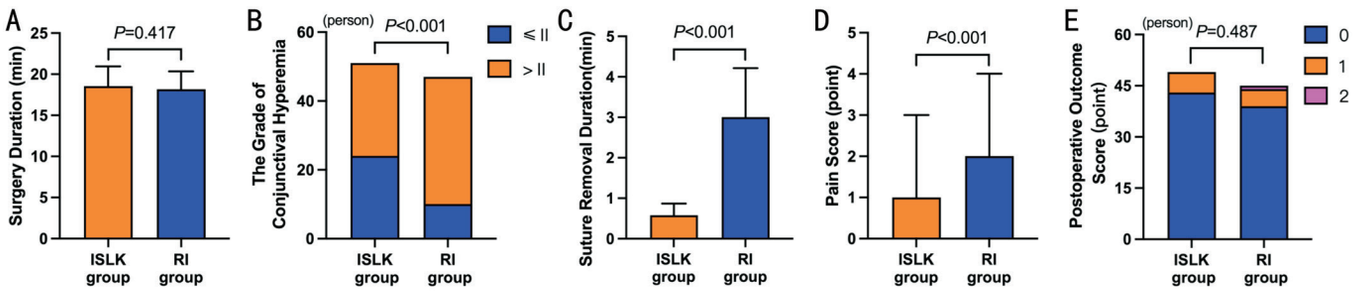

Figure 2 Comparison of main outcomes between ISLK and RI fixation Comparison of the surgery duration (A), the degree of conjunctiva hyperemia on day 1 (B), suture removal duration (C), patients' pain score during suture removal procedure (D) and long-term outcomes at the follow-up of 6mo (E) between ISLK group and RI group. The degree of conjunctival hyperemia was based on the scoring criteria set by Srinivasan *et al*[10], and the degree of conjunctival hyperemia ≤II was included as mild and >II was set as moderate to severe. Pain scores at suture removal were performed according to the scoring criteria set by Lim-Bon-Siong *et al*[12]. The postoperative outcome score was based on the evaluation criteria of Bista *et al*[13]. ISLK: Intermittent sliding-lock-knot; RI: Routine intermittent.

and the commercial fibrin glue is costly[9,22]. Therefore, despite the drawbacks of postoperative discomfort and significant inflammatory reactions associated with RI suture fixation, limbal conjunctival autograft fixation using sutures remains the main technique[5]. Given the above situation, we innovatively employed the ISLK fixation method during the surgery. The method left only one sliding-lock knot with a long ending, thereby making the sutures easy to pull off, with a comparable surgery duration to RI fixation, milder conjunctival hyperemia on the first day after surgery, and less pain during suture removal.

In this study, the duration of surgery in the two groups were comparable. The operation time was similar to that of Zloto *et al*[23] who reported a surgery duration of 16.72min, which was slightly shorter than that reported by Bista *et al*[13] (22.14±1.79min), which may be related to the pterygium length and the degree of corneal infiltration.

In addition, we observed that the degree of conjunctival hyperemia on the first day after surgery in the ISLK group was milder than that in the RI group. This may be because that, in comparison with the routine method where the thread ends of the knot stand, the thread ends of the knot lay flat on the ocular surface in the slide knot suture method. This results in less irritating to the ocular surface, consequently decreasing the degree of postoperative inflammatory reaction (Figure 3)[8].

The shorter suture removal time may reduce the risk of infection when patients remove sutures[25-26]. In the present analysis, the suture removal time of the ISLK group was much shorter than that of the RI group. This may be because ISLK fixation left only one sliding-lock knot with a long ending, and only the end of the line needs to be pulled when the suture is removed. In contrast, the RI fixation requires the use of a lid speculum to support the eyelid and the suture needs to be picked up one by one before cutting it off.

Significantly lower pain levels were observed in the ISLK group, compared to RI group. This may be because, during RI suture removal, the lid speculum needs to be used to support the eyelid and the removal process is achieved with two hands, one holding the suture while the other hand is used to cut the knot off, with tools (Video 3, online supplementary). Patients in the RI group often suffer more from the use of the lid speculum and the corneal exposure during the suture removal[25]. Moreover, there may be buried suture knots buried under the conjunctival graft using RI method. When the RI suture is removed, part of the conjunctival graft tissue needs to be cut open, which may cause bleeding and pain[27-29].

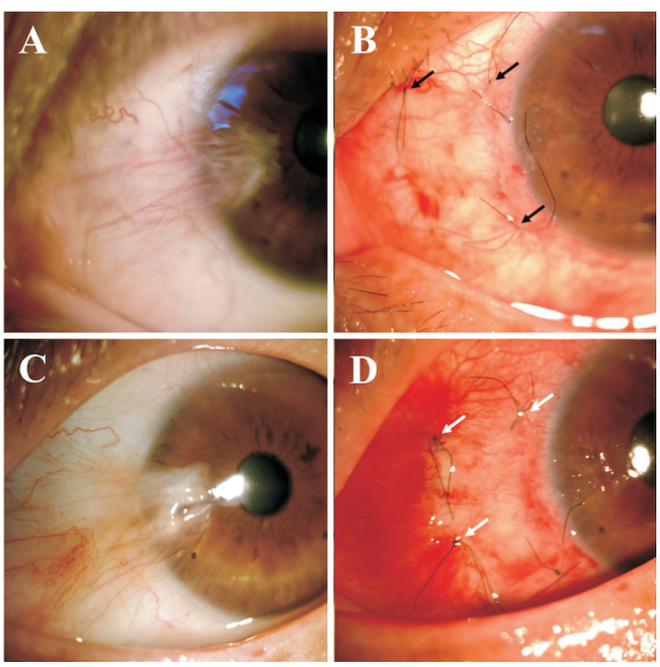

Figure 3 Comparison of patients with ISLK fixation and RI fixation A pterygium patient undergoing ISLK fixation: before surgery (A) and one day after surgery (B). The thread ends of the knot laid flat upon the surface (black arrow), were less irritating to the ocular surface. Another pterygium patient undergoing RI fixation: before surgery (C) and one day after the surgery (D). The thread ends of the knot can be seen standing (white arrow) which may cause more irritation. As shown, conjunctival hyperemia was significantly milder in ISLK group. ISLK: Intermittent sliding-lock-knot; RI: Routine intermittent.

Regarding the long-term outcomes, there was no significant difference between ISLK group and RI group at the 6-month follow-up. The experience of foreign body sensation, conjunctival hyperemia, and graft stability in the two groups were comparable.

Patients in both groups showed no recurrence within the six-month follow-up period. The main reason may be that the limbal conjunctival autograft used in both group plays a significant role in inhibiting recurrence[11,30-31]. Limbal conjunctival autograft can be used as a barrier to prevent conjunctiva from invading the cornea, and can also provide stem cells to the corneal epithelium[32].

There are several limitations in this study. First, due to the limited data, the invasion depth and morphology of the pterygium have not been taken into consideration, which may affect the surgery duration. Second, removing the ISLK sutures may be inconvenient when the knot loop attaches to the conjunctiva during being tightened. Third, it may take more time to secure the conjunctival graft during ISLK sutures compared to the utilization of fibrin glue and biological adhesives. Further studies may be focused on these issues. Finally, prospective studies are warranted to include an index of general patient satisfaction with each of the procedures.

In conclusion, we propose ISLK as an innovative method for limbal conjunctival autograft fixation after pterygium excision. This technique facilitated suture removal and reduced discomfort compared to RI fixation, with a comparable surgery duration and less conjunctival hyperemia. Future studies with larger sample sizes are warranted to validate this technique.

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