Original Article

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Innovative Approaches to Butterfly Sutures in Penetrating Keratoplasty: A Quasi-experimental Study

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ABSTRACT

Background: Penetrating keratoplasty (PK) is a widely performed surgical procedure to treat various end-stage corneal diseases. The success of PK relies primarily on suturing techniques that secure the donor corneal button to the recipient's eye. This research paper evaluates a novel method of corneal suturing in PK termed butterfly suturing. We have analyzed butterfly sutures in terms of their impact on wound healing and astigmatism, the two major factors influencing the outcome of a successful PK.

Methods: This quasi-experimental study was conducted at the tertiary level at the Sindh Institute of Ophthalmology and Visual Sciences, Hyderabad, Sindh. Five PK cases were selected for the study, where butterfly sutures were applied. Post-operative evaluations were carried out to assess astigmatism, graft-host healing and overall surgical success.

Results: Among the five cases that underwent PK with butterfly sutures, four demonstrated stable graft-host junctions with adequate healing. One case resulted in a disrupted graft-host interface, necessitating further intervention. Regarding post-operative refractive outcomes, our cases showed varying degrees of astigmatism.

Conclusion: The butterfly suture technique in PK is an innovative approach to improving surgical success. Its unique cross-over pattern provides improved wound stability and enhanced healing. Better wound dynamics should lead to a reduction of post-operative astigmatism. Most cases in our study showed favorable outcomes regarding healing, though a higher amount of astigmatism was noticed with butterfly sutures.

Keywords: Astigmatism, Butterfly sutures, Cornea, Penetrating keratoplasty, Wound.

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INTRODUCTION

The cornea is a prime component of the ocular optical complex. A transparent cornea is essential for its optimum functioning. Corneal transparency can be compromised by many diseases, including corneal infections, dystrophies, degenerations and trauma[1-4].

Keratoplasty is a surgical procedure which replaces a diseased host cornea with a clear donor corneal button. Conventional keratoplasty replaces all layers of the cornea, termed penetrating keratoplasty, in contrast to lamellar keratoplasty, which substitutes only selected layers. Though lamellar keratoplasty has largely superseded penetrating keratoplasty, PK remains the option of choice due to various limitations at many centres[5-9].

The outcome of successful PK relies on effective suture placement, which secures the host tissue and sends it to the recipient's bed. Interrupted, continuous or both varieties of suturing can be utilized. Interrupted sutures are likely to give rise to higher amounts of astigmatism, but each suture can be individually manipulated in the post-operative period if needed. Continuous sutures, on the other hand, produce lesser astigmatism by evenly distributing tension across the wound, but selective manipulation is not possible[10-12]. The combination of interrupted and continuous sutures offers the benefits of both techniques. Butterfly

suturing is a type of combined suturing method. For butterfly sutures, the cardinal stitches are placed at 12, 6, 3, and 9 clock hours; the application of further follows this interrupted stitches between 1.5, 4.5, 7.5, and 10.5 clock hours. The interrupted sutures act as trunks of butterflies, around each of which a cross-over continuous suture forms the wings[13,14,15].

Although suturing maneuvers are evolving, stable wound closure and avoiding post-PK astigmatism remain burning issues. While theoretically valuable for joining interrupted suture techniques with continuous forms, butterfly suturing remains the least studied in a clinical environment. This study aims to assess the surgical outcomes and wound integrity and to further delineate the refractive implications of butterfly suturing in penetrating keratoplasty. By analyzing astigmatism and complication rates post-operatively, this study will demonstrate whether butterfly sutures represent a viable alternative to conventional interrupted or continuous suture techniques.

METHODOLOGY

Study Design

The study employed a quasi-experimental design to assess the butterfly sutures in penetrating keratoplasty (PK). A total of five PK cases were purposefully selected from Sindh Institute of Opthalmologty & Visual Sciences (SIOVS), focuing on patients aged between 22 to 65 years. The indications for PK included Fuchs' endothelial dystrophy, pseudophakic bollus keratopathy, corneal opacity resulting from resolved infectious keratitis, and corneal dystrophy.

Preoperative Assessment

Preoperative assessments included visual acuities with Snellen's chart; besides these, all cases had complete ocular examinations to rule out posterior segment abnormalities. Corneal topography was done to rule out pre-existing astigmatism and determine peripheral corneal thickness.

Surgical Procedure

All surgeries were performed under general anesthesia by one corneal surgeon. The grafts were prepared using suction trephine, which was also used to excise host corneal tissue. The trephine used was 7.75 mm for the donor and 7.25 mm for the recipient. Butterfly suturing was applied to secure the graft using 10.0 nylon sutures.

Post-operative Follow-Up

The follow-ups were scheduled as follows:

- Weekly for the first month,
- Biweekly in the second month,
- Monthly from the third day to the sixth month, and every three months thereafter until all sutures were removed.

Every follow-up consisted of:

- Visual acuity measurement by Snellen's chart,
- Astigmatism grading through corneal topography,
- Slit lamp examination for wound healing and graft integrity evaluation.

Suturing Method

Butterfly suturing involving a crossover pattern of interrupted and continuous sutures was committed to maximizing wound stability. The modified method focused on enhancing graft-host approximation and minimizing post-operative astigmatism.

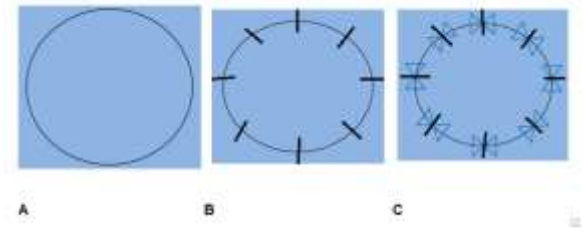

Fig.1 Suturing Method

Case Summaries

Case#1: A 68-year-old man with bilateral Fuchs endothelial dystrophy underwent PK with butterfly sutures in the right eye. Post-operative uncorrected visual acuity was 3/60, which improved to 6/18 with correction. The patient had a -6.00D cylinder at 75 degrees, which improved to -2.75D after suture removal at 18 months.

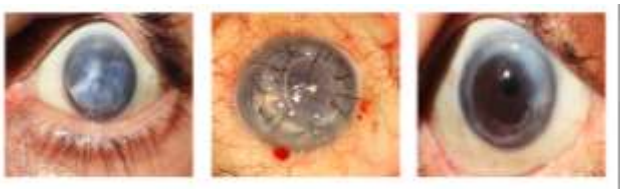

Fig.2 Case-1 with Bilateral Fuchs Endothelial Dystrophy

Case#2: A 65-year-old male with pseudophakic bullous keratopathy of the right eye underwent PK. Post-operative uncorrected visual acuity was 3/60, improving with correction to 6/24. Refractive status showed -9.75D cylinder at 25 degrees.

Fig.3 Case-2 with Pseudophakic Bullous Keratopathy

Case#3: An active 28-year-old male with corneal opacity, being at the center of his right eye due to a past-healed episode of infective keratitis. Post-operatively, the uncorrected vision was 3/60, but it improved to 6/18 with correction. The refractive state was a -7.00D cylinder at 180 degrees.

Fig.3 Case-3 with Corneal Opacity

Case#4: A 30-year-old female diagnosed with corneal dystrophy underwent PK in her right eye. Post-operatively unassisted visual acuity was 6/60, which improved with correction to 6/24. The eye's refractive status was a -6.00D cylinder at 180 degrees.

Fig.4 Case-3 with Corneal Dystrophy

Case#5: A 38-year-old female and the sister of Case#4, again diagnosed with corneal dystrophy, had PK performed in her right eye. Post-operatively, unaided visual acuity was 6/60, improving to 6/24 with correction. The refractive status showed a -10.00D cylinder at 170 degrees.

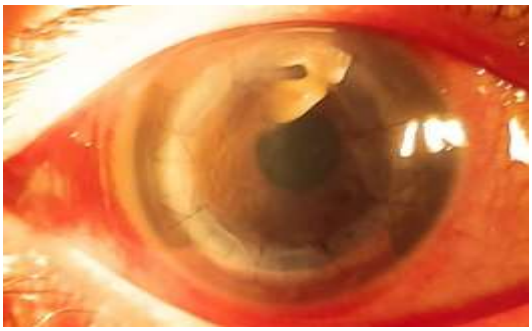

Fig.5 Case-3 with Corneal Dystrophy

Clinical Relevance

This study provides insights concerning the clinical outcome of butterfly sutures used in PK, specifically in addressing post-operative astigmatism and bettering graft stability. These findings will help refine the surgical technique for better visual rehabilitation in PK patients.

RESULTS

Surgical Outcomes

Four of the five cases of PK during which butterfly sutures were used could be categorized as successful based on wound approximation and healing parameters. However, one case experienced wound dehiscence 3 months post-operatively due to an underlying ocular surface disease.

Post-operative Astigmatism

The cases recorded a higher-than-expected level of post-operative astigmatism (>4.00 diopters) among the patients who received butterfly sutures. Literature suggests that post-operative astigmatism affects <30% of patients undergoing PK, with the highest reported incidence being 38%.

Post-operative Astigmatism Risk Factors

Various factors influence the incidence of post-operative astigmatism, which can be classified as preoperative, intraoperative, and post-operative risk factors:

- **Pre-operative Risk Factors:** The diagnosis and severity of the corneal condition are key considerations. In cases of corneal ectasia, the graft may extend into irregular host tissue, contributing to astigmatism, but certainly,

none of our patients had PK for corneal ectasia.

- **Intra-operative Risk Factors:** These manual trephination with non-facilitation of appropriate graft sizes and considering the donor cornea's characteristics. In this study, suction trephination and moderate graft sizes were used. However, a fixed graft size would not be suitable for all cases, particularly in patients with encroachment on a large cornea area. Pre-existing astigmatism in the donor cornea may also constitute another variable.

- **Post-operative Factors:** Poor inflammation control has been known to aggravate astigmatism. However, our cases had well-controlled inflammation after surgery. The first case followed until the complete removal of sutures significantly reduced astigmatism, suggesting that with the removal of sutures, similar improvements could be expected in other cases.

Astigmatism Management and Suture Removal

According to Burk LL, selective suture removal post-PK causes an average reduction in astigmatism of about 2-3 diopters, with some cases experiencing as much as 12 diopters. Selective suture removal is ideally timed at least six months after PK; at this point, astigmatism may be managed using spectacles or contact lenses. Other corrective options may also be used, including relaxing incisions, compression sutures, LASIK, and toric intraocular lenses.

Table-1 Summary of Findings

Aspect	Findings
Favorable Surgical Outcomes	4/5 cases
Wound Dehiscence	1/5 cases (due to pre-existing ocular disorder)
Postoperative Astigmatism (>4.00 D)	Higher than expected
Literature Reference	Typically <30%, highest reported: 38% (Williams et al.)
Selective Suture Removal (Burk LL)	2-3 D reduction, max 12 D
Ideal Suture Removal Time	6+ months post-PK

DISCUSSION

Innovative approaches to butterfly sutures in PK offer promising advancements in surgical outcomes, particularly in enhancing wound stability and minimizing post-operative complications. The butterfly suture technique, characterized by its unique cross-over pattern, aims to optimize graft-host junction integrity and promote more efficient corneal healing. Our study at the SIOVS involved five PK cases utilizing butterfly sutures. Post-operative assessments focused on two critical factors influencing PK success: wound healing and astigmatism. Among the five cases, four demonstrated stable graft-host junctions with adequate healing, while one case encountered graft-host interface disruption necessitating further intervention. This suggests that butterfly sutures provide a reliable method for securing the donor corneal button, although individual variations in healing response must be considered.

Future research should involve larger sample sizes to confirm the effectiveness and reliability of butterfly sutures in PK. Additionally, conducting a parallel study comparing butterfly sutures with other techniques, such as interrupted and continuous sutures, could help reduce potential surgeon-induced variability in astigmatism outcomes.

CONCLUSION

Our study revealed higher post-operative astigmatism with butterfly sutures in PK. Comparative studies are advocated to establish the efficacy of this novel technique further. The butterfly sutures assured potential benefits in reducing astigmatism and improving wound stability. Although, all cases need a careful technical evaluation for further precision. Five cases highlight the varying degrees of visual impairment and refractive errors associated with corneal dystrophies and related conditions, even after surgical intervention. Each patient had significant corneal irregularities, primarily astigmatism, requiring careful management through corrective lenses or additional procedures. The outcomes emphasize the importance of personalized follow-up and treatment plans to optimize visual acuity and ensure each patient's best possible quality of life.

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Author Contributions
Shahzad Memon conceptualized and designed the study. **Fariha Sher Wali, Bibi Rafeen Talpur**, and **Asra Talpur** contributed to data collection and analysis. **Shehnilla Shujaat** and **Abdul Adnan Majeed** assisted in surgical procedures and patient follow-ups. Nazish Rizwan and Ahdi Hassan contributed to manuscript writing, revisions, and literature review. All authors reviewed and approved the final manuscript.

Ethical Approval
Ethical approval for this study was granted by the Institutional Review Board of the Sindh Institute of Ophthalmology and Visual Sciences (SIOVS).

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None.

Conflict of Interests
None.

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