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ORIGINAL ARTICLE

Evaluating sub-tenon anesthesia in manual small incision cataract surgery: efficacy and safety

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ABSTRACT

Background: Cataract remains the leading cause of preventable blindness worldwide. While local anesthesia is essential for cataract surgery, traditional techniques like peribulbar and retrobulbar blocks carry significant risks. Sub-Tenon anesthesia has emerged as a potentially safer alternative, though its efficacy rates vary widely in literature, and data from the local population is limited. Our objective is to evaluate the efficacy and safety of Sub-Tenon anesthesia in patients undergoing Manual Small Incision Cataract Surgery (MSICS) at a tertiary care hospital in Peshawar, Pakistan.

Methods: This descriptive case series was conducted at the Department of Ophthalmology, Hayatabad Medical Complex. A total of 148 patients undergoing MSICS under Sub-Tenon anesthesia were enrolled using non-probability consecutive sampling. Akinesia was assessed using a standardized scoring system (0-12) ten minutes after anesthetic administration, with complete akinesia (score=0) defined as effective. Secondary outcomes included intraoperative pain (measured using the 10-point Visual Analog Scale (VAS; 0 = no pain, 10 = worst possible pain), surgical duration, and adverse events. Data were analyzed using SPSS version 24 with appropriate statistical tests.

Results: The overall efficacy of Sub-Tenon anesthesia was 56.1% (83/148). Patients with effective blocks reported significantly lower pain scores (median VAS: 1.30 vs 3.90, $p<0.001$) and had shorter surgical duration (median: 26 vs 33 minutes, $p<0.001$). Multivariate analysis showed that lower pain scores (adjusted OR: 0.11, 95% CI: 0.05-0.21, $p<0.001$) and shorter surgery duration (adjusted OR: 0.91, 95% CI: 0.82-0.99, $p=0.031$) were significantly associated with effective anesthesia. The technique demonstrated favorable safety profile with only minor, self-limiting adverse events (overall incidence: 4.1%).

Conclusion: Sub-Tenon anesthesia provides moderate efficacy with exceptional safety for MSICS. Successful blocks are associated with significantly improved patient comfort and surgical efficiency. This technique represents a viable alternative to sharp-needle approaches, particularly in settings prioritizing patient safety.

Keywords: Sub-Tenon anesthesia, Manual Small Incision Cataract Surgery, Akinesia, Anesthesia efficacy, Ophthalmic anesthesia, Surgical duration, Patient safety

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Introduction

Cataract is the leading cause of preventable blindness worldwide, with cataract extraction and intraocular lens (IOL) implantation standing as one of the most successful surgical interventions in modern medicine (1). The transition to outpatient surgery under local anesthesia has been pivotal in making cataract treatment widely accessible and cost-effective (2).

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Local anesthesia techniques for ophthalmic surgery have evolved significantly, with the primary goals being adequate akinesia, analgesia, and patient safety (3). Traditional methods such as retrobulbar and peribulbar anesthesia, while effective, carry well-documented risks including globe perforation, retrobulbar hemorrhage, optic nerve injury, and rare but serious complications like brainstem anesthesia (4,5). These potential complications have driven the search for safer alternative techniques that maintain surgical efficacy while minimizing procedural risks.

Sub-Tenon anesthesia, first introduced by Greenbaum in 1992, represents a significant advancement in ophthalmic regional anesthesia (6). This technique involves the administration of local anesthetic into the potential space between Tenon's capsule and the sclera using a blunt cannula, thereby blocking the ciliary nerves as they penetrate the globe (7). The theoretical advantages of this approach include a reduced risk of globe perforation, avoidance of sharp needles, and potentially fewer systemic complications (8).

Existing literature reports variable success rates for Sub-Tenon anesthesia in cataract surgery. While some studies report efficacy rates as high as 88% in achieving adequate akinesia, others demonstrate more modest success(9). A particularly relevant study by Fasih et al. reported a 56% efficacy rate for Sub-Tenon anesthesia in manual small incision cataract surgery (MSICS)(10) MSICS itself represents an important surgical technique, particularly in developing countries, where it offers advantages in terms of cost-effectiveness and rapid visual rehabilitation (11).Despite the established role of Sub-Tenon anesthesia in ophthalmic practice, there remains a notable gap in contemporary literature regarding its efficacy in specific patient populations and surgical settings. Furthermore, no recent studies have evaluated its performance in the local population of Khyber Pakhtunkhwa, Pakistan, where demographic and anatomical factors might influence anesthetic outcomes. However, there is also limited contemporary data evaluating the efficacy and safety of Sub-Tenon anesthesia in the local population.

This study, therefore, aims to evaluate the efficacy of Sub-Tenon anesthesia in patients undergoing Manual Small Incision Cataract Surgery at a tertiary care hospital in Peshawar, Pakistan. The findings will provide valuable contemporary data on the success rates, associated factors, and safety profile of this technique, contributing to evidence-based practice in ophthalmic anesthesia.

Methodology

This descriptive case series study was conducted at the Department of Ophthalmology, Hayatabad Medical Complex (HMC), a 124-bed tertiary care hospital situated in Peshawar (12). The study was completed in a duration of 6 months.

The sample size was determined to be 148 participants using the World Health Organization (WHO) formula for sample size calculation. The calculation was based on an expected population proportion (efficacy) of 56% from a previous study (13), a 95% confidence interval, and an absolute precision of 7%. All eligible patients were included in the study using a non-probability sampling technique.

Ethical approval was obtained from the Institutional Research and Ethical Board (IREB) of Hayatabad Medical Complex (Approval No: 1538, dated 26 September 2023). The protocol adhered to the guidelines of the 2013 Helsinki Declaration. Written informed consent was obtained from each study participant before their enrolment in the national language (Urdu).

Patients of any gender, aged 18-60 years, who were scheduled for Manual Small Incision Cataract Surgery (MSICS) under local anesthesia were included in this study. Patients with ocular inflammation, hypersensitivity to local anesthetics, clotting abnormalities, or inability to provide informed consent were excluded from the study

Eligible patients were recruited from the Ophthalmology Outpatient Department of HMC Peshawar for Manual Small Incision Cataract Surgery (MSICS) under sub-Tenon anesthesia. Following preoperative preparation and administration of a 3mL anesthetic mixture (2% Lignocaine with 1:200,000 adrenaline and 0.5% Bupivacaine) via the inferonasal quadrant, akinesia was quantitatively assessed after ten minutes using a standardized quadrant movement score. Akinesia was assessed by the operating surgeon and was not blinded. Ocular motility was evaluated in four directions (superior, inferior, medial, lateral) with each quadrant scored as: 0 (no movement), 1 (twitching), 2 (partial movement), or 3 (full movement). The scores from all four quadrants were summed (range 0-12), with a total score of 0 defining an effective block. Pain was assessed using a 10-point Visual Analog Scale (VAS; 0 = no pain, 10 = worst possible pain). All procedures were performed by a single CPSP fellow under senior supervision, with continuous monitoring for adverse events**.** Data were recorded on a pre-designed proforma. Statistical Package for the Social Sciences (SPSS), Version 24, was used to analyze the data. Descriptive statistics were computed; mean and standard deviation (SD) were used for numerical variables like age. Frequencies and percentages were calculated for categorical variables like gender and efficacy. The primary outcome (efficacy) was stratified across age groups and gender to identify any effect modification. A post-stratification Chi-square test was applied to assess the significance of associations, with a p-value of ≤ 0.05 considered statistically significant. Confidence intervals were calculated using the binomial exact method. The results were presented using tables and graphs.

Results

A total of 148 patients undergoing Manual Small Incision Cataract Surgery (MSICS) under Sub-Tenon anesthesia were included in this study. The demographic and clinical characteristics of the study participants are summarized in **Table 1**. The mean age of the cohort was 46.1 ± 11.0 years, with 86 (58.1%) males and 62 (41.9%) females. There were no statistically significant differences in age, gender distribution, or operated eye between patients who achieved adequate akinesia and those who did not (all $p > 0.05$).

Table 1. Baseline and Clinical Characteristics of Patients Stratified by Efficacy of Sub-Tenon Anesthesia.

Variable	Overall N = 148	Effective N = 83	Not effective N = 65	p-value[2]
Age	46 (11) / 47 (42, 54)	46 (10) / 46 (42, 55)	46 (11) / 49 (41, 54)	0.8
Age Group				
18-39	22 (15%)	10 (12%)	12 (18%)	0.3
40-49	67 (45%)	42 (51%)	25 (38%)	
50-60	59 (40%)	31 (37%)	28 (43%)	
Gender				
Female	62 (42%)	33 (40%)	29 (45%)	0.6
Male	86 (58%)	50 (60%)	36 (55%)	
Eye				
Left	71 (48%)	39 (47%)	32 (49%)	0.8
Right	77 (52%)	44 (53%)	33 (51%)	

The overall success rate of Sub-Tenon anesthesia, defined as complete globe akinesia (total score = 0) achieved within ten minutes of administration, was 56.1% (83), **Figure1**. Detailed analysis of ocular movement patterns revealed that 83 (56.1%) achieved complete akinesia('No movements'), while the remaining 65 (43.9%) exhibited varying degrees of residual movement: 7 (4.7%) demonstrated twitching, 19 (12.8%) showed partial movements, and 39 (26.4%) maintained full ocular motility.

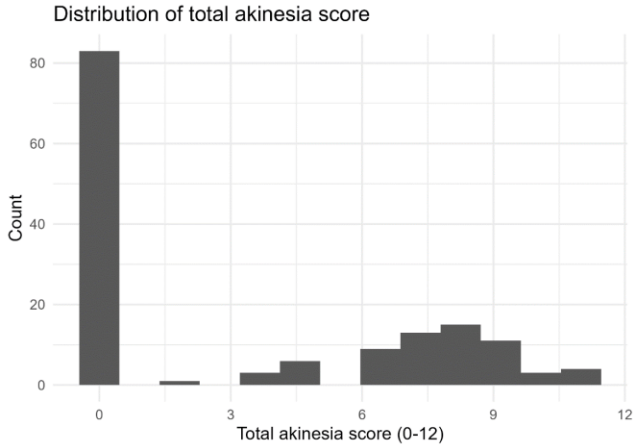

Figure 1 Distribution of Total Akinesia Scores Following Sub-Tenon Anesthesia

Significant differences emerged in key intraoperative parameters between efficacy groups. Patients with successful anesthesia blocks reported substantially lower pain levels (median VAS: 1.30, IQR: 0.80-1.80) compared to the failure group (median VAS: 3.90, IQR: 3.20-5.00; $p < 0.001$). Surgical efficiency was notably superior in the effective anesthesia group, with a median surgical duration of 26 minutes (IQR: 22-32) versus 33 minutes (IQR: 27-37) in the ineffective group ($p < 0.001$) as shown in Figure 2.

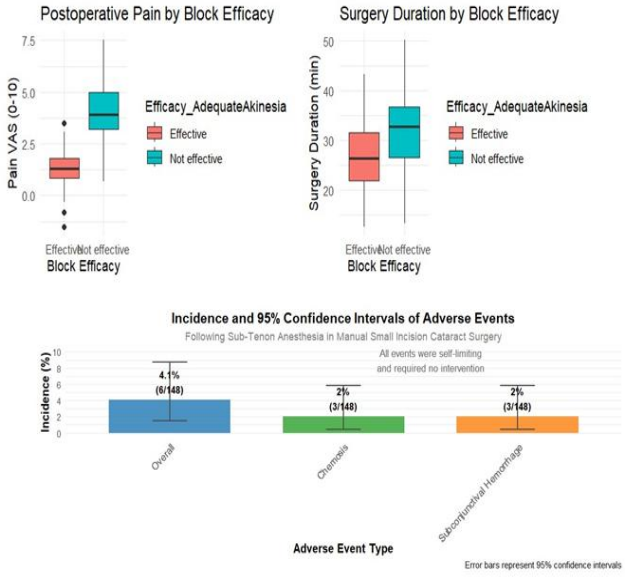

Figure 2 Comparative Intraoperative Outcomes and Adverse Event Profile of Sub-Tenon Anesthesia in Manual Small Incision Cataract Surgery

Univariate logistic regression analysis (Table 2) showed that lower intraoperative pain scores OR: 0.12, (95% CI: 0.06-0.22) p < 0.001 and shorter surgical duration OR: 0.91, (95% CI: 0.86-0.95), p < 0.001 were significantly associated with effective anesthesia. In multivariate analysis adjusting for age and gender (Table 2), both lower pain VAS scores adjusted OR: 0.11, (95% CI: 0.05-0.21), p < 0.001 and reduced surgery duration adjusted OR: 0.91 (95% CI: 0.82-0.99), p = 0.031 remained independently associated with effective akinesia.

Table 2. Univariate and Multivariate Logistic Regression Analysis of Factors Associated with Effective Sub Tenon Anesthesia

Characteristic	Univariate Analysis		Multivariate Analysis*	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Age (per year)	1.00 (0.97–1.03)	0.9	1.03 (0.97–1.09)	0.4
Gender				
Female	Reference	–	Reference	–
Male	1.22 (0.63–2.36)	0.6	1.63 (0.50–5.70)	0.4
Eye				
Left	Reference	–	–	–
Right	1.09 (0.57–2.10)	0.8	–	–
Pain VAS (per point)	0.12 (0.06–0.22)	<0.001	0.11 (0.05–0.21)	<0.001
Surgery duration (per minute)	0.91 (0.86–0.95)	<0.001	0.91 (0.82–0.99)	0.031

Abbreviations: aOR = adjusted odds ratio; CI = confidence interval; OR = odds ratio; VAS = visual analog scale.
Note: Multivariate model adjusted for age and gender. The eye was not included in the multivariate analysis

The Sub-Tenon anesthesia technique demonstrated a favorable safety profile with minimal complications. Among the 148 procedures, only six minor adverse events were recorded, yielding an overall incidence of 4.1% (95% CI: 1.5-8.7). The adverse events comprised subconjunctival hemorrhage n=3, 2.0%; (95% CI: 0.4-5.8) and chemosis n=3, 2.0%; (95% CI: 0.4-5.8). Fisher's exact test revealed no significant association between adverse event occurrence and anesthesia efficacy (p= 1.0), indicating that complications were distributed equally between effective and ineffective blocks. All adverse events were self-limiting and resolved spontaneously without medical intervention or surgical delay. The mean resolution time for subconjunctival hemorrhage was 7.3 ± 2.1 days, while chemosis resolved within 2.4 ± 0.9 days postoperatively. No serious adverse events, including globe perforation, retrobulbar hemorrhage, or optic nerve injury, were observed during the study period. **Figure 2** illustrates the distribution and incidence rates of adverse events, while **Table 3** provides a detailed statistical analysis of complication patterns.

Table 3. Analysis of Adverse Events Following Sub-Tenon Anesthesia

Adverse Event Type	n	Incidence (%)	95% CI	Resolution Time (days)
Subconjunctival hemorrhage	3	2.0	0.4-5.8	7.3 ± 2.1
Chemosis	3	2.0	0.4-5.8	2.4 ± 0.9
Total	**6**	**4.1**	**1.5-8.7**	**4.9 ± 3.2**

Discussion

This study demonstrates that Sub-Tenon anesthesia provides adequate surgical akinesia in 56.1% of patients undergoing

Manual Small Incision Cataract Surgery. Furthermore, successful anesthesia was significantly associated with lower intraoperative pain and reduced surgical duration, while maintaining a favorable safety profile with a low incidence of minor, self-limiting complications.

The primary efficacy rate of 56.1% found in our study is identical to the rate reported by Fasih et al. in a similar patient population, which was used as the reference for our sample size calculation. This consistency supports the reliability of the observed efficacy in the context of MSICS. However, this figure sits at the lower end of the spectrum reported in the wider literature, where success rates for Sub-Tenon anesthesia have varied considerably, from 56% to over 88% (14). The disparity may be attributable to several factors. Firstly, the definition of "success" or "adequate akinesia" is not universally standardized. Our study employed a rigorous, quantitative scoring system, where only a total score of 0 (indicating complete absence of ocular movement) was considered a success. Other studies utilizing less stringent criteria or different assessment scales may report higher efficacy rates. Secondly, technical factors such as the exact site of cannula insertion, the depth of anesthetic deposition, and the volume of anesthetic used can influence the spread and effectiveness of the block (15). The consistent use of a single, experienced operator in our study minimizes procedural variation but may also reflect a specific technique that could be optimized.

An important finding of our investigation is the strong association between anesthetic efficacy and secondary outcomes. Patients with an effective block reported markedly lower intraoperative pain scores. This finding is physiologically plausible, as adequate diffusion of the local anesthetic agent in the Sub-Tenon space effectively blocks the sensory ciliary nerves, providing superior analgesia. This correlation between motor akinesia and sensory analgesia underscores the importance of achieving a complete block for optimal patient comfort (16).

Furthermore, surgical duration was significantly shorter in the effective anesthesia group. This can be attributed to the stable surgical field afforded by complete akinesia, which facilitates key steps of MSICS such as capsulorhexis and nucleus delivery without the need for compensatory maneuvers to manage ocular movement. This finding has important implications for operating room efficiency and surgical workflow, particularly in high-volume settings (17).

Our multivariate regression analysis solidified these relationships, demonstrating that lower pain scores and shorter surgery duration were significantly associated with effective anesthesia, even after adjusting for age and gender. This statistical model suggests that these are not merely associative findings but are intrinsically linked to the quality of the block. The fact that demographic factors like age and gender were not significant predictors is reassuring, indicating that the efficacy of Sub-Tenon anesthesia is not disproportionately influenced by these patient characteristics, making it a broadly applicable technique. Although lower pain scores and shorter surgical duration were statistically associated with effective anesthesia, these variables are better interpreted as outcomes reflecting successful block performance rather than true preoperative predictors, as they occur intraoperatively rather than before anesthetic administration.

The safety profile observed in this study aligns with the well-documented advantages

of the Sub-Tenon technique. The overall complication rate of 4.1%, comprising only minor subconjunctival hemorrhage and chemosis, is low and consistent with previous reports (9). The absence of serious sight-threatening or systemic complications, such as globe perforation or brainstem anesthesia known risks associated with sharp-needle techniques like peribulbar and retrobulbar blocks highlights a significant safety benefit of the blunt cannula approach (6). All adverse events were self-limiting, requiring no intervention and resolving without sequelae, which reinforces the role of Sub-Tenon anesthesia as a safe option for ophthalmic surgery.

Conclusion

In conclusion, Sub-Tenon anesthesia is a moderately efficacious and technique with strong safety profile for achieving akinesia in Manual Small Incision Cataract Surgery. Based on our findings, this technique may be considered as a viable and safe alternative to sharp-needle techniques, particularly in settings where patient safety and comfort are paramount.

Limitations of the Study

This study has several limitations. Being a single-center descriptive case series, the generalizability of the findings may be limited. The use of non-probability consecutive sampling may introduce selection bias, and the absence of a comparison group restricts direct evaluation against other anesthetic techniques. Additionally, akinesia assessment was not blinded, which may introduce observer bias.

Future Recommendations

Future research should involve randomized controlled trials directly comparing Sub-Tenon with peribulbar anesthesia, and explore the impact of technical modifications, such as anesthetic volume and injection site, on the success rate of the block.

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Data acquisition, analysis and interpretation	NU
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All the authors agree to take responsibility for every facet of the work, making sure that any concerns about its integrity or veracity are thoroughly examined and addressed.