Incidence and Factors Associated with Visual Axis Opacification Following Pediatric Cataract Surgery at Kilimanjaro Christian Medical Centre, 2013-2023.

ABSTRACT

Background: Pediatric cataract remains a major cause of childhood blindness worldwide, with visual axis opacification (VAO) representing a frequent and challenging postoperative complication.

Objective: To evaluate the incidence and factors associated with VAO following pediatric cataract surgery at Kilimanjaro Christian Medical Centre from January 2013 to January 2023.

Methods: We conducted a retrospective cohort study including 345 children (612 eyes) who underwent cataract surgery. Demographic and clinical data were extracted from medical records. Data analysis was performed using STATA version 17. Kaplan-Meier survival curves were used to estimate the probability of VAO over time. Poisson regression models identified factors associated with VAO, with statistical significance set at $P < 0.05$.

Results: Among 345 children, 189 (54.8%) were male, and 267 (77.4%) had bilateral cataracts. The median age at surgery was 28.5 months (range 9-72). The overall incidence of VAO was 19.9% (122/612), corresponding to an incidence rate of 0.251 events per eye-year, with a median follow-up duration of 1 year. Secondary surgeries were performed in 20.3% (124/612) of eyes. Postoperatively, 69.4% of eyes achieved no visual impairment, highlighting the overall success of surgical intervention when VAO is prevented. Significant factors associated with VAO included age at surgery <60 months (AHR = 4.90; 95% CI: 2.77-8.70); P-value<0.001), surgical technique involving lens washout without posterior capsulotomy or anterior vitrectomy (LWO+IOL) (AHR = 7.58; 95% CI: 3.85-14.91); P-value<0.001), and postoperative acute fibrinous reaction (AHR = 5.91; 95% CI: 4.01-8.71); P-value<0.001).

Conclusion: The incidence of VAO at KCMC is consistent with global data. Early age at surgery, surgical technique without PPC and AV, and postoperative inflammation were significantly associated with VAO. Adoption of preventive strategies and enhanced postoperative care are critical for improving visual outcomes.

Keywords: Pediatric Cataract, Incidence, Visual Axis Opacification, Risk Factors, Postoperative Complications, Secondary Surgical Procedures, Visual Outcomes.

INTRODUCTION

Pediatric cataract remains one of the leading treatable causes of childhood blindness globally(1). Its prevalence ranges from 0.32 to 22.9 per 10,000 children globally, with over 19,000 new cases reported annually in Africa (2). In Tanzania, the prevalence of severe visual impairment and blindness is estimated at 0.05%, with lens-related disorders accounting for approximately 27% of all cases (3).

Pediatric cataract is defined as opacification of the natural crystalline lens, either present at birth or developing later in childhood. It may occur unilaterally or bilaterally and can result from idiopathic, hereditary, infectious, metabolic, or syndromic causes (4). Since visual system continues to mature after birth, any lens opacity may interrupt this critical developmental process, possibly resulting in irreversible visual impairment or blindness(5). Such impairment carries profound emotional, social, and economic consequences for affected children, their families, and society at large. Consequently, global initiatives such as *VISION 2020* have prioritized the management and prevention of congenital cataract (6).

Surgical removal remains the definitive treatment for visually significant pediatric cataracts. Although surgical techniques have advanced substantially, particularly in resource-limited settings, the combination of primary posterior capsulotomy, in-the-bag intraocular lens (IOL) implantation, and anterior vitrectomy continues to represent the standard approach (7). Despite these improvements, **visual axis opacification (VAO)** remains one of the most frequent and challenging postoperative complications, with incidence rates ranging from 7.5% to over 50% even in well-resourced healthcare (8)(9). VAO primarily results from rapid proliferation of residual lens epithelial cells and fibrotic tissue formation on the anterior vitreous face and remaining capsule (10). Techniques such as posterior optic capture have demonstrated a significant reduction in the risk of VAO without the need for anterior vitrectomy (11).

VAO can compromise otherwise successful surgical outcomes. When present, it often necessitates secondary surgical interventions under general anesthesia, which raises additional concerns about anesthetic risks and possible neurodevelopment effects in young children (12).

Moreover, visual axis obstruction can lead to sensory deprivation and amblyopia, emphasizing the importance of timely detection and management (13).

Secondary surgical procedures following pediatric cataract extraction are common and may include capsulotomy or membranectomy to restore a clear visual axis, as well as IOL repositioning or secondary IOL implantation (14)(15). These interventions have been shown to improve visual outcomes significantly (16). Reported risk factors for VAO include younger age at surgery, microphthalmia, persistent hyperplastic primary vitreous (PHPV), IOL implantation, IOL material and design, fixation site, and the adequacy of postoperative anti-inflammatory therapy (17).

At the Kilimanjaro Christian Medical Centre (KCMC), a tertiary referral hospital in northern Tanzania, pediatric cataract surgery has been routinely performed for more than a decade by experienced ophthalmologists. However, local evidence on the incidence and determinants of VAO remains scarce.

This study therefore aims to determine the incidence and factors associated with visual axis opacification following pediatric cataract surgery at KCMC over a ten-year period. The findings are expected to enhance understanding of VAO in this setting, evaluate current surgical practices, and inform the development of strategies to prevent or manage VAO particularly in resource-limited contexts such as Tanzania.

METHODOLOGY

Study Design and Setting

This was a retrospective cohort study conducted in the Department of Ophthalmology at the Kilimanjaro Christian Medical Centre (KCMC), a zonal referral hospital located in Moshi Municipality, Kilimanjaro Region, Northern Tanzania. The study included 345 children who underwent surgery for congenital or developmental cataract at KCMC between January 2013 and January 2023. All patients were followed up for one year postoperatively.

Ethical Approval

Ethical clearance for this study was obtained from the Kilimanjaro Christian Medical University College (KCMUCo) **Research** and **Ethics Committee (Ref: PG.30/2023).** Approval was granted on 15 August 2023 for duration of one year **(15 August 2023 – 14 August 2024).** Data collection was conducted between 16 October 2023 and 31 May 2024, using both patient files and the hospital's Electronic Health Management System. All collected data were **fully anonymized** and handled with **strict confidentiality** in accordance with institutional and ethical guidelines.

Participants

The study population comprised children aged below 16 years who were diagnosed with congenital or developmental cataracts and underwent cataract surgery at KCMC during the study period. Exclusion criteria included children with traumatic or uveitic cataracts, those with incomplete or missing demographic or clinical data, and patients who underwent only secondary intraocular lens (IOL) implantation. Participants were selected using a consecutive non-probability sampling technique.

Data Collection

Medical records were reviewed retrospectively using a structured data collection form. Extracted information included demographic characteristics, pre- and postoperative clinical findings (such as best-corrected visual acuity and intraocular pressure), details of the surgical procedure (including IOL type, power, and fixation technique), postoperative outcomes and complications, as well as details of any secondary surgeries and their indications.

Statistical Analysis

Data were analyzed using **STATA version 17** (StataCorp LLC, College Station, Texas, USA). Categorical variables were summarized as frequencies and percentages, while continuous variables were presented as means with standard deviations (SD) or medians with interquartile ranges (IQR), depending on data distribution.

Kaplan–Meier survival analysis was used to estimate the probability of remaining free from VAO over time. Stratified analyses were performed according to age at surgery and surgical technique. Group comparisons were made using the log-rank test, with statistical significance set at $P < 0.05$.

A Poisson regression model was applied to identify factors associated with VAO. Univariate analyses were first performed to estimate crude hazard ratios (CHR), followed by multivariable analyses to obtain adjusted hazard ratios (AHR) with corresponding 95% confidence intervals (CI). Variables with $P < 0.05$ were considered statistically significant.

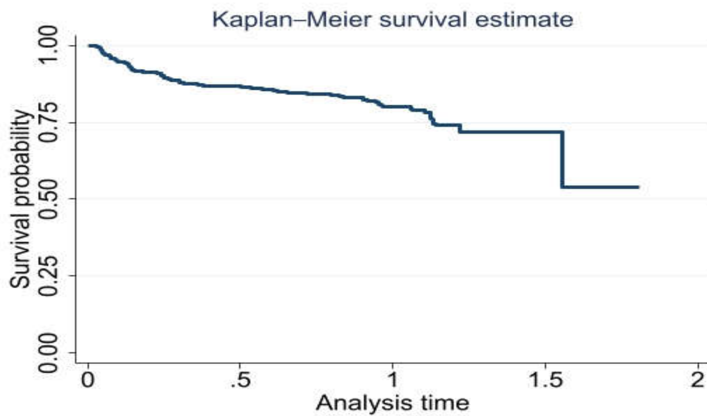
RESULTS

This study included a total of 345 participants (612 eyes) with a median age at surgery of 28.5 months *(IQR: 9–72)*. Of these, 189 (54.8%) were male, and 267 (77.4%) presented with bilateral cataracts. The majority of participants, 231 (67%), originated from the Northern Zone. Among the 612 operated eyes, 304 (49.7%) underwent surgery at ≤24 months of age. The most common presenting complaints were a combination of white pupillary reflex, strabismus, and poor vision, observed in 244 (39.8%) eyes. The median duration from symptom onset to hospital presentation was 12 months *(IQR: 5–36),* while the median waiting time from diagnosis to surgery was 5 days *(IQR: 2–8)*. The most frequently employed surgical technique was lens washout with primary posterior capsulotomy, anterior vitrectomy, and in-the-bag intraocular lens implantation (LWO+PPC+AV+BAG IOL), performed in 343 (56%) eyes. At one-year follow-up, 519 eyes (84.8%) were pseudophakic and 93 (15.2%) remained aphakic. The most commonly prescribed postoperative topical medication was a combination of dexamethasone and chloramphenicol, used in 534 (87.3%) eyes **(Table 1).**

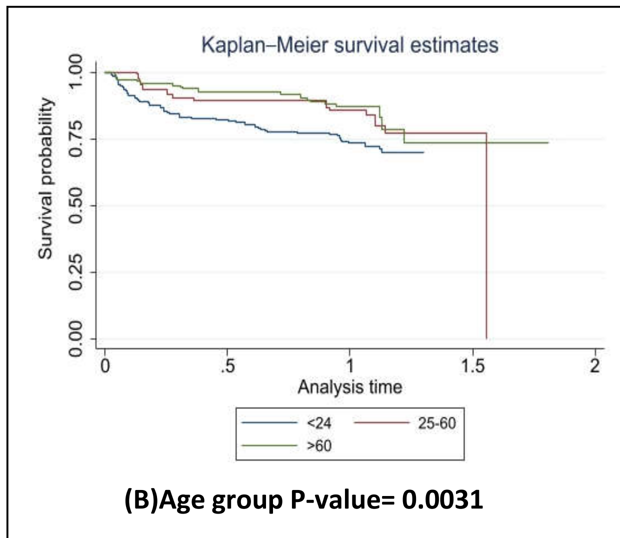
Table 1: **Demographic and Clinical characteristics of participants' eyes underwent cataract surgery (N=612)**

Variable	Frequency	Percentage
Age at Surgery in months		
≤24	304	49.7
25-60	127	20.8
≥61	181	29.6
Median (IQR)	*28.5(9-72)*	
Sex of the participant		
Male	189	54.8
Female	156	45.2
Laterality of cataract		
Unilateral	78	22.6
Bilateral	267	77.4
Waiting time for surgery in days		
Median (IQR)	*5(2-8)*	
Time from symptom onset to hospital presentation (months)		
Median (IQR)	*12(5-36)*	
IOL power implanted in Diopters		
Median (IQR)	*25(22-28)*	
Presenting symptoms/complain		
White pupillary reflex	153	25
Poor Vision	214	35
Strabismus	1	0.2
Combined symptoms	244	39.8
Surgical Approach Used		
Anterior approach	561	91.7
Pars Plana approach	51	8.3
Surgical Technique used		
LWO+PPC+AV+BAG IOL	343	56
LWO+PPC+AV+SULCUS IOL	98	16
LWO+BAG IOL	78	12.8
LWO+PPC+AV+APHAKIA	93	15.2
Post Op. Lens status at 1 year of FU		
Pseudophakia	519	84.8
Aphakia	93	15.2
Post Op. Topical steroid used		
Dexamethasone + Chloramphenicol	534	87.3
Prednisolone acetate 1%	78	12.7

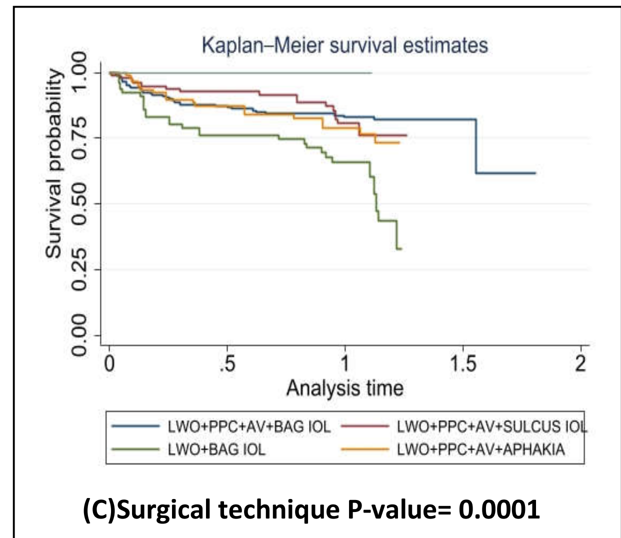
In this study, the overall incidence of VAO was 19.9% (122/612), corresponding to an incidence rate of 0.251 events per eye-year, with a median follow-up duration of 1 year (IQR: 0.36–1.11). Kaplan–Meier survival analysis demonstrated an overall survival probability of 0.80. Eyes operated on at ≤24 months of age and those managed with the LWO+IOL surgical technique exhibited lower survival probabilities of 0.75 and 0.65, respectively, compared with other age groups and surgical approaches (Figure 1A–C)



(A) Overall survival probability



(B)Age group P-value= 0.0031



(C)Surgical technique P-value= 0.0001

Figure 1 (A, B&C) demonstrate Kaplan Meier survival curves showing overall survival probability and the survival probability by age groups and surgical techniques used.

In this study, 124 eyes (20.3%) required secondary surgical interventions, corresponding to an incidence rate of 1.72 procedures per year. The most common secondary procedures were surgical capsulotomy (10.3%), membranectomy (6.4%), and YAG laser capsulotomy (3.6%). Additional interventions included secondary intraocular lens (IOL) insertion (3.1%), IOL repositioning (1.3%), IOL exchange (0.7%), synechiolysis (1.8%), and pupilloplasty (2.0%) **(Table 2)**

Table 2: Secondary surgeries performed following pediatric cataract surgery (N=612)

Variable	**Frequency**	**Percentage**
Surgical Capsulotomy	63	10.3
Membranectomy	39	6.4
IOL reposition	8	1.3
Secondary IOL insertion	19	3.1
YAG capsulotomy	22	3.6
IOL exchange	4	0.7
Synechiolysis	11	1.8
Pupilloplasty	12	2

Regarding visual outcomes, at one year postoperatively, 69.4% of eyes had no visual impairment, 17% had moderate impairment, 4.6% had severe impairment, and 9% remained blind. This represents a significant improvement in visual function compared to the preoperative status, where 53.3% of eyes were classified as blind according to WHO criteria, 42.1% had moderate visual impairment, 3.5% had severe impairment, and only 1.2% had no impairment **(Figure 2)**

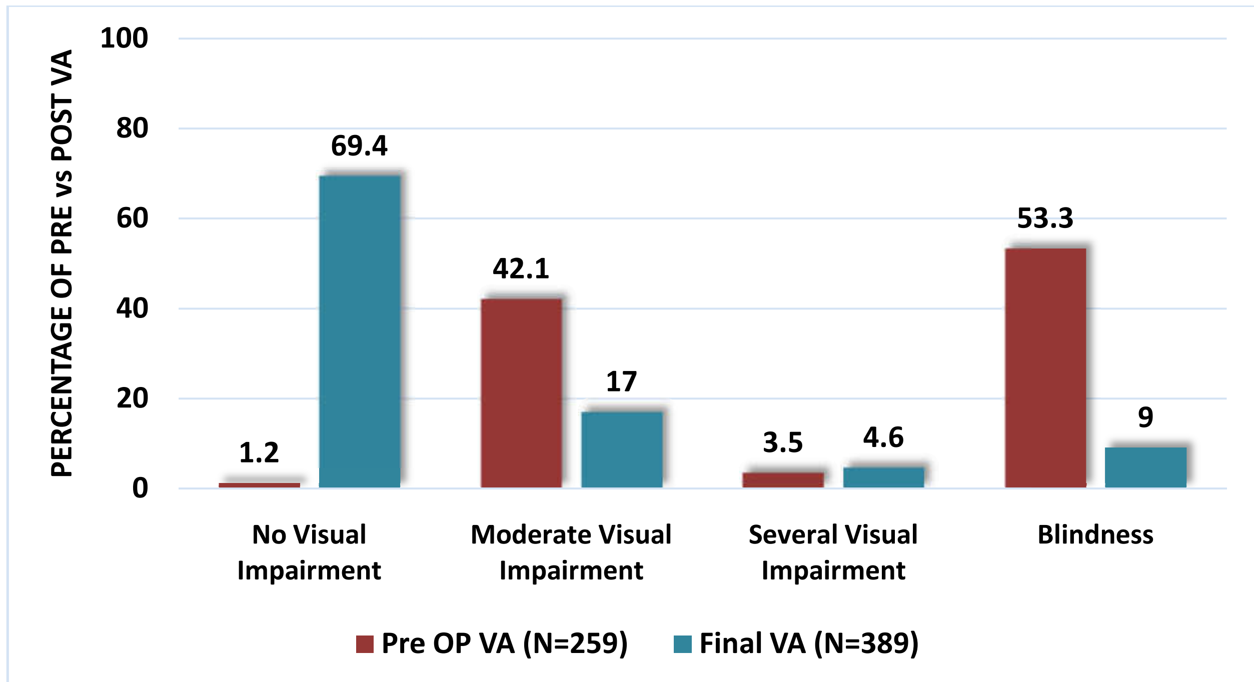


Figure 2: Proportion of Pre and Post operative best corrected visual acuity according to W.H.O classification

In assessing factors associated with visual axis opacification (VAO), univariate analysis showed that age at surgery <60 months (CHR = 1.77; 95% CI: 1.14–2.76; P = 0.011), the LWO+BAG IOL surgical technique (CHR = 2.18; 95% CI: 1.22–3.89; P < 0.001), and postoperative acute fibrinous reaction (CHR = 5.44; 95% CI: 3.75–7.90; P < 0.001) were significantly associated with VAO. In the multivariable analysis, age at surgery <60 months (AHR = 4.90; 95% CI: 2.77–8.70; P < 0.001), the LWO+BAG IOL technique (AHR = 7.58; 95% CI: 3.85–14.91; P < 0.001), and postoperative fibrinous reaction (AHR = 5.91; 95% CI: 4.01–8.71; P < 0.001) remained independently associated with VAO. Other variables, including IOL type, implantation site, hemoglobin level, and type of postoperative steroid, did not show statistically significant associations with VAO **(Table 3).**

Table 3: Factors Associated with Visual Axis Opacification occurrence following pediatric cataract surgery

Variable	CHR(95% CI)	P-value	AHR(95%CI)	P-value
Age at Surgery in months				
60+	Ref			
<60	1.77(1.14-2.76)	0.011	4.90(2.77-8.70)	<0.001
Post op. Lens status				
Aphakia	Ref			
Pseudophakia	0.98(0.60-1.62)	0.945		
Surgical technique used				
LWO+PPC+AV+APHAKIA	Ref		Ref	
LWO+PPC+AV+BAG IOL	0.78(0.46-1.32)	0.359	0.81(0.47-1.38	0.441
LWO+PPC+AV+SULCUS IOL	0.82(0.42-1.60)	0.843	0.78(0.40-1.53)	0.472
LWO+BAG IOL	2.18(1.22-3.89)	<0.001	7.58(3.85-14.91)	<0.001
IOL model used				
Aphakia	Ref			
ALCON SA60AT	0.75(0.41-1.38)	0.355		
ALCON MA60AC	0.65(0.24-1.22)	0.185		
SPNT200	1.68(0.98-2.90)	0.062		
IOL fixation site				
Aphakia	Ref			
Bag IOL fixation	1.09(0.64-1.86)	0.752		
Sulcus IOL fixation	0.88(0.45-1.73)	0.721		
IOL implantation				
Aphakia	Ref			
Primary IOL implantation	1.06(0.59-1.88)	0.854		
Secondary IOL implantation	1.45(0.52-4.07)	0.479		
Post op. Acute Fibrinous Reaction				
No	Ref		Ref	
Yes	5.44(3.75-7.90)	<0.001	5.91(4.01-8.71)	<0.001
Post Op. Topical steroid used				
Dexamethasone+chloramphenicol	Ref			
Prednisolone acetate 1%	1.43(0.89-2.32)	0.140		
Hemoglobin Level at time of surgery (g/dl)				
Anemia	Ref			
Normal Hb level	0.72(0.50-1.02)	0.065		

DISCUSSION

This study included 345 children with congenital or developmental cataracts who underwent surgery at KCMC between 2013 and 2023. The majority were male (54.8%), with a median age at surgery of 28.5 months. Bilateral cataracts were more common (77.4%), and a total of 612 eyes were analyzed with a median follow-up period of one year.

The overall incidence of visual axis opacification (VAO) was 19.9%, corresponding to an incidence rate of 0.251 events per eye-year. These findings reflect the benefits of standardized surgical protocols, particularly those incorporating primary posterior capsulotomy (PPC) and anterior vitrectomy (AV). The observed incidence aligns with rates reported in Kenya (17.8% and 21.05%) (18)(19), though the Kenyan studies were limited by shorter follow-up and significant loss to follow-up, which may have led to underestimation. Conversely, higher VAO incidences reported in Sweden (44.1%) and the United Kingdom (45%) (20)(21) could be attributed to younger surgical age and longer follow-up periods. A lower rate reported in Japan (7.1%) may reflect the consistent use of PPC and AV, though the small sample size may have influenced the results (22).

In this study, 20.3% of eyes required secondary surgery, primarily for VAO management, with surgical capsulotomy being the most frequent (10.3%). This finding is consistent with a Tanzanian study (23), which reported a rate of 4.6%, and with studies from India (6.9%) (24), where membranectomy was the most common procedure. These observations highlight VAO as a leading cause of secondary procedures. Similar trends have been observed in Brazil (17.6%) (15), and Bangladesh (33%) (25), the latter likely influenced by a longer follow-up duration of five years. Additional secondary procedures in the present study, such as synechiolysis (1.8%) and pupilloplasty (2.0%), further underscore the need for meticulous surgical planning and long-term postoperative monitoring.

Significant visual improvement was achieved postoperatively. At one year, 69.4% of eyes had no visual impairment, compared to 53.3% classified as blind preoperatively. This improvement can be attributed to timely surgical intervention, the use of modern microsurgical techniques, effective postoperative management, and prompt correction of refractive errors and amblyopia.

This study showed marked improvement in best corrected visual acuity post operatively in which at one year, 69.4% had no visual impairment while preoperatively 53.3% of eyes were blind. Improvements can be attributed to timely intervention, use of microsurgical techniques, intensive postoperative care, refractive errors correction, and amblyopia management by experienced surgeons in this study. Comparable visual outcomes were reported in England, where 73.5% achieved visual acuity of 6/12 or better (26). The outcomes in this study were superior to those reported in Kenya (44–44.5%) (19), (27) and Bangladesh (48%) (25), where shorter follow-up durations may have limited the observed improvements.

Age at surgery below 60 months (AHR = 4.90, $P < 0.001$), surgical technique without PPC and AV (AHR = 7.58, $P < 0.001$), and postoperative acute fibrinous reaction (AHR = 5.91, $P < 0.001$) were identified as significant risk factors for VAO. The increased risk in younger children may be due to higher lens epithelial cell proliferation, stronger inflammatory responses, and prolonged healing. Similar associations have been reported in prior studies (28)(15)(14). The protective effect of PPC and AV observed in this study supports previous findings (22)(29) emphasizing their role in preventing lens epithelial cell migration and reducing VAO incidence. Despite the use of microsurgical techniques and intensive postoperative steroid therapy, postoperative fibrinous reaction was observed in 13.2% of eyes and was strongly associated with VAO, likely reflecting the robust inflammatory response typical in pediatric eyes. Comparable results have been reported elsewhere (16)(23), underscoring the importance of rigorous postoperative inflammation control.

Although all intraocular lenses (IOLs) used in this study were hydrophobic acrylic, univariate analysis suggested that the SPNT200 model might carry a higher VAO risk. Previous literature has shown an association between hydrophilic IOLs, single-piece designs, and increased VAO risk (8). Variations in IOL design and follow-up duration may account for discrepancies among studies.

CONCLUSION

This study provides important insights into pediatric cataract surgery outcomes in a tertiary center in Northern Tanzania, representative of many Sub-Saharan African settings. The incidence of VAO was 19.9%, with 20.3% of eyes requiring secondary surgery. Surgical techniques incorporating PPC and AV were associated with a significantly lower risk of VAO. Younger age at surgery, absence of PPC and AV, and postoperative acute fibrinous inflammation were key risk factors. These findings emphasize the importance of meticulous surgical technique selection, vigilant postoperative care, and timely intervention to minimize VAO and optimize visual outcomes.

RECOMMENDATIONS

We recommend consistent use of surgical protocols incorporating PPC and AV, particularly for children under 60 months of age. Strengthening training for pediatric ophthalmic surgeons in low-resource settings, ensuring effective postoperative inflammation control, and improving caregiver education to enhance follow-up adherence are essential. Future multicenter prospective studies with longer follow-up durations are encouraged to further elucidate long-term outcomes and modifiable risk factors for improved visual rehabilitation.

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