Visual and Refractive Outcomes of Children After Early Secondary Cataract Extraction Following Wound Repair for Penetrating Ocular Trauma

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ABSTRACT

Purpose: To evaluate the visual and refractive outcomes in children 8 years of age or younger with corneal laceration and cataract following penetrating ocular injuries who underwent primary corneal tear repair followed within 1 to 8 weeks by early secondary cataract extraction.

Methods: This retrospective, non-comparative case series reviewed the admission and operative charts of children 8 years of age or younger (range: 3 to 8 years) who underwent corneal wound repair as the primary surgical procedure followed within 1 to 8 weeks by cataract extraction with intraocular lens implantation, with a minimum follow-up period of 6 months. The main outcome measures were best corrected visual acuity (BCVA) and refractive error as the spherical equivalent at the final follow-up visit.

Results: A total of 47 children (33 boys, 14 girls) were included. The mean age at the time of injury was 5.9 ± 2.2 years (range: 3 to 8 years). Follow-up periods ranged from 6 months to 3 years (median: 18 months). The mean time gap between the wound repair and cataract extraction was 5 weeks (range: 1 to 8 weeks). Approximately 36 (77%) eyes obtained BCVA better than 6/18. All but one eye achieved BCVA better than 6/60. The deviation from emmetropia was less than 1.00 diopter (D) in 23 (54%) eyes, 1.00 to 3.00 D in 15 (35%) eyes, and more than 3.00 D in 5 (12%) eyes.

Conclusions: Early removal of cataract with intraocular lens implantation 1 to 8 weeks after the primary wound repair in young children with penetrating corneal injuries can result in excellent visual and refractive outcomes with early intervention and aggressive amblyopia treatment.


INTRODUCTION

In the pediatric and adolescent age group, ocular trauma is an important cause of acquired visual loss. Approximately 60% to 70% of cases occur as a result of penetrating trauma, which leads to the development of lenticular opacities in 18% to 55% of cases. The cataract that develops is often visually significant and requires removal. The corneal lacerations and cataract secondary to ocular trauma remain a challenge to the treating ophthalmologist, with the ultimate goal of useful visual restoration.

This is achieved through restoration of the globe integrity followed by visual axis clearing of the cataractous lens and rehabilitation of the child’s vision. To restore the globe integrity, the primary corneal tear needs to be repaired as early as possible. If the anterior capsule is disrupted with the presence of flocculent lens matter in the anterior chamber, it should be removed at the time of the wound repair. However, there is no consensus regarding the op-
timal time gap between the primary wound repair and the secondary cataract extraction when the anterior capsule is intact.

In an adult eye with corneal laceration and traumatic cataract with the anterior capsule intact, it is advised to wait for the secondary cataract extraction until the corneal wound is stable, usually 3 to 4 months after the suture removal. However, this approach is not acceptable for children because of the risk of developing amblyopia. In children with congenital cataract, the sensitive period for deprivation amblyopia maximizes up to 14 weeks. Thereafter, the sensitivity declines, with the upper limit of the sensitive period being the end of the seventh year.

For the previously stated reasons, early intervention is proposed for the pediatric age group rather than waiting for corneal wound stabilization. The purpose of the current study was to evaluate the visual and refractive outcomes in children 8 years of age or younger with penetrating ocular trauma who underwent corneal wound repair as the primary surgical procedure followed within 1 to 8 weeks by cataract extraction with intraocular lens (IOL) implantation as the secondary procedure in a tertiary care teaching hospital were assessed. Patients with a minimum follow-up period of 6 months were included in the study. Eyes with an intraocular foreign body, retinal pathology, large corneal tear (≥ 8 mm or involving the visual axis), endophthalmitis, and a follow-up period of less than 6 months were excluded. Approval for the study was obtained from the institutional review board and consents from the parents/legal guardians were obtained.

The data retrieved from patient admission charts and surgical records were recorded, including age, sex, description of the injuring object, preoperative visual acuity, status of lens, time between primary wound repair and subsequent cataract extraction, preoperative keratometry, type and power of the IOL implanted, length of the follow-up period, amblyopia therapy, final visual acuity, and final refraction. Penetrating trauma was defined as having full-thickness lacerations of the cornea or sclera.

PATIENTS AND METHODS

This retrospective study was conducted from February 2008 to January 2010. Children 8 years of age or younger with penetrating ocular trauma who underwent corneal wound repair as the primary surgical procedure followed within 1 to 8 weeks by cataract extraction with intraocular lens (IOL) implantation as the secondary procedure in a tertiary care teaching hospital were assessed. Patients with a minimum follow-up period of 6 months were included in the study. Eyes with an intraocular foreign body, retinal pathology, large corneal tear (≥ 8 mm or involving the visual axis), endophthalmitis, and a follow-up period of less than 6 months were excluded. Approval for the study was obtained from the institutional review board and consents from the parents/legal guardians were obtained.

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Ultrasonography (A- and B-scan) was performed in all cases before cataract extraction to rule out any retained foreign body or posterior segment pathology. The IOL power calculations were performed using the SRK II formula (based on axial length obtained by A-scan ultrasonography) and keratometry results. In case of difficulty in obtaining the accurate keratometry values from the injured eye, the values from the normal contralateral eye were used. The power was calculated with consideration of the postoperative emmetropia.

In all children, the primary surgery performed was corneal wound repair, followed 1 to 8 weeks later by cataract extraction. Primary wound repair included corneal tear repair (10-0 nylon interrupted sutures), iris reposition (when required), and formation of the anterior chamber. Lens removal was performed as a second stage procedure after the necessary repair of the globe in all patients. Under general anesthesia, the eye was immobilized with a superior rectus stay suture. A partial-thickness scleral tunnel was dissected 1 mm posterior to the surgical limbus and up to 1.5 mm into the cornea. Two side ports at the 10- and 2-o’clock positions were made adjacent to the limbus. The anterior chamber was entered with a 3.2-mm disposable keratome. Anterior continuous curvilinear capsulorhexis was performed with Utrata forceps (Accutome, Inc., Malvern, PA) after staining the capsule with trypan blue dye where possible. This was followed by hydrodissection and cortical aspiration using an automated bimanual irrigation and aspiration system. Primary posterior curvilinear capsulorhexis (Utrata forceps) and automated vitrectomy were performed in patients younger than 6 years of age. The capsular bag was then filled with 2% methylcellulose and the IOL was placed in the bag when adequate posterior capsular support was present. In cases with an irregular anterior capsulorhexis or those in which the posterior capsule was deficient, the IOL was placed in the ciliary sulcus. An IOL was implanted in all 47 cases. Surgical peripheral iridectomy was performed for all cases in which the IOL was placed in the sulcus. Both the side ports and main tunnel incision were sutured with a 10-0 nylon suture.

The assessment and follow-up visits were performed as per the protocol of the hospital. Postoperative assessments were performed the next day and at 1, 3, and 6 weeks. Patients returned
for follow-up monthly until 3 months, every 3 months until 1 year, and then every 6 months thereafter. Postoperatively, glasses were prescribed after 1 week and occlusion therapy was initiated as soon as possible and continued as per the guideline.13 Bifocals were prescribed in all cases. Postoperative visual acuity was measured using a Snellen chart. Repeat refraction was performed every 3 months and the spectacle lenses and occlusion therapy were modified as necessary.

Visual acuity was recorded at each visit. Slit-lamp examination, applanation tonometry using the AVIA tonopen (Reichert, Inc., Depew, NY), and posterior segment examination were performed to record both early and late postoperative complications. The final visual acuity of each patient was recorded at the 6-month follow-up visit and converted to logarithm of the minimum angle of resolution (logMAR) units. The final refractive error was recorded as spherical equivalent. Posterior capsule opacification was considered visually significant when vision decreased by two or more lines from the postoperative best corrected visual acuity (BCVA) or when retinoscopy or funduscopy were difficult. The children were treated appropriately (Nd:YAG laser capsulotomy or membranectomy) as per their ages and thickness of the membrane.

Statistical Analysis
Descriptive statistics were used to summarize the findings. The Statistical Package for the Social Sciences software (version 16; SPSS, Inc., Chicago, IL) was used for all analyses. The mean of the continuous variables was compared using the independent samples t test. The Mann–Whitney U test was used for the analysis of non-parametric data. A P value of less than .05 was considered significant.

### TABLE 1

<table>
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<th>Visual Acuity</th>
<th>No. (%)</th>
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<tr>
<td>&gt; 6/18</td>
<td>36 (77%)</td>
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<tr>
<td>6/18 to 6/36</td>
<td>10 (21%)</td>
</tr>
<tr>
<td>6/36 to 2/60</td>
<td>1 (2%)</td>
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<tr>
<td>2/60 to light perception</td>
<td>0</td>
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<tr>
<td>No light perception</td>
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RESULTS

Our study included 47 eyes of 47 children (boys: 33 [70%]; girls: 14 [30%]). The mean age at the time of injury was 5.9 ± 2.2 years (range: 3 to 8 years). Follow-up periods ranged from 6 months to 3 years, with a median of 18 months. The mean time gap between the wound repair and cataract extraction was 5 weeks (range: 1 to 8 weeks).

Type of Corneal Injury

Corneal involvement was in the form of a peripheral corneal tear without involving the limbus in 22 (46.8%) children, paracentral corneal tear in 13 (27.7%) children, corneal tear with limbal involvement in 7 (14.9%) children, and limbal tear alone with uveal prolapse in 5 (10.6%) children.

Visual Outcome

The final BCVA of the 47 eyes ranged between 1.48 and 0 logMAR (3/60 to 6/6 Snellen acuity), with a mean value of 0.3 ± 0.4 logMAR. Thirty-six (76%) eyes obtained a final visual acuity of 6/12 or better. All but one (98%) eye achieved a final visual acuity of better than 6/60 (Table 1). Mean visual acuity was 0.13 ± 0.16 logMAR.

Refractive Outcome

Final refraction was obtained in 43 of the 47 eyes (91.5%). The mean postoperative spherical equivalent of refraction was -1.80 diopters sphere. The deviation from emmetropia was less than 1.00 diopter (D) in 23 (54%) eyes, 1.00 to 3.00 D in 15 (35%) eyes, and more than 3.00 D in 5 (11%) eyes. Thirty-one of the 43 (72%) eyes had a postoperative corneal astigmatism of up to 3.50 D, 6 (14%) eyes had an astigmatism between 3.50 and 5.00 D, and 6 (14%) eyes developed a postoperative astigmatism of more than 5.00 D (one of these was rehabilitated with glasses and two with rigid gas permeable contact lenses).

Analysis of final refraction for 22 eyes in which the keratometry of the fellow eye was used for IOL power calculation revealed that the absolute mean deviation from emmetropia was 1.40 ± 2.60 D. In the 21 eyes for which the keratometry value of the injured eye was used for IOL power calculation, the absolute mean deviation from emmetropia was 1.78 ± 1.46 D (Table 2) and the difference was not statistically significant (P = .37).

Nineteen (40%) patients developed posterior capsule opacification, which was treated by Nd:YAG
capsulotomy in 12 patients and membranectomy in 7 patients. There were 7 children younger than 6 years of age who developed posterior capsule opacification that required treatment (membranectomy).

**DISCUSSION**

Treatment of unilateral traumatic cataract associated with corneal tear in children is a great challenge, with developmental amblyopia being the factor for poor outcome. A delay in restoring clear media, correcting refractive error, or ocular dominance within several weeks can cause severe intractable amblyopia. The inability to obtain accurate IOL power and the resulting risk of significant postoperative anisometropia highlights the importance of an early but cautious approach to manage pediatric cases.

The current study retrospectively analyzed the visual outcome in a series of 47 children with traumatic cataract and corneal laceration when treated by two staged surgical procedures spaced over a short interval (< 8 weeks). The cases received refractive correction and occlusion therapy in the early postoperative period to minimize stimulus deprivation amblyopia. Approximately 77% of the children achieved a visual acuity of better than 6/18 and 98% achieved a visual acuity of 6/60 or better. Refraction at the final follow-up visit was within 3.00 D of emmetropia in 89% of the children, and only 6 children developed an astigmatism of more than 5.00 D.

We have summarized the results of previous studies on the visual acuity outcomes of pediatric patients following surgery for traumatic cataract (Table 3). A previous study reported amblyopia to be a major risk factor for poor visual outcome in children younger than 6 years of age. The mean time gap between the trauma and cataract extraction in that study was 18 weeks. However, amblyopia was not a significant factor in the current study, most likely because of early clearance of the visual axis and aggressive anti-amblyopia therapy.

When traumatic cataracts are present in the pediatric age group, older ages at the time of cataract surgery have been correlated with better visual outcomes. Animal experiments and clinical observations have noted that the critical period for the

<table>
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<th>TABLE 2</th>
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<td><strong>Keratometry and Final Refraction</strong> (Mean Spherical Equivalent)</td>
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<tr>
<td>Keratometry</td>
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<td>Injured eye (n = 21)</td>
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<td>Fellow eye (n = 22)</td>
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D = diopters

Table 2. Keratometry and Final Refraction (Mean Spherical Equivalent)

<table>
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<th>TABLE 3</th>
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<tr>
<td><strong>Visual Acuity Outcomes of Pediatric Patients Following Surgery for Traumatic Cataract</strong></td>
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<tr>
<td>Author</td>
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<td>Bienfait et al. (1990)</td>
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<td>Staffieri et al. (2010)</td>
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<td>Kumar et al. (2008)</td>
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<td>Current study</td>
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VA = visual acuity; PCO = posterior capsule opacification
development of stimulus deprivation amblyopia is up to 18 months of age.\textsuperscript{10} If deprivation starts between 3 and 10 years of age, visual acuity decreases at a slower rate and is more likely to respond to total full-time occlusion.\textsuperscript{10} Considering the fact that pediatric traumatic cataract peaks between 4 and 6 years of age,\textsuperscript{16} many would achieve excellent visual acuity and binocularity if treated with early intensive full-time occlusion therapy.

Some authors advocate primary cataract extraction and IOL implantation at the time of the corneal tear repair.\textsuperscript{11,12,20} This is advantageous because it avoids the need for repeated general anesthesia and a single-step surgery facilitates rapid postoperative recovery and faster visual rehabilitation. However, primary cataract extraction is not always possible because visualization may be poor due to corneal edema, cortical matter, or hyphema, or vitreous may be present in the anterior chamber. Posterior segment status cannot be evaluated because B-scan ultrasonography is not possible in the presence of an open wound and there is a potential risk of infection and exaggerated inflammation with primary IOL implantation. In developing countries such as the setting of the current study, there is often a delay in treatment due to geographical or financial reasons.

The history obtained is unreliable in the pediatric age group due to a parental lack of awareness. As a result, the injured eye is often acutely inflamed with vascular engorgement, raised intraocular pressure, and synechiae formation on presentation, leading to difficulties in achieving a comprehensive procedure. One study that included 228 children with perforating eye injuries proposed to defer the cataract extraction in the primary procedure because it is not always easy to ascertain the lens damage at that time. Alternatively, they recommended early deliberate surgical intervention to achieve clear media as quickly as possible to prevent irreversible amblyopia.\textsuperscript{5}

Secondary lens removal has its own distinct advantage because the eye may be less inflamed, accurate biometric measurements can be obtained, and surgery can be performed as an elective procedure.\textsuperscript{21} We preferred to perform cataract extraction as a secondary procedure and reserve the single staged surgery only for the patients with anterior capsule rupture and flocculent lens matter in the anterior chamber at the time of the primary repair.

Another risk of developing amblyopia in children with corneal tear and traumatic cataract is a large anisometropic spherical refractive error, or irregular astigmatism.\textsuperscript{18} In this study, we were able to provide the children with postoperative refractions approaching emmetropia. Only 6 of the 47 children developed an astigmatism of more than 5.00 D. However, this was successfully corrected by rigid gas permeable contact lenses in 3 patients and spectacles in 3 patients. One patient 4 years of age did not improve beyond a visual acuity of 2/60. Cataract extraction was performed 8 weeks after the primary repair, at which point the child developed an astigmatism of 8.50 D due to corneal scarring and was non-compliant with patching therapy. For cases in which visual recovery is limited by corneal scarring in the visual axis, good results have been reported with penetrating keratoplasty.\textsuperscript{14,22} None of the children in the current study underwent corneal transplant surgery for corneal scarring.

The final refraction using the SRK II formula fell within 3.00 D of emmetropia in 88% of the cases. Using the data from the uninjured eye, the final refraction was comparable to that of the injured eye. The effect of corneal scarring and astigmatism would be partly confounding to these results. Similar results have been reported by others.\textsuperscript{20} The most common long-term postoperative complication in the current study was posterior capsule opacification. Approximately 40% of patients developed visually significant posterior capsule opacification that required treatment. It is reported to occur in 17% to 100% of pediatric patients undergoing cataract extraction with IOL placement.\textsuperscript{17,23,24} Some authors have suggested that its incidence may be greater in patients with traumatic cataract.\textsuperscript{12,18,25} The prevalence of posterior capsule opacification after cataract extraction in children in the current study (40%) is within the range reported in the pediatric literature.

We reported good visual recovery after primary corneal tear repair followed by early secondary cataract surgery with IOL implantation in a select group of children with penetrating ocular injuries. Most reports on pediatric traumatic cataract have included patients with both blunt and penetrating trauma.\textsuperscript{9,12-15,17} The prognosis for final visual recovery following blunt trauma is better than after penetrating trauma, which may have confounded their final results regarding visual acuity. In the current study, we found that the keratometry readings of the fellow eye were even more
reliable than those of the injured eye. Although it is standard practice to take readings of the fellow eye in case of trauma or injury to the other eye, we could not find any published study comparing the readings of both. Future studies should compare the readings to validate the current study findings.

The limitations of the current study are those inherent to any retrospective study, such as selection bias and variable periods of follow-up. A small sample size was another limitation.

Early removal of cataract with implantation of an IOL after primary wound repair in young children with penetrating corneal injury and traumatic cataract and no other associated ocular damage can result in excellent visual outcomes. In children of amblyogenic ages, visual outcomes comparable to older children can be achieved with early cataract surgery, a limited period of visual deprivation of less than 8 weeks, visual rehabilitation with an IOL, and elective primary posterior capsulotomy with anterior vitrectomy followed by aggressive amblyopia therapy.

REFERENCES