INTRODUCTION
Since the introduction of pars plana vitrectomy (PPV) in 1971, the most revolutionary development in vitreoretinal surgery in the past few years has been transconjunctival sutureless vitrectomy (TSV). The large number of potential advantages of TSV include reduced surgical trauma, shorter operating time, lesser conjunctival scarring, decreased postoperative inflammation, faster postoperative healing, early visual recovery, improved patient comfort, and reduced postoperative astigmatism when compared to traditional vitrectomy. Fuji et al. introduced 23-gauge vitrectomy in 2002. It had some inherent problems with the instrument flexibility, lower flow rate, and high incidence of complications. Later, modifications in 25-gauge TSV led to improvement in wound integrity and sterility, potentially decreasing the likelihood of these complications. Eckardt introduced 23-gauge TSV in 2005. It offered improved flow rates and stiffer instrumentation with fewer complications and resolved most of the problems with the 25-gauge system.

Any sutureless surgery in children has been of concern due to the increased chances of wound...
leakage. Postoperative hypotony due to wound leakage is a matter of concern in children due to their relatively more elastic sclera. The 25-gauge vitrectomy has been used successfully in a variety of pediatric conditions. Suturing of the sclerotomy and conjunctiva has been advocated in a few studies using 25-gauge vitrectomy, especially in younger children, where sclerotomy incisions were made through the pars plicata. The 23-gauge vitrectomy overcomes most of the limitations of the 25-gauge vitrectomy, but its role in children has not been well reported.

In this retrospective study, we evaluated the feasibility and short-term outcome of 23-gauge TSV in children younger than 14 years.

**PATIENTS AND METHODS**

A retrospective chart review of consecutive children younger than 14 years who underwent 23-gauge TSV for various indications from January 2008 to December 2011 at a tertiary care center was undertaken.

Infants with retinopathy of prematurity (ROP) were examined with indirect ophthalmoscopy. Anterior segments of these children were examined by indirect ophthalmoscopy with magnification provided by a 20-diopter lens. Posterior segment examination was done after pupillary dilation with 2.5% phenylephrine and 0.5% cyclopentolate in the clinic. The retinal periphery was examined by using doll's eye movement. If needed, peripheral depression was done after applying a pediatric speculum with scleral depressor under topical proparacaine (0.5%). Intraocular pressure (IOP) was assessed digitally in these infants. Children without ROP cooperated for slit-lamp examination of anterior segment and non-contact tonometer for IOP measurement. Posterior segment examination was performed with indirect ophthalmoscopy.

Charts of these children were reviewed after obtaining approval from the institutional ethics committee. Preoperative data including age, gender, indication for surgery, visual acuity, and ocular findings were noted. Surgical notes were reviewed for complications related to vitrectomy such as cannula displacement, bleeding at sclerotomy sites, iatrogenic breaks, need for fluid–air exchange, or suture of sclerotomy site. Postoperative data were evaluated for anatomical and functional success. Anatomical success was defined for infants with ROP as attached posterior pole after PPV at the last follow-up. Early and late postoperative complications such as hypotony, vitreous hemorrhage, choroidal detachment, retinal detachment, endophthalmitis, and need for second surgery were also evaluated. Postoperative transient hypotony is defined as IOP less than 6 mm Hg for eyes in which IOP could be measured, resolving spontaneously within 1 week. However, in eyes with ROP, fluctuation elicited on digital tonometry was considered as hypotony. Final outcome was noted at a minimum follow-up of 3 months.

All procedures were performed by two surgeons (MRD and RS) using the 23-gauge surgical vitrectomy system (Accurus 400 VS; Alcon Laboratories, Inc., Fort Worth, TX). Sclerotomies were made through the pars plicata 1.25 mm from the limbus in eyes with ROP and 2.5 to 3.5 mm in other children. If the surgery was prolonged and required more manipulation at sclerotomy sites, leakage from sclerotomy sites was suspected and partial fluid–air exchange was done at the end of surgery. If sclerotomy sites showed wound leakage after removal of the cannula, then sutures were applied. Apart from the PPV, other surgical procedures included pars plana lensectomy (PPL) and transcleral fixation of intraocular lens (IOL). Limbal incisions were sutured with 10-0 nylon suture in eyes with scleral fixation of IOL.

**RESULTS**

Thirty-seven eyes of 31 children underwent 23-gauge TSV for a variety of vitreoretinal conditions. There were 20 boys and 11 girls, aged between 1.25 months and 14 years (median: 10 years, mean: 7.23 years). These children were observed for an average of 7.86 months (range: 0.25 to 28 months, median: 5 months).

The surgical indications for 23-gauge TSV were subluxated crystalline lens (8 eyes), ROP stage 4a and 4b (5 and 3 eyes, respectively), post-traumatic cataract with ruptured posterior capsule (6 eyes), vitreous hemorrhage (5 eyes), dislocated crystalline lens (4 eyes), endophthalmitis (2 eyes), retinal detachment with vitreous hemorrhage (1 eye), dislocated IOL (1 eye), epiretinal membrane (1 eye), and increased IOP after intravitreal steroid implantation (Ozurdex; Allergan, Inc., Irvine, CA) (1 eye) (Table 1).

Intraoperatively, 4 (10.81%) eyes required fluid–air exchange due to prolonged surgery with more manipulation at sclerotomy sites, partial in 3 eyes and complete in 1 eye. There were 3 eyes with partial exchange, 2 of which had stage 4 ROP and 1 that had post-traumatic cataract. One eye with stage 4b ROP required complete exchange due to...
intraoperative iatrogenic break. Overall, 6 of the 37 eyes (16.21%) required suturing of one or more active sclerotomy ports. Two of these eyes were from a child with Marfan syndrome with dislocated crystalline lens. Eyes that required suturing included 1 with dislocated IOL, 1 with epiretinal membrane, 1 with ROP stage 4b, and 1 with increased IOP due to intravitreal steroid implantation.

All 10 eyes with ectopia lentis underwent lensectomy and 4 eyes underwent transcleral fixation of the IOL (polymethylmethacrylate) using polypropylene suture. Intralamellar scleral tucking of IOL (three-piece acrylic) using fibrin glue was done in 4 eyes. Two eyes were left aphakic. Other concomitant procedures were intraocular injection of antibiotics (2 eyes), silicone oil injection (1 eye), steroid implant removal (1 eye), and IOL removal (1 eye).

Of the 8 eyes that underwent PPV for stage 4a and 4b ROP, 6 had lens-sparing vitrectomy and two had lensectomy with vitrectomy. None of these eyes had prior scleral buckling surgery. One eye with stage 4a ROP received intravitreal bevacizumab elsewhere before PPV. Intraoperative complications included intraoperative bleeding in one eye with stage 4a ROP from fibrovascular ridge. Iatrogenic break occurred in one eye with stage 4b ROP. This eye underwent fluid-air exchange but revealed residual traction with fibrovascular proliferation. Silicone oil tamponade was not considered in view of significant traction. There was no need for conversion of sclerotomy ports to 20-gauge vitrectomy in any of the eyes. Anatomical success was achieved in 7 of 8 eyes with ROP (87.5%).

Other intraoperative iatrogenic retinal break was encountered in a case of total retinal detachment with vitreous hemorrhage. This was managed successfully during the surgical procedure.

Postoperative complications included loose blood in vitreous cavity (5 eyes, 13.51%), retinal detachment (3 eyes, 8.10%), early postoperative hypotony (2 eyes, 5.40%), and preretinal bleeding (2 eyes, 5.40%). Loose blood after PPV cleared on its own during the follow-up period. Retinal detachment developed in one eye of an infant with ROP stage 4b who had intraoperative iatrogenic retinal break. Two eyes with ectopia lentis developed retinal detachment, in which three-piece acrylic IOLs with intralamellar scleral tucking were implanted. A second PPV along with belt buckle and silicone oil tamponade was done in both eyes. Postoperative hypotony was noted in two eyes, one case of post-traumatic cataract and one case of bleb-related endophthalmitis. Hypotony in both eyes resolved during follow-up in 10 days. Preretinal bleeding was noted in 2 eyes, one case of dislocated IOL and one case of ROP stage 4a. Preretinal bleeding resolved in both eyes in 2 weeks. There were no cases of endophthalmitis, choroidal detachment, sclerotomy-related retinal breaks, or cataract.

### Table 1

**Indications for Surgical Intervention**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. of Eyes (%)</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subluxated crystalline lens</td>
<td>8 (21.62)</td>
<td>8 (ectopia lentis)</td>
</tr>
<tr>
<td>Post-traumatic (repaired PEI) cataract with ruptured capsule</td>
<td>6 (16.21)</td>
<td>Zone 1 PEI = 5 eyes; zone 1 and 2 = 1 eye</td>
</tr>
<tr>
<td>Retinopathy of prematurity</td>
<td>8 (21.62)</td>
<td>3 (stage 4b); 5 (stage 4a)</td>
</tr>
<tr>
<td>Vitreous hemorrhage</td>
<td>5 (13.51)</td>
<td>2 (vasculitis); 2 (hemorrhagic disorders); 1 (post-traumatic)</td>
</tr>
<tr>
<td>Dislocated crystalline lens</td>
<td>4 (10.81)</td>
<td>2 (ectopia lentis); 1 (traumatic); 1 (microsherphakia)</td>
</tr>
<tr>
<td>Endophthalmitis</td>
<td>2 (5.40)</td>
<td>1 (post-traumatic); 1 (bleb-related)</td>
</tr>
<tr>
<td>Total retinal detachment with vitreous hemorrhage</td>
<td>1 (2.70)</td>
<td>Idiopathic</td>
</tr>
<tr>
<td>Dislocated IOL</td>
<td>1 (2.70)</td>
<td>Phaco-aspiration with IOL for congenital cataract</td>
</tr>
<tr>
<td>Epiretinal membrane</td>
<td>1 (2.70)</td>
<td>Traumatic</td>
</tr>
<tr>
<td>Increased IOP after intravitreal steroid implant</td>
<td>1 (2.70)</td>
<td>Intravitreal steroid implant for intermediate uveitis</td>
</tr>
</tbody>
</table>

PEI = perforating eye injury; IOL = intraocular lens; IOP = intraocular pressure
Visual Outcome

Three (8.10%) of the 37 eyes developed retinal detachment in this series. One eye with ROP stage 4b developed retinal detachment due to intraoperative iatrogenic break. Two eyes with ectopia lentis in which three-piece acrylic IOLs with intralamellar scleral tucking were implanted developed retinal detachment. A second PPV along with belt buckle and silicone oil tamponade was done in both eyes with attached retina at the last follow-up.

Twenty-seven eyes (72.97%) had reliable visual acuity recorded preoperatively and postoperatively. Preoperative visual acuity ranged from light perception to 20/80 (median: 20/100). Postoperative visual acuity at last follow-up ranged between light perception and 20/30 (median: 20/40). Of these 27 eyes, 25 had improvement in visual acuity at 4 weeks of follow-up that persisted at last follow-up. Two eyes that did not show improvement in visual acuity had bleb-related endophthalmitis with total glaucomatous optic atrophy and post-traumatic dislocated crystalline lens with macular scar. Visual acuity could not be assessed in cases of ROP.

DISCUSSION

Multiple reports have discussed the safety of 23-gauge vitrectomy surgery in adults. Various advantages of 23-gauge TSV described in these reports include faster healing, increased patient comfort, and faster visual recovery. Small instruments have been shown to be advantageous in children, especially in infants with ROP.

In our series, the pars plicata approach was used in younger children (8 ROP eyes) and 87.5% (7 of 8 ROP eyes) achieved anatomical attachment after a single operation. None of the eyes underwent a second surgery. In previous studies, authors have described a modified/suturing approach for children in whom the pars plicata approach was used with both 23- and 25-gauge vitrectomy. Wu et al. used the 23-gauge pars plicata approach with fluid–air exchange and suturing of sclerotomies and conjunctiva at the end of surgery in all eyes. However, they reported 77% retinal attachment after the first surgery and 88% after multiple procedures. The anatomical success rate of 87.5% in our series is comparable to the 88% reported by Wu et al. with sutured sclerotomies. In our series, rhegmatogenous retinal detachment developed in one eye that had intraoperative iatrogenic retinal break. We performed partial or complete fluid–air exchange in 3 of the 8 eyes with ROP (37.5%). Sclerotomies and conjunctival suturing was done in one eye only. We report for the first time that 23-gauge sclerotomies can be left unsutured in most children with ROP. The results are comparable to the suturing of all 23-gauge sclerotomies by Wu et al.

There is a paucity of literature available on experience with 23-gauge vitrectomy in older children (eyes without ROP). However, Kay et al. reported limbus-based use of the 23-gauge vitrectomy system for aphakic pediatric eyes for indications other than ROP. The authors had to suture all of the limbal wounds in their study. In our study, 6 of the 37 eyes (16.21%) required suturing of one or more sclerotomy ports. Two of these eyes were from a child with Marfan syndrome with dislocated crystalline lens. One eye each requiring suturing had dislocated IOL, epiretinal membrane, ROP stage 4b, and increased IOP due to steroid implantation.

Suturing of sclerotomy is rarely required in adults. Gonzales et al. reported modified/sutured technique in 52% of eyes with 25-gauge vitrectomy, of which 10% were older than 1 year. Lam et al. did not encounter the need to suture conjunctiva or sclera in any case of 10 pseudophakic eyes in children aged 1 to 30 months, where 25-gauge vitrectomy and posterior capsulotomy was done for opacified posterior capsule after cataract extraction. However, 40% of their eyes had an IOP less than 5 mm Hg on postoperative day 1. Basti et al. highlighted the risk of wound leakage after primary posterior capsulotomy with anterior vitrectomy because vitrectomy collapses the sclera, making the already elastic sclera of children even less rigid. This study emphasized the requirement for suturing in pediatric eyes owing to scleral rigidity problems in children.

Postoperative transient hypotony has been reported in 0% to 6.5% of 23-gauge PPV cases in adults. In our series, postoperative hypotony was observed in 2 of 29 eyes without ROP (6.89%) where IOP could be measured with non-contact tonometer. This hypotony resolved with conservative management by 10 days. None of the eyes with ROP revealed hypotony. Postoperative hypotony in children has been reported in 0% to 40% after 25-gauge PPV. Our results of postoperative hypotony are comparable with other studies.

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Two eyes with ectopia lentis in which we implanted three-piece acrylic IOLs with intralamellar scleral tucking developed retinal detachment. These eyes are already predisposed to retinal detachment after cataract surgery with IOL implantation in 8% to 25.6%.20,21

Vitreous hemorrhage and preretal bleeding can occur after PPV. Gonzales et al.12 reported vitreous hemorrhage after PPV that did not clear on its own and required second PPV surgery in 13% of their cases. Vitreous hemorrhage occurred in 13.51% (5 of 37 eyes) and preretal bleeding in 5.4% (2 eyes) in our series. It cleared on its own during follow-up without the need for a second surgery.

Gonzales et al.10 encountered one case of lens touch that required lensectomy. The authors speculated this touch was due to bending of instruments. We did not observe any case of lens touch. Rigidity of 23-gauge instruments would have prevented lens touch.

In our series, the anatomical goal of primary surgery was achieved in 7 of 8 (87.5%) eyes with ROP. Wu et al.18 reported an 88% retinal attachment rate after multiple surgeries using 23-gauge vitrectomy in eyes with ROP. Gonzales et al.10 reported 75% anatomical success with 25-gauge vitrectomy in eyes with ROP, familial proliferative vitreoretinopathy, and persistent fetal vasculature. Poorer success rate in their series could be attributed to the variety of vitreoretinal conditions.

Results of our series were similar to the 25-gauge vitrectomy study by Gonzales et al.10 with regard to safety and efficacy. Earlier 25-gauge vitrectomy had a high incidence of hypotony and endophthalmitis, apart from flexibility issues. The approach of using angled entry of 23-gauge trocar and cannula, partial fluid–air exchange, careful examination of sclerotomy sites for wound leak at the end of surgery, and applying sutures to leaky sclerotomy sites in 23-gauge vitrectomy appears to be a promising approach to avoid complications such as hypotony.

A potential limitation of the study is that it is a retrospective study. Despite this, the study highlights the safety and efficacy of 23-gauge vitrectomy in a variety of vitreoretinal conditions and shows comparable results with 25-gauge vitrectomy.

Sutureless 23-gauge TSV in children appears effective and safe. Rates of hypotony, sclerotomy leakage, endophthalmitis, or choroidal detachment were similar to those of 23- or 25-gauge vitrectomy reported in children where suturing of sclerotomy was done in the majority of cases. Further study directly comparing 23- and 25-gauge systems in children with or without suturing of scleratomies would clarify which approach is best for children.

REFERENCES