Purpose of review
Pediatric cataract surgery remains a very important and difficult problem to manage. While dramatic advances have occurred in this field over the past 10 years, some technical aspects of surgery, changing refraction and functional outcome continue to pose significant problems. The aim of the present review is to update the reader on advances reported on the topic during the past year.

Recent findings
Manual capsulorhexis still remains a gold standard for the successful outcome of pediatric cataract surgery. Primary management of the posterior capsule is mandatory depending on the age of the child at surgery. Primary implantation of the intraocular lens after cataract removal is gaining popularity even in infants and young children. Short-term results of single-piece Acrysof in pediatric eyes are encouraging. Predicting axial growth and the refractive change that accompanies it is one of the major challenges for long-term care of children after surgery. The evaluation of rate of axial growth and its correlation with age at surgery, laterality, aphakia/pseudophakia and visual-axis obscuration is a positive step in the right direction. Despite satisfactory technical outcomes, the functional outcomes remain unpredictable.

Summary
With refinements in surgical techniques, improvisation of intraocular lenses and better understanding of growth of the pediatric eye, in the coming years intraocular lens implantation is likely to become an established mode of treatment of children even in the youngest age group.

Keywords
anterior vitrectomy, cognitive vision, congenital cataract, pediatric cataract surgery, visual rehabilitation

Introduction
Pediatric cataract is the most common cause of treatable childhood blindness, accounting for 5–20% of blindness in children worldwide [1–3]. Managing cataracts in children remains a challenge. Treatment is often difficult and tedious and requires a dedicated team effort, the most important members being parents [3]. The timing of treatment is crucial to the visual development and successful rehabilitation of children. Managing pediatric cataract poses important problems related to technical aspects of surgery, changing refraction and functional outcome. However, with refinements in surgical techniques, improvisation in quality and designs of intraocular lenses (IOLs) and amblyopia regimes, both technical and functional outcomes of pediatric cataract surgery are improving.

Etiology of congenital cataract
Zetterstrom and co-authors [4**] in a review and update of cataracts in children enumerated the etiology of the cataract in the developed world. The most common cause of bilateral congenital cataract was idiopathic. About one third of cases were hereditary, without a systemic disease. Rare causes included metabolic disorders, systemic abnormalities, intra-uterine infection and a few ocular conditions. In contrast, unilateral cataract in most cases was idiopathic. For the first time, Raghu and colleagues [5] reported association of herpes simplex virus type 1 (HSV-1) with congenital cataract.

Indications for surgery
Indications for cataract surgery include visually significant central cataracts larger than 3 mm in diameter, dense nuclear cataracts, cataracts obstructing the examiner’s view of the fundus and cataracts associated with strabismus [4].

Pre-operative examination
The importance of counseling parents cannot be overstressed. Parents should understand that treatment of the child starts only after surgery. They need to come for regular follow-up visits and see that the child wears glasses or contact lenses despite the IOL implantation; the child may also need occlusion therapy following surgery. It is important to assess the visual function of the child, if possible with charts such as preferential looking charts (Teller acuity card, Keeler, Berkshire, SL4 4AA), Lea gratings and symbols (Precision vision, Lasalle, USA), Sheridan Gardiner tests, ‘E’ charts or Snellen’s...
charts as in older children. In very young children, who cannot cooperate for vision tests, the ability to fixate or follow light or objects should be assessed. The presence of squint or nystagmus should be noted and ocular movements should be checked.

Preoperative examination with fully dilated pupils if necessary under anesthesia is mandatory in both eyes. This should include examination under operating microscope or slit lamp biomicroscope to assess the cataract, tonometry to rule out any association of glaucoma, measurement of corneal diameter, posterior segment evaluation, keratometry and biometry. The surgeon should look for a preexisting posterior capsule defect, which may turn out to be a camouflaged catastrophe [6].

Are pediatric eyes different?
In comparison with adult eyes, pediatric eyes have greater elasticity of the capsule, lower scleral rigidity and mitotically active lens epithelial cells, leading to higher incidence of posterior capsule opacification (PCO) necessitating primary management of the posterior capsule and thick vitreous gel giving protection against cystoid macular edema.

Special considerations in pediatric cataract surgery
The following subsections discuss three areas that require special consideration.

Technical aspects of surgery
The surgeon should strictly adhere to the principles of the closed chamber technique, such as valvular incision, injection of viscoelastic before removing any instrument from the eye, bimanual irrigation–aspiration and two-port anterior vitrectomy. A 3 mm wide limbal valvular incision with 1–1.5 mm internal entry or a scleral incision is preferred. Most surgeons prefer to suture these incisions in view of the low scleral rigidity and a child’s tendency to rub the eyes. This suturing may induce astigmatism; hence it is advisable to remove the suture within 4–6 weeks of surgery. Bradfield and colleagues [7] demonstrated that small-incision clear corneal cataract extraction with IOL implantation led to minimal postoperative astigmatism that remained stable over time.

High-viscosity viscoelastic agents [8] and trypan blue dye [9,10] are useful adjuncts in pediatric surgery. In a mature cataract, or where visibility is poor, trypan blue staining of the anterior capsule is extremely helpful. Saini and colleagues [11] have stated that Acrysof IOLs should not be implanted during pediatric cataract surgery if trypan blue dye is used. Brown and co-authors [12] have suggested that both trypan blue and acrylic IOLs are valuable tools in the treatment of pediatric cataracts and should not be declared mutually exclusive without better evidence.

Anterior lens capsule management
The anterior capsulotomy shape, size and edge integrity are now recognized as being very important for long-term centration of a capsule bag fixated IOL [13, 14**,15**]. Manual continuous curvilinear capsulorhexis (CCC) is a popular anterior capsulotomy technique for adult cataract surgery. The anterior capsule in children, however, is very elastic. Manual CCC is therefore difficult to perform and control in pediatric eyes. This has led researchers and surgeons to search for alternative methods to open the anterior capsule in children [13]. Alternatives currently available include vitrectorhexis, radio-frequency diathermy and Fugo plasma blade. Wilson [14**] compared five different anterior capsulotomy techniques using a porcine model. Extensibility and edge characteristics were reviewed with each technique. Manual CCC was found to produce the most extensible capsulotomy with most regular edge. These findings were confirmed by scanning electron microscopy (Trivedi RH, Wilson ME, Bartholomew LR presented at the congress of the American Society of Cataract and Refractive Surgery; 15–20 April 2005; Washington DC). Manual CCC remains a gold standard for resistance to tearing and should be accomplished whenever possible (Fig. 1). Most surgeons prefer manual CCC for children above 2 years.

Vitrectorhexis has proved to be a good alternative to manual CCC for young children, especially in the first
two years of life when the capsule is very elastic and difficult to control. Vitrectorhexis is easier to perform and is a good option for children when anterior vitrectomy is performed as part of primary management. In contrast, a diathermy-cut capsulotomy, even when performed perfectly, can be seen to have coagulated capsular debris along the edge. In addition, this edge has been shown experimentally to be less elastic than a manual CCC [16]. The Fugo blade is a unique cutting instrument that uses plasma for ablating tissue [17,18]. The Fugo blade helps make a perfectly controlled anterior capsulotomy of any size, without the risk of a radial tear. The peculiar structure of the cut edge ensures that even if a deliberate radial cut is made in the capsulotomy, it will not spontaneously extend towards the equator. Radio-frequency diathermy and the Fugo blade are recommended when fibrotic capsules are encountered or in white cataracts with the absence of the red reflex.

Titiyal and colleagues [19] recommend postage-stamp multiple anterior capsulorhexisotomies following IOL implantation. They have observed that after CCC, anterior capsule opacification and fibrosis were most marked

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Figure 2 Primary anterior limbal vitrectomy being performed in a 1-year-old child

![Figure 2](image2)

Figure 3 A well centered single-piece Acrysof in a 2-year-old boy, showing clear visual axis and early proliferation at the margin of posterior capsulorhexis at 2.2 year follow-up

![Figure 3](image3)

Figure 4 Anterior vitreous face response (AVR response) within the posterior capsulorhexis margin at 1.8 year follow-up in a 5-year-old child with PCCC only

![Figure 4](image4)

Figure 5 A photograph showing proliferative PCO in an 8-year-old child with single-piece Acrysof at 1.5 year follow-up

![Figure 5](image5)
at the margin of capsular rims. They believe capsulorhexisotomies will prevent phimosis of anterior capsule opening and capsular contraction syndrome.

**Management of the posterior capsule**

The most frequent and significant problem following pediatric cataract surgery is PCO [20–23]. The younger the child, the higher the incidence and the earlier the onset of PCO. Maintenance of a clear visual axis remains a high priority when planning management of the posterior capsule in the amblyogenic age range. Guo and co-authors [15] have reviewed the literature related to pediatric cataract surgery and have summarized the advantages and disadvantages of various approaches related to surgical management of the anterior capsule, posterior capsule and anterior vitreous. The consensus is to perform posterior continuous curvilinear capsulorhexis (PCCC) with anterior vitrectomy in children under 6–7 years or in children who have poor cooperation for probable Nd:YAG capsulotomy. PCCC without anterior vitrectomy was found to be a preferred approach in children above 7 years or for those who cooperate for Nd:YAG laser capsulotomy at a later time. PCCC alone may delay the onset of PCO but cannot eliminate it [15*,24]. The posterior capsule should be left intact in children above 9–10 years or in those who cooperate for laser treatment when indicated.

Most surgeons prefer to manage the posterior capsule at the time of cataract surgery [20,22]. The common practice is to carry out posterior capsulotomy before IOL implantation if the limbal approach is used (Fig. 1). If the pars plana approach is used, however, posterior capsulotomy and vitrectomy should be performed after IOL implantation. Ideally one should aim for a 3.5–4 mm posterior capsulotomy, which is circular and centric. Posterior capsulotomy can be performed with various approaches including manual PCCC, vitrectorhexis, radio-frequency diathermy and the Fugo plasma blade [15*]. Like ACCC, manual PCCC remains a gold standard for performing posterior capsulotomy. The current opinion of management of the posterior capsule seems to be a manual PCCC of 3.5–4 mm size in children under 7 years of age.

**Is vitrectomy necessary?**

The anterior vitreous face is closely linked to the posterior capsule. It is more ‘reactive’ in infants and young children. It acts as a scaffold [25], not only for lens epithelial cells but also for metaplastic cells. The inflammatory response in small children is severe and fibrous membranes may form on the intact anterior vitreous face, resulting in visual axis opacification (VAO). Hence anterior vitrectomy along with posterior capsulotomy is advocated in infants and young children [15*]. In our experience, the need for vitrectomy depends on the age of the child and IOL material [24,26–28]. The consensus is that primary vitrectomy is not necessary in children above 5 years (Fig. 2).

Bimanual anterior limbal vitrectomy is preferred by most pediatric cataract surgeons over pars plana vitrectomy. Pars plana vitrectomy is performed for secondary procedure in eyes with VAO. A transconjunctival sutureless vitrectomy system, being less traumatic, may prove invaluable in pediatric eyes [29*].

**Intraocular lens implantation**

Options for optical correction following pediatric cataract surgery are primary IOL implantation, aphakic glasses and contact lenses. Primary IOL implantation has become a preferred approach in children above 2 years [30–32]. IOL implantation is still questioned in children under 2 years as these eyes are most susceptible to intense PCO and excessive uveal inflammation [4*,26,31,32]. Microcornea, microphthalmos and uveitis are absolute contraindications whereas aniridia, glaucoma and persistent hyperplastic primary vitreous are relative contraindications of IOL implantation.

IOL fixation, material and size are important determinants of immediate and long-term outcome. In-the-bag fixation is the most preferred site of IOL implantation. PMMA (polymethyl methacrylate) IOLs have remained the IOL of choice for many years but the current opinion favors the use of Acrysof [27,28,33–41,42*]. With Acrysof, the type of PCO is predominantly proliferative. PCO sets in at a later stage, typically at 14–16 months. Visual obstruction produced with Acrysof is less severe than PMMA and is therefore less amblyogenic (Figs 3, 4 and 5).

The preliminary results of single-piece Acrysof have been encouraging [40,41,42*]. Trivedi and Wilson [40] believe that single-piece Acrysof SA series IOLs would be ideal for children. Kugelberg and colleagues [42*] performed a randomized study on 66 children aged 3 to 15 years to evaluate PCO in children having cataract surgery with or without anterior vitrectomy. They also examined properties of single-piece Acrysof SA30AL. The authors found that children in the younger age group (≤62 months) had surgery for after-cataract more often than children in the older age group (P < 0.1) and patients who did not receive anterior vitrectomy had surgery for after-cataract more often (P < 0.1). They also found that SA30AL maintained good centration, produced minimal inflammation and was well tolerated in pediatric eyes. Single-piece Acrysof has extremely flexible haptics, combined with excellent memory, which makes the lens easy to implant and not prone to deformation. As the haptics unfold slowly, it is easier to manipulate IOLs in the bag even in the presence of
Contact lenses seem to be a good option for optical correction [43]. They also provide an answer to the problem of changing refraction, which often accompanies IOL implantation. Expenses, compliance and setup, however, are important for contact lens practice. Autrata and co-authors [44] compared visual acuity, ocular alignment, re-treatment rate and binocular visual outcomes in children with primary IOL implantation with contact lens correction for aphakia in one-year old children. The study included 41 children with unilateral congenital cataract undergoing cataract surgery with PCCC and anterior vitrectomy coupled with IOLs ($n = 18$) or with contact lenses ($n = 23$). The mean age at surgery was $3.11 \pm 2.65$ months. The authors found that the IOL group had improved visual acuity and binocular visual outcome with less occurrence of strabismus. The re-operation rate, however, was 78% in the IOL group compared with 35% in the contact lens group ($P = 0.017$). Lambert and colleagues [45] found similar results while evaluating children undergoing unilateral cataract surgery during the first six months of life ($n = 25$). They observed that visual acuity results were similar in the two treatment groups ($P = 0.99$); however, 50% of children in the IOL group compared with 28% in contact lens group had 20/40 or better visual acuity. A large randomized clinical trial, the Infant Aphakia Treatment study, is currently under way to compare primary IOL implantation with contact lens correction in children undergoing unilateral cataract surgery in the first six months of life [45]. A current trend among high-volume cataract surgeons dealing with pediatric cataracts and many pediatric ophthalmologists is to consider IOL implantation as a viable option on a selective basis in children under 2 years.

Speeg-Schatz and colleagues [46] found that initial rehabilitation of bilateral cataracts with aphakic correction and secondary IOL implantation in children under 1 year led to predictable postoperative refraction and fewer complications. Visual rehabilitation in unilateral aphakia, however, was more difficult because of poor compliance with contact lenses, which led to a preference for early IOL implantation. For secondary implantation, in-the-bag fixation of foldable IOLs was found to be associated with a low rate of complications [47]. A higher rate of decentration, however, was noted in foldable lenses compared with PMMA lenses when IOLs were placed in sulcus, particularly in eyes of myopic males.

Is optic capture essential?

It was believed that optic capture would allow surgeons to avoid planned anterior vitrectomy and minimize the risk of PCO [48–50]. Anterior vitrectomy, however, was necessary with optic capture even in children above 5 years [49]. Optic capture maintained better IOL centration but was predisposed to an increased inflammatory response [50]. Hence optic capture has become less popular among pediatric surgeons. Recently, Grieshaber and colleagues [51] performed anterior and posterior vertical capsulotomy with optic entrapment of IOLs by maintaining anterior hyaloid in children aged 2 months to 8 years. They found that this technique, although challenging, was safe and ensured clear visual axis and IOL centration.

Complications of pediatric cataract surgery

The following complications occur frequently during pediatric cataract surgery.

Visual axis opacification

VAO still remains the most frequent complication of pediatric cataract surgery [20–23]. The most critical factor influencing the occurrence of VAO is age. While opacification is nearly universal in infantile eyes, the incidence decreases with increasing age. Primary management of the posterior capsule and anterior vitrectomy are effective in preventing re-opacification of visual pathways [52]. The type and material of the IOL is another factor affecting the incidence of VAO. A new IOL implanted using an innovative ‘bag-in-the-lens’ technique seems promising in greatly reducing or eliminating PCO (Godts DJ, De Veuster I, Tassignon MJ, et al. presented at the 23rd Congress of the European Society of Cataract and Refractive Surgery; 10–14 September 2005; Lisbon). A Sealed Capsule Irrigation device has a potential clinical usefulness in reducing the incidence of VAO, which needs to be confirmed in pediatric eyes [53].

Glaucoma

Glaucoma is a recognized complication of pediatric cataract surgery. Despite improved surgical techniques, the incidence of glaucoma following successful cataract removal remains high [54**,55,56]. A significant number of surgeons regard aphakia as a cause of glaucoma [56,57]. This glaucoma, however, may be better described as ‘glaucoma in aphakia and pseudophakia’ [54**]. The most common type of glaucoma to develop following congenital cataract surgery is open-angle glaucoma [54**,55]. The risk factors include age at surgery, preexisting ocular abnormalities, type of cataract and the effect of lens particles, lens proteins, inflammatory cells and retained...
lens material. In addition, microcornea, secondary surgery, chronic postoperative inflammation, the type of lensectomy procedure or instrumentation, pupillary block and the duration of postoperative observation have been found to influence the likelihood of glaucoma after pediatric cataract surgery [54**]. Undergoing lensectomy at a young age, especially in the first year of life, may be a risk factor for development of glaucoma [55]. It has been suggested that the immaturity of the developing infant’s angle leads to increased susceptibility to secondary surgical trauma [55]. Hence some surgeons believe it prudent to consider delaying surgery until the infant is 4 weeks old in bilateral cases. Glaucoma can occur at any time after congenital cataract surgery. Therefore, pediatric aphakic and pseudophakic patients should be routinely monitored for glaucoma throughout their lives.

Uveal inflammation Intense uveal inflammation or severe fibrinoid reaction is a concern particularly in infants and younger children. Addition of heparin to the irrigating solution has been suggested to reduce postoperative inflammatory reaction and related complications such as synechiae, pupil irregularity and IOL decentration [58]. In our opinion, atraumatic surgical techniques and in-the-bag fixation of IOLs are other contributing factors, which may help reduce the inflammatory response.

Other complications Rabiah and colleagues [59] performed a retrospective review to determine the frequency and to identify the predictors of retinal detachment. They found that retinal detachment is infrequent following aphakia in pediatric cataract surgery, at least at short-term follow-up. They believe that a postoperative aphakic refractive error, more myopic than the age-adjusted aphakic norm, is predictive of retinal detachment.

Corneal astigmatism [7,60] is recognized as a problem arising from cataract surgery. Postoperative astigmatism is of greater importance in children than in adults because of its adverse effect on vision development and the risk of amblyopia. Children, however, show spontaneous regression of astigmatism during the first 5 months of follow-up [60]. An interesting finding is that relatively less astigmatism was observed in children having surgery under 3 years [7].

Eye growth and changing refraction Predicting axial growth, and the refractive change that accompanies it, is one of the major challenges for long-term care following pediatric cataract surgery [61]. This is especially true with wide-spread acceptance of fixed power IOL implantation. Unless the growth of the eye can be accurately predicted, selection of IOL power is a difficult task [62].

Axial growth after cataract surgery can be attributed to normal eye growth, other factors – including age at surgery, visual input, the presence or absence of IOL, laterality, genetic factors – also influence this process [61,63**]. The interocular axial length difference was found to be another important variable influencing axial growth [64]. Understanding pediatric eye growth will help in IOL power calculation and the prediction of refractive changes after IOL implantation.

Functional outcome Congenital cataract causes visual deprivation that results in severe amblyopia. Changing refraction with amblyopia poses a grave challenge to visual rehabilitation. Strabismus is another factor influencing visual rehabilitation following pediatric cataract surgery [65]. Despite a satisfactory technical outcome, functional outcome remains unpredictable. Children who do not get good visual acuity can be rehabilitated with cognitive vision [66].

Conclusion With refinements in surgical techniques, improvisation of IOLs and better understanding of pediatric eye growth, IOL implantation will become an established modality of treatment in the years ahead even for children in the youngest age group.

References and recommended reading Papers of particular interest, published within the annual period of review, have been highlighted as:
• of special interest
** of outstanding interest
Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 108–109).
An excellent and comprehensive review of cataracts in children including all aspects of management of congenital cataract.
Cataract surgery and lens implantation


32 The paper highlights the properties of single-piece Acrysol in pediatric eyes.


This article adds to the knowledge of postoperative eye growth by analyzing the rate of axial growth after pediatric cataract surgery.


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