A Retrospective Analysis of Refractive Changes in Pediatric Pseudophakia

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Abstract

Purpose: *To evaluate the refractive changes occurring after pediatric cataract surgery with primary Intraocular lens implantation considering several factors to provide an accurate prediction of the IOL power to be selected.*

Setting: *Sankara Eye Hospital, Pedakakani, Guntur, Andhra Pradesh, India.*

Methods: *Our study includes 85 eyes of 52 patients of age 2-18 years who underwent cataract surgery with primary IOL implantation. Patients with follow up greater than 6 months were included. The median myopic shift was assessed and compared among various age groups.*

Results: *In the 2-5 year age group (17 eyes), the median myopic shift was -1.125 D [Interquartile range (IQR): -3.25, -0.375] over a median follow up of 16 (IQR: 12, 38) months. In the 6-8 year age group (33 eyes), the median myopic shift was -1.125D (IQR: -1.85,-0.625) over a median follow up of 18 (IQR: 12, 33) months. In the 9-11 year age group (14 eyes), median myopic shift was -0.687 D (IQR: -1.625, -0.250) over a median follow up of 11.50 (IQR: 7, 27.75) months. In the 12-18 year age group (21 eyes), the median myopic shift was -0.75 D (IQR: -1.06, -0.25) over a median follow up of 16 (IQR: 7, 25.50) months. The difference of myopic shift between the 4 age groups was statistically significant. In unilateral cases, the operated eye had more myopic shift than the fellow eye and this difference was statistically significant. No statistically significant difference was found in comparing developmental with traumatic cataracts and amblyopic with non-amblyopic eyes.*

Conclusion: *Our data shows a decreasing myopic shift as the age progresses in pediatric patients following IOL implantation. We conclude that correcting the eye to emmetropia or mild hypermetropia is a better option, as treating the refractive error that may occur as the age progresses is easier than treating the resultant amblyopia that can occur with under correction at the time of surgery.*

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Keywords: *Myopic shift, Pediatric cataract, Primary Intraocular lens implantation, Complications, Axial length*

Introduction

Congenital cataract is the most common cause of treatable childhood blindness. Surgery is an important part of the management of congenital cataract. Optimal selection of Intra ocular lenses (IOL) in growing eyes remains controversial and uncertain because of multiple factors. The main challenge is to decide whether to implant an IOL calculated for emmetropia or to under correct based on the patient's age.[1,2] Our study is intended to provide information on the refractive change after IOL implantation taking into consideration not only the age of the patient but also other factors that can affect the change in refraction which include type of cataract, laterality, amblyopia status, type of IOL etc.

Patients and Methods

In a retrospective study conducted at Sankara Eye Hospital, Guntur. Records of patients aged 2-18 years who underwent cataract surgery with primary IOL implantation from 2012 to 2017 with a minimum of 6 months of follow up were studied. Eighty five eyes of 52 patients were evaluated.

Data Collection: The patient's age, gender, Best Corrected Visual Acuity (BCVA), full cycloplegic refraction, refraction using Automated Refractometer, slit lamp examination and fundus examination were noted at the 1st visit and each follow-up thereafter. Visual acuity was assessed using Snellen's chart, Cardiff acuity cards or Lea symbols charts as was most suitable in each case.

Preoperative assessment included keratometry, axial length, IOL power calculation, and B-scan ultrasonography (if necessary). Axial length and keratometry were measured using IOL Master. Wherever these variables could not be measured with IOL master, axial length was measured using manual A Scan Ultrasonography and keratometry was measured using Automated Keratometry. IOL power calculation was done using the standard SRK T formula. The type of IOL used included both hydrophobic and hydrophilic lenses.

The location of IOL placement (Bag/sulcus), whether Primary Posterior Capsulorhexis (PPC) was done or not and intra operative complications were recorded. Post-operatively, refraction (spherical equivalent) using Automated Refractometer was recorded at all follow up visits. Myopic shift was calculated as the difference between spherical equivalent on the last follow up with first stable refraction (1 month) and the follow up. The length of follow-up was defined as the difference between the date of last known follow up and the date of surgery. Status of amblyopia and any therapy taken for it were also noted.

Surgical Procedure

All patients were operated on by a single surgeon using the same procedure. A 3 mm scleral tunnel extending into the clear cornea was made using a keratome. Continuous curvilinear capsulorhexis was done. The lens was aspirated using Bimanual Irrigation and Aspiration. Depending upon the age of the patient, PPC and anterior vitrectomy were done using Automated Vitrector. IOL was placed in the capsular bag/sulcus depending on the type of case. The main incision was closed using one 10-0 nylon suture. Sideports were sutured with 10-0 Vicryl.

Post operative medications included 1% Prednisolone acetate eye drops 10 times a day for 1 week and tapered thereafter over 6 weeks. Homatropine bromide 0.5% eye drops 3 times a day were prescribed for 2 weeks. Oral steroids were given if necessary. The patients were followed up at 1 week, 4 weeks and at regular intervals thereafter depending upon their amblyopic status.

Statistical Analysis

Age at surgery, follow-up period (months), myopic shift (in diopters), rate of myopic shift (per year) were considered as primary outcome variables. Age at surgery, status of amblyopia, type of IOL, PPC status, position of IOL were considered as primary explanatory variables.

All quantitative variables were checked for normal distribution within each category of explanatory variable by using visual inspection of histograms and normality Q-Q plots. Shapiro-Wilk test was also conducted to assess normal distribution. Shapiro Wilk test p value of >0.05 was considered as normal distribution.

For non-normally distributed age at surgery, follow-up period (months), myopic shift (in diopters), rate myopic shift (per year) parameters, medians and Interquartile range (IQR) were compared between status of amblyopia, type of IOL, PPC status, position of IOL, age at surgery group using Mann Whitney u test (2 groups)/Kruskal Wallis test (>2 groups). P value <0.05 was considered statistically significant. IBM SPSS version 22 was used for statistical analysis.

Results

Eighty five (85) eyes of 52 patients of age between 2-18 years who underwent cataract surgery with primary IOL implantation, having a follow up of more than 6 months were considered. Of these, 57 eyes belonged to male patients and 28 to female patients. The median myopic shift in males was -0.875D (IQR: -1.25, -0.25) and in females, it was -1.437 (IQR: -1.987, 0.281). Of the 85 eyes, on the last 69 eyes had a BCVA of 6/12 Snellen equivalent or better (81%) follow up. The highest myopic shift seen was -5.875 D over a follow up period of 47 months.

The patients were divided into 4 age groups. In the 2-5 year age group (17 eyes), the median myopic shift was -1.125 D (IQR: -3.25, -0.375) over a median follow up of 16 (IQR: 12, 38)months. In the 6-8 year age group (33 eyes), the median myopic shift was -1.125D (IQR: -1.85, -0.625) over a median follow up of 18 (IQR: 12, 33) months. In the 9-11 year age group (14 eyes), median myopic shift was -0.687 D (IQR: -1.625, -0.250) over a median follow up of 11.5 (IQR: 7, 27.75) months. In the 12-18 year age group (21 eyes), the median myopic shift was -0.75 D (IQR: -1.06, -0.25) over a median follow up of 16 (IQR: 7, 25.5) months. The difference of myopic shift between the 4 age groups was statistically significant (P=0.022). The statistics of the age groups are given in Table 1.

Table 1: Myopic shift in different age groups

Age at Surgery (in years)	Number of eyes	Follow up (in months) Median (IQR)	Myopic shift (in diopters) Median (IQR)	Rate of myopic shift (per year) Median (IQR)
2-5	17	16 (12, 38)	-1.125 (-3.25, -0.375)	-0.68 (-1.25, -0.22)
6-8	33	18 (12, 33)	-1.125 (-1.85, -0.625)	-0.71 (-1.36, -0.29)
9-11	14	11.50 (7, 27.75)	-0.687 (-1.625, -0.250)	-0.50 (-1.07, -0.25)
12-18	21	16 (7, 25.50)	-0.75 (-1.06, -0.25)	-0.33 (-0.73, -0.205)

IQR: Inter Quartile Range

Of the 85 eyes, 65 had developmental cataracts, 13 had traumatic cataracts and 7 had other causes like complicated cataract and steroid induced cataract. The median myopic shift in patients operated for developmental cataract was -1.25 D (IQR: -2.0, -0.75) over a median follow up of 24 (IQR: 7.50, 30) months. The median myopic shift in patients operated for traumatic cataract was -0.87D (IQR -1.56, -0.25) over a median follow up of 16 (IQR: 12, 30.5) months. The median myopic shift in patients operated for miscellaneous cataracts was -1.0D (IQR: -1.0, -0.25) over a median follow up of 12 (IQR: 7, 30) months. On comparing the median myopic shift between the 3 groups, it was not statistically significant (P= 0.312). Details are given in Table 2.

Table 2: Myopic shift in different types of cataract

Type of cataract	Number of eyes	Follow up (in months) Median(IQR)	Myopic shift (in diopters) Median(IQR)	Rate of myopic shift (per year) Median(IQR)
Develop-mental	13	24 (7.50, 30)	-1.25 (-2.0, -0.75)	-1.0 (-1.20, -0.47)
Miscella-neous	7	12 (7, 30)	-1.0 (-1.0, -0.25)	-0.50 (-1.0, -0.21)
Trau-matic	65	16 (12, 30.5)	-0.87 (-1.56, -0.25)	-0.50 (-1.10, -0.25)

IQR: Inter Quartile Range

Of the 17 cases in which unilateral cataract surgery was done, the myopic shift of the operated eye was compared with the fellow eye. The median myopic shift in the operated eye was -1.06D (IQR:-1.96, -0.75) over a mean follow up of 17 months. The median myopic shift in the fellow eye was -0.31D (-0.56, 0.15). The difference between both the groups was statistically significant (P< 0.001).

On the basis of pre operative axial length, patients were divided into 4 groups: <19.99 mm, 20-20.99 mm, 21-21.99 mm, >22 mm. The myopic shift was found to be highest in the 21-21.99 axial length group, closely followed by <19.99 group as compared to the other 2 groups. The difference between the groups was statistically significant (P=0.034). Details given in Table 3.

Table 3: Myopic shift in relation to pre-operative axial length

Axial length (operated eye) in mm	Follow up (in months) Median(IQR)	Myopic shift (in diopters) Median(IQR)	Rate of myopic shift (per year) Median(IQR)
≤ 19.99	12 (11.25, 30)	-1.31 (-2.0, -0.62)	-0.67 (-1.67, -0.64)
20 to 20.99	17.50 (12.75, 37.50)	-0.82 (-1.18, -0.34)	-0.48 (-0.76, -0.17)
21 to 21.99	23 (12, 30)	-1.62 (-2.28, -0.78)	-0.77 (-1.93, -0.39)
≥ 22	13 (8.50, 25.50)	-0.75 (-1.18, -0.25)	-0.33 (-1.28, -0.21)

IQR: Inter Quartile Range, mm: Millimeters

The median myopic shift in the Amblyopic group (35 eyes) was -0.87 (IQR: -1.375, -0.25) and the median myopic shift in the Non-Amblyopic group (50 eyes) was -1.00 (IQR: -1.81, -0.37). The difference was not statistically significant (P=0.176). The median myopic shift in eyes in which IOL was implanted in the capsular bag (69) was -1.0 (IQR: -1.75, -0.375) and the median myopic shift in eyes in which IOL was placed in the sulcus (15) was -0.375 (IQR: -1.375, -0.25). The difference was not statistically significant. The median myopic shift in cases where Hydrophobic IOL (73 eyes) was implanted was -1.0D which was the same as that with Hydrophilic IOLs (7 eyes).

Of the 85 eyes, PPC was done in 59 eyes and not done in 26 eyes. Of the 26 eyes, 10 eyes (38%) developed Posterior capsular Opacification (PCO) for which Nd: YAG capsulotomy was done. PCO was the most common complication encountered postoperatively followed by deposits on IOL (6 eyes). The other complications include vitritis (3 eyes), pupillary membrane (2 eyes), subluxated IOL (1 eye), and secondary glaucoma (1 eye).

Discussion

Our study includes 85 eyes of 52 patients of age between 2-18 years who underwent cataract surgery with primary IOL implantation by a single surgeon at a tertiary care centre in South India. Our centre caters to a population that is predominantly rural. We have recorded good visual outcome in 81% of our patients (6/12 Snellen equivalent or better). Demirkilinc et al[3] reported that 92.3% of their patients showed improvements in visual acuity. Crouch et al[4] reported a visual acuity 20/40 or better in 85% of their patients. Kleinmann et al[5] reported that 80% of their patients had improvement in visual acuity and more than 50% of the patients ended up with visual acuity of 20/40 or better at last follow up.

In pediatric eyes, the axial length, corneal curvature and lens thickness change over time to maintain the eye in an emmetropic state. The axial length grows rapidly during the first 2 years of life and then continues at a slower rate till the end of the first decade.[6] The corneal curvature keeps changing markedly during the first year after birth and minimally thereafter.[7] Lens changes also occur throughout childhood. Therefore, after cataract surgery, there is an inevitable trend towards myopic shift as a result of ongoing axial elongation.[2]

In our study, myopic shift was observed in all age groups. The median myopic shift in age groups 2-5 years and 6-8 years was essentially the same (-1.125D) and was greater than that found in the 9-11 years group (-0.687D) and 12-18 years group (-0.75D). This difference in the median myopic shift between the age groups was statistically significant but the rate of myopic shift per year was not statistically significant. This can be attributed to our patients having a wide range of follow ups and individual variability. Demirkilinc et al[3] also reported that myopic shift was found in all their age groups and also the highest myopic shift was found in 2-5 years age group and was statistically significant compared to other age groups. Crouch et al[4] observed a myopic shift that continued until early adolescence following cataract surgery. Plager et al[2] studied 38 eyes that underwent cataract surgery and primary IOL implantation and concluded that the rate of myopic shift decreases with age and the variability among individuals decreases with age. Enyedi et al[1] reported that they found an overall myopic shift which was greatest in the youngest patients and also that the rate of change in refraction varies with age. But they concluded that this trend of myopia in pediatric pseudophakia is not the result of excessive elongation but just the normal growth of an eye which has a fixed intraocular lens power.

In our study, the median myopic shift was greater in eyes with developmental cataracts as compared to eyes with traumatic cataracts but the difference was not statistically significant. This was in concordance with Enyedi et al.[1] According to Hutchinson et al[8], the difference in myopic shift between children with developmental and traumatic cataract was also not significant, however, they reported a greater myopic shift in the 6-9 age group than the 3-5 age group and attributed this to more number of traumatic cataracts in the older age group. Eyes with developmental cataracts are frequently shorter than normal at the time of cataract surgery.[9] This could be secondary to blurred retinal image during infancy or due to intrinsic abnormalities that alter the ocular growth.[8]

In our study, among the 18 unilateral cataract eyes, we have compared the median myopic shift of the operated eyes with the fellow eye. We observed that the myopic shift was greater in the operated eye than the fellow eye and this difference was statistically significant. This probably can be explained by the fact that the phakic lens power continues to change to compensate for the developmental elongation whereas the intraocular lens power remains stable in the operated eye. These findings were similar to those reported by Enyedi et al[1] and Crouch et al.[4] Demirkilinc et al[3] found no significant difference in the axial length or refractive power of the cornea between the operated and unoperated eyes but reported a myopic change in the operated eyes though it was not statistically significant. McClatchey et al[10] inferred that as the eye grows, the IOL moves farther and farther from the retina and this anterior movement of the IOL induces a myopic shift by itself. Therefore we suggest that children who have undergone surgery for unilateral cataracts should be closely monitored to prevent anisometropic amblyopia.

In our study, we have classified the patients on the basis of pre-operative axial lengths into 4 groups and we found a decreasing trend of myopic shift from the lower axial length to the higher axial length group except in the 21-21.99 mm group in which we found the highest myopic shift. This could probably be explained by individual variability. Valera and Flores found no statistically significant relationship between initial axial length and myopic shift at 3 years in all patients; however, in the bilateral cataract group, they found a tendency of greater myopic shift with smaller axial lengths.[11] Trivedi and Wilson[12] concluded that eyes with a shorter axial length showed postoperative rate of axial growth that exceeded the growth rate of eyes with a longer intraocular axial length. Hutchinson et al[13] and Hussin and Markham[14] did not find this relationship.

In primates, severe visual deprivation usually results in axial elongation.[15,16,17] In addition, humans with corneal opacities or unilateral cataracts may develop excessive axial elongation.[18,19,20] However, these theories do not explain our study findings, as 81% of our patients had a BCVA of at least 6/12, and there was no statistically significant difference in the myopic shift between the amblyopic and non-amblyopic group. Our findings were similar to those reported by Enyedi et al[1] and Crouch et al.[4] However, Kim et al[21] and Dahan et al[22] found greater myopic shift in amblyopic eyes.

We have recorded the post operative complications in our study and the most common complication was visual axis opacification (VAO) which included PCO, IOL deposits and secondary membranes. Out of 26 eyes in which PPC was not done, 10 developed PCO and they underwent Nd:YAG capsulotomy. Also 6 eyes showed deposits on IOL, none of which caused significant visual loss. Our study is in agreement with most of the studies which reported VAO (PCO, secondary membranes, lens proliferation, capsular phimosis) as the most common complication[5,23], and PCO ranging from 14-72% in different studies.[3,4,5,24,25,26] Some studies[27,28] reported re-opacification of visual axis and suggested that it might be determined by the site of IOL implantation and adequacy of anterior vitrectomy.[28] None of our cases in which PPC was done developed re-opacification. In a study done by Pehereet et al[29] they reported an increased incidence of significant deposits on the IOL when hydrophilic IOLs were implanted in infants. This was possibly due to the IOL material and its processing which attracts calcium and phosphorus in the irrigating solutions and viscoelastics to form deposits over the IOL.[26] In our study, we did not find any correlation probably because hydrophilic lenses were implanted in only 7 of our patients. Glaucoma is another complication following pediatric cataract surgery. The Infant Aphakia Treatment Study[30] reported an incidence of 19% in the pseudophakic eyes and suggested younger age at the time of surgery and smaller corneal diameter to be significant risk factors. Other studies[3,31,32] have reported a low incidence of glaucoma which was explained by the protective effect of IOL against glaucoma. Our study too was in support of this theory as only one of our patients developed secondary glaucoma.

Most of the authors[1,4,8] recommend under correcting the child to hypermetropia to achieve emmetropia in adult life. Some other authors like Superstein et al[33] recommend correcting the eye to emmetropia in the immediate post operative period to overcome the hurdle of amblyopia therapy in the critical period of visual development. Few other authors[34] suggest correcting the eye to emmetropia in unilateral cases and children less than 2 years to avoid anisometropic amblyopia in the immediate postoperative period. In our study, although we found a trend towards decreasing myopic shift as the age progresses, the median myopic shift even in the youngest age group was -1.125D. Therefore the decision to leave a child hypermetropic, mild hypermetropic or emmetropic should depend not just on the age of the patient but also on many other factors like laterality, compliance, affordability, parental care and awareness regarding the seriousness of the condition. Refractive status of the fellow eye should also be taken into consideration.

A limitation of our study was its retrospective nature. Although many surgeries were performed between 2012 and 2017, we could record complete details of only 85 eyes of 52 patients as the remaining were lost to follow up. Another limitation was that we did not record axial length on follow up visits, hence we could not explain the relationship between axial length and myopic shift. Also, we couldn't comment on the refractive change in the age group of less than 2 years as very few pediatric patients that were operated in our hospital were less than 2 years of age. This could be attributed to lack of awareness and poor general health of these patients as most of them belong to rural areas.

Conclusion

Based on our results, we concluded that the decision on choosing the IOL power depends on a multifactorial approach. On the whole, we believe that treating the resultant amblyopia following undercorrection of the refraction is far more challenging than treating the eventual myopic shift that develops with age. So we prefer to aim for emmetropia or mild hypermetropia in our cases and correct the myopic refractive error if it develops later. This practice of ours has been proven to be beneficial as 81% of our patients had excellent visual outcome and none of them required IOL exchange.

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