Original Article

# Overcoming myopic shift by the initial inductive hypermetropia in pediatric cataract surgery

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**Purpose:** To assess the outcome of under-correction of intraocular lens (IOL) power in pediatric cataract surgery. **Methods:** We collected clinical data of 103 patients (181 eyes), all aged ≤15 years, who had undergone cataract surgery by a surgeon during 2006–2016. The mean duration of follow-up was 73 ± 38 months (range: 24–108). IOL power was calculated by Hoffer Q formula in axial length (AL) <21 mm and SRKT formula in AL ≥21 mm and then modified based on this approach: 7D initial inductive hypermetropization in children ≤1-year-old, 5D in 1–3, 3.5D in 3–5, 2.5D in 5–7, 1.5D in 7–9, 1D in 9–10, and 0 in children >10 years old. **Results:** The mean age of all children at surgery time was 5.85 ± 4.56 years (range: 1–178 months). There was a mean myopic shift of −6.379 D in the ≤1 year, −5.532 in the 1–3, −3.194 in the 3–5, −2.301 in the 5–7, −1.06 in the 7–9, −1.567 in the 9–10, and 0.114 in the >10-year-old age group. In 125 eyes (69.1%) of 181, the final SE was between −2 and +2 D, and 21 eyes (11.6%) achieved the goal of emmetropization. Mean best-corrected visual acuity logarithm of the minimum angle of the resolution was 0.30 in children ≤1 year, 0.39 in 1–3, 0.21 in 3–5, 0.18 in 5–7, 0.14 in 7–9, 0.16 in 9–10, and 0.11 in children >10 years old. **Conclusion:** This study shows a larger myopic shift in younger children. Using our approach, all age groups could finally achieve acceptable final refraction.

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Cataract is one of the leading causes of preventable childhood blindness worldwide.[1,2] Research has shown that up to 75% of childhood blindness in developing countries happens due to congenital cataract.[3] The incidence of pediatric is 1.8–3.6/10000 per year, and its prevalence is about 1.03/10000 children.[4] Early diagnosis and surgical management and regular follow-up can lead to good visual outcomes, especially in unilateral cases.[5-10] Recent advances in cataract surgical methods, intraocular lens designs, and materials drive better visual outcomes.[1] There is a rising tendency toward intraocular lens (IOL) implantation, which results in a refractive change in children whose eyes are still growing rapidly.[11] Selecting a proper IOL power is not a straightforward decision because eye growth affects the axial length (AL) and keratometry readings (KR), and eventually may lead to an unpredicted refractive error.[12] Although there has been significant progress made in surgical methods, instrumentation, and design, one of the main challenges in pediatric cataract surgery is achieved to the expected final post-operative refraction.[13]

Due to eye growth, a rapid increase in AL happens during the first 2 years of life and then tapers gradually and stabilizes at the age of 7–10. Moreover, flattening of the cornea and decreasing lens power are the other critical reasons for refractive changes by eye growth, making the eye more myopic. This procedure is called emmetropization.[14,15]

In the study conducted by Dahan *et al*.,[16] the IOL power was under-corrected by 80% of the emmetropic IOL power for patients under 2 years old and 90% for patients older than 2 years of age. Another study offered an initial hypermetropia in children of different ages and evaluated the myopic shift during serial follow-up.[15]

Based on these promising results, in the current study, we investigated the long-term refractive changes in children 15 years old and below who underwent cataract surgery with initial inductive hypermetropization suggested by the authors.

## Methods

This retrospective study considered all recorded case notes and clinical data obtained from patients aged 15 years and younger who underwent cataract surgery by a surgeon during 2006–2016 with at least 12 months post-operative follow-up. Records included age at the time of surgery, KR (in D), AL (in mm), implanted IOL power, and post-operation serial refractive error (SE). Patient follow-ups were performed at 1, 3, 6, and 12 months after surgery and continued annually. The

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exclusion criteria included traumatic cataract, glaucoma, ocular pathology, and patients with an irregular follow-up [Fig. 1]. The research ethics committee of Ahwaz Jundishapur Medical University approved this study. The ethical code of this study is IR.AJUMS.REC.1398.447.

All 103 patients (181 eyes) were categorized into seven groups regarding age at the time of surgery [Table 1]. Twenty-eight eyes (16%) were located in the ≤1 year, 44 eyes (24%) in 1–3, 17 eyes (9%) in 3–5, 30 eyes (17%) in 5–7, 11 eyes (6%) in 7–9, 14 eyes (8%) in 9–10, and 37 eyes (20%) in >10-years-old age groups. Data were collected regarding demographics and serial follow-up refractions (by retinoscopy in younger children, which was double-checked and auto-refractometry in the older one) and best-corrected visual acuity (BCVA).

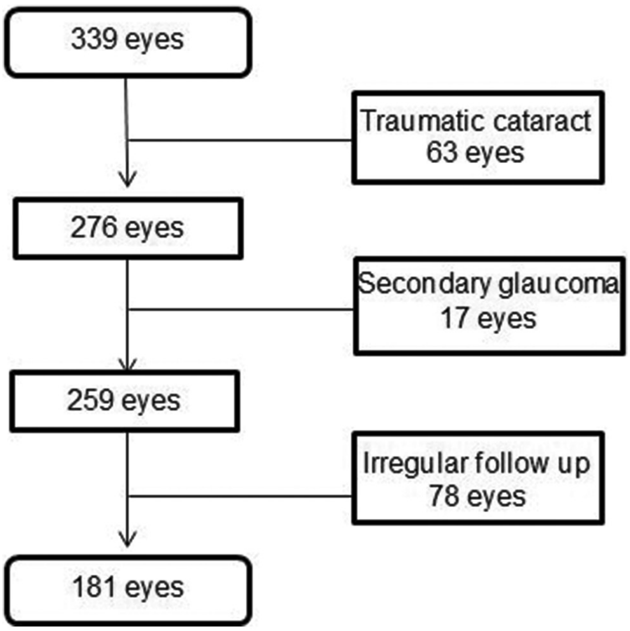


**Figure 1:** Flowchart for the exclusion data

**Table 1: Suggested Induced Hypermetropia Corresponding with Age**

| Age group (Y/O) | Induced hypermetropia (D) |
|---|---|
| <1 | 7 |
| 1-3 | 5 |
| 3-5 | 3.5 |
| 5-7 | 2.5 |
| 7-9 | 1.5 |
| 9-10 | 1 |

Y/O: Years Old; D: Diopter

Lensectomy with primary posterior capsulotomy, anterior vitrectomy, and IOL implantation in the capsular bag were performed for all patients under general anesthesia. In this surgery, two limbal incisions were performed using a 2.8-mm and 15-degree knife. Lensectomy, primary posterior capsulotomy, and anterior vitrectomy were done by vitrectomy probe gauge 23 after capsulorhexis. IOL was implanted in a capsular bag and then corneal incisions were sutured using 10.0 nylon. Corneal sutures were removed after one month in all patients.

The IOL power was calculated by Hoffer Q formula in AL <21 mm and SRKT formula in AL ≥21 mm and then modified according to the proposed approach by authors [Table 1], which induced an initial hypermetropia.

Postoperatively, all patients were placed on oral prednisolone (0.5–1 mg/kg daily) accompanied by topical betamethasone (Q 30 min and then tapers) and ciprofloxacin (Q 6 h for 1 week), initial hypermetropia was corrected with spectacle. BCVA was assessed with fix and follow, CSM, finger count, or Snellen chart according to their age group.

Case records were collected and analyzed by SPSS software (version 26). The effect of KR, AL, and age at the surgery time on myopic shift was then evaluated using multivariate and univariate analysis. *P* value of < 0.05 was assumed statistically significant.

## Results

A total of 181 eyes of 103 children ≤15 years old were studied. From this number, 25 patients (24.2%) had unilateral cataract (15 patients with cataract in the right eye and 10 in the left eye); 58 patients (56.3%) were male, and 45 (43.7%) were female. Five patients (4.8%) had a primary posterior capsular defect; 24 patients (23.3%) had nystagmus. The youngest was one month old, and the oldest was 15 years old. Calculated IOL power was from 8D to 34D (average: 21.33D). Table 2 shows the details about the preoperative clinical data of patients.

The mean age of all patients at surgery time was 5.85 ± 4.56 years (range: 1–178 months). Twenty-one of 181 eyes (11.6%) achieved the goal of emmetropization; 63 of

**Table 2: Preoperative clinical data of patients**

| Age (year) | SEX | | | Implanted IOL | | KR | | AL | |
|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | Total | Range | Mean | Range | Mean | Range | Mean |
| <1 | 10 | 6 | 16 | 16.5-30 | 22.48 | 43.07-45 | 44.31 | 18.11-22.34 | 19.71 |
| 1-3 | 14 | 10 | 24 | 8-34 | 22.30 | 41.75-48.52 | 44.73 | 18.02-25.69 | 21.04 |
| 3-5 | 4 | 8 | 12 | 12.5-23 | 19.82 | 41.02-45.6 | 44.15 | 21.01-25.11 | 22.48 |
| 5-7 | 9 | 8 | 17 | 14-28 | 21.73 | 41.32-47.84 | 44.24 | 19.48-23.73 | 21.92 |
| 7-9 | 6 | 2 | 8 | 20.5-32 | 24.77 | 38.46-44.72 | 42.08 | 20.63-22.64 | 21.98 |
| 9-10 | 5 | 5 | 10 | 13-29 | 21.30 | 39.48-47.06 | 42.90 | 20.88-24.77 | 22.62 |
| >10 | 10 | 6 | 16 | 9.5-25 | 20.26 | 39.20-46.85 | 43.07 | 22.11-27.78 | 23.33 |

IOL: Intra Ocular Lens; AL: Axial Length; KR: Keratometry Readings

181 eyes (34.81%) had the final SE between −0.5, and +0.5 D. 95 eyes (52.5%) had the final SE between −1 and +1 D. In 125 eyes (69.1%), final SE was between −2 and +2 D. However, only 11.60% of children met the final goal of emmetropization. Most patients (69.1%) had an acceptable refractive error between −2 and +2 D [Table 3].

In addition, we had a low percentage of patients with a final emmetropia. However, most of the samples achieved an acceptable final refractive error. A greater percentage of older children at the time of surgery had a lower range of SE than the youngsters [Fig. 2].

**Table 3: Refractive Error range (Diopters) in this study**

| Refractive Error (Diopters) | Eyes No. | Percentage |
|---|---|---|
| 0 | 21 | 11.60% |
| −0.5-+0.5 | 63 | 34.81% |
| −1-+1 | 95 | 52.50% |
| −2-+2 | 127 | 69.10% |
| <−2 or >+2 | 54 | 29.83% |

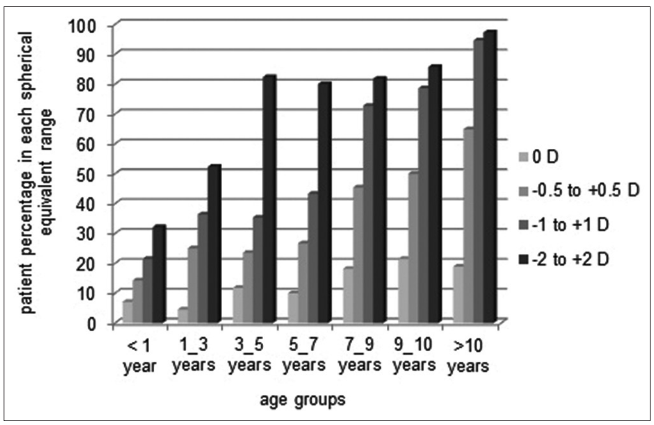


**Figure 2:** Distribution of spherical equivalent (%) in different age group

The most myopic shift occurs in the first year of follow-up and then tapers gradually. The details are summarized in Table 4.

A mean myopic shift of − 6.379 occurred in children ≤1 year, −5.532 in 1–3 years, −3.194 in 3–5 years, −2.301 in 5–7 years, −1.06 in 7–9 years, −1.576 in 9–10 years, and 0.114 in children **>**10 years of age. Thus, the most refractive changes occurred in the younger and the least in the older group [Fig. 3a]. This figure demonstrates that children ≤1-year-old undergo a faster myopic shift in comparison with other age groups.

The mean refractive error in the younger age groups is quickly changing. As expected, the slowest myopic shift was observed in patients older than 10 years of age. We also have a small under-correction in patients older than 10 years old [Fig. 3b].

Finally, BCVA LogMAR of 158 eyes (87%) was ≥0.30; 8 eyes had a BCVA between 0.3 and 0.5 LogMAR, 6 eyes between 0.5 and 1, and 9 eyes had a BCVA LogMAR ≥1. The minimum mean BCVA LogMAR (0.11) was obtained in children >10 years old, and the maximum (0.39) in the 1–3-years age group [Table 5].

## Discussion

Nowadays, IOL power under-correction in pediatric cataract surgery is a challenging issue. There are several studies about AL changes and refraction under-correction. Because of the fast-myopic shift, which causes refractive changes, most ophthalmologists suggest an under-corrected IOL power in children to make an initial hypermetropia. On the contrary, the amount of myopic shift varies in different children and is not entirely predictable.[17]

A large body of studies has indicated that the mean myopic shift in the first-year post-cataract surgery in children <1–2 years

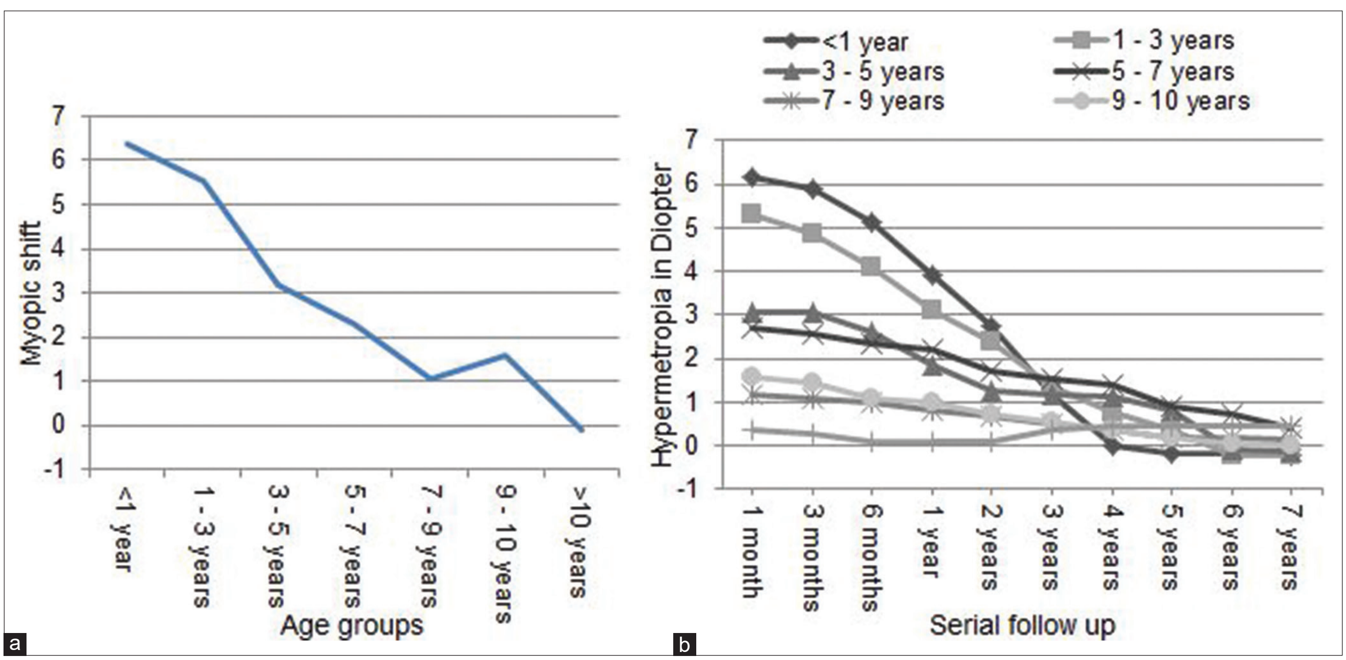


**Figure 3:** (a) Mean myopic shift during serial follow (b) Myopic shifts in different groups

**Table 4: Mean myopic shift seen in the first 3 and 6 months after cataract surgery and then, first to seventh year after surgery**

| | <1 year | 1-3 years | 3-5 years | 5-7 years | 7-9 years | 9-10 years | >10 years |
|---|---|---|---|---|---|---|---|
| Mean myopic shift at 1st 3 months of follow-up | -0.268 | -0.473 | -0.022 | -0.128 | -0.12 | -0.105 | -0.094 |
| Mean myopic shift at 1st 6 months of follow-up | -1.049 | -1.253 | -0.485 | -0.362 | -0.213 | -0.461 | -0.272 |
| Mean myopic shift at 1st year of follow-up | −2.259 | −2.213 | −1.231 | −0.526 | −0.375 | −0.589 | −0.241 |
| Mean myopic shift at 2nd year of follow-up | −1.162 | −0.743 | −0.579 | −0.495 | −0.141 | −0.262 | 0.001 |
| Mean myopic shift at 3rd year of follow-up | −1.602 | −1.027 | −0.087 | −0.167 | −0.175 | −0.155 | 0.261 |
| Mean myopic shift at 4th year of follow-up | −1.143 | −0.572 | −0.037 | −0.109 | −0.138 | −0.176 | 0.063 |
| Mean myopic shift at 5th year of follow-up | −0.194 | −0.388 | −0.317 | −0.511 | −0.161 | −0.197 | 0.012 |
| Mean myopic shift at 6th year of follow-up | −0.009 | −0.582 | −0.893 | −0.185 | −0.031 | −0.112 | 0.024 |
| Mean myopic shift at 7th year of follow-up | −0.01 | −0.007 | −0.05 | −0.308 | −0.039 | −0.076 | −0.006 |
| Mean total myopic shift in 7 years of follow-up | −6.379 | −5.532 | −3.194 | −2.301 | −1.06 | −1.567 | 0.114 |

**Table 5: Mean best-corrected visual acuity logarithm of minimum angle of resolution in different age groups**

| Age groups (year old) | Range | Mean |
|---|---|---|
| ≤1 | 0.04-1.60 | 0.30 |
| 1-3 | 0-1.60 | 0.39 |
| 3-5 | 0-1 | 0.21 |
| 5-7 | 0-1 | 0.18 |
| 7-9 | 0-0.22 | 0.14 |
| 9-10 | 0-0.30 | 0.16 |
| >10 | 0-0.39 | 0.11 |

of age was 5.43 to 5.49 D.[18,19] Ganesh *et al*.[20] reported a mean myopic shift as −0.78 ± 1.2 in the first 6 months, −1.66 ± 1.7 in the first year, and −0.75 ± 1.06 in the second year. They reported a mean total myopic shift of −2.35 ± 2.15 in 2 years post-operation follow-up. As Table 4 shows, in our study, the highest myopic shift was recorded in the first-year post-operation in almost all groups that taper as time goes on.

In the current study, the myopic shift is seen in all age groups; the maximum found in children ≤1 year and the minimum was observed in children >10 years old. The differences between children ≤1 year, 1–3 years, and 3–5-year-old children were statistically significant ($P$ value = 0.001, $P$ value = 0.01). For the other groups, the differences were not significant. Our findings are in agreement with most relevant studies that described a long lasting myopic shift until early adolescence after cataract surgery.[21] The highest myopic shift occurred in the youngest age group and variable rate of refraction changed with age.[15,22] Plager *et al*.[23] concluded that the amount of myopic shift in children decreases with age. Muppidi *et al*.[24] studied the median myopic shift in children aged 2–18 years who underwent cataract surgery and recorded the most myopic shift in their younger group and the least in the older. As expected, our study shows that maximum myopic shift happens in children ≤1 year of age and the minimum observed in children >10 years old. During follow-up, it was observed that as the age increases, the myopic shift decreases. The less myopic shift in children >10 years of age may be related to low target refraction postoperatively.

According to Fig. 3a and 3b, the suggested approach may be used safely to select pediatric IOL power except for children over 10 years old, which should be under-corrected more than our approach.

We found good visual outcomes (BCVA LogMAR ≤0.3) in 87% of all patients (n = 158) who cooperated for the Snellen chart. BCVA LogMAR ≤0.3 was reported in 50%–85% of the patients.[21,24,25] Studies described that 80%–92.3% of their cases had improvements in their visual acuity.[22,25]

In this study, we compared AL, KR, and age at the surgery vs. myopic shift to find a statistically significant relationship between them. We found a statistically significant relationship between age at the surgery time and myopic shift ($P$ = 0.02, $\beta$ = −0.30) by using regression analysis, but KR and AL had no significant relation with myopic shift ($P$ = 0.71).

There are other methods for managing pediatric cataract surgery. One of the initial small under-correction or emmetropization methods is performed initially for the child, and after the child grows older, one of the three methods—IOL exchange, corneal refractive surgery, or piggyback IOL implantation—corrects the remaining refractive error. In the above mentioned methods, reoperation, in addition to imposing more costs on the patient, leads to an increase in complications of several surgeries compared to the one-step method proposed by the authors.[26-28] Complications of piggyback IOL implantation include glaucoma, IOL decentration, and interlenticular membranes, which may themselves require reoperation.[26]

On the contrary, the results of pediatric refractive surgery are not adopted as those obtained in adult surgery by ophthalmologists.[29] It should be noted that there are only limited studies and results for these methods of pediatric surgery.

Our study limitations include the retrospective status, no control group, AL measurement in the supine position by contact technique in most patients, no record of AL in the latest follow-up visit, and a decrease in samples due to irregular follow-up. Despite these limitations, this study involved a wide range of patients within 1 month to 15 years of age. More studies are needed to validate our approach.

## Conclusion

The current study reveals that myopic shift decreases as age increases after pediatric cataract surgery. We conclude that our approach results in achieving an acceptable refractive error in patients with initial inductive hypermetropization. However, there is an urgent need for the use of spectacle and amblyopia therapy at that time. Our suggested approach has proven to be useful as 87% of our children had great final visual acuity and none of them needed IOL exchange.

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### Conflicts of interest

There are no conflicts of interest.


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