# Chapter 14
# Refractive Targets

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Choosing the initial postoperative refractive target for an infant or child who will be undergoing cataract extraction with intraocular lens (IOL) implantation is perhaps the area in which pediatric IOL surgery differs most from the procedure in adults. It is also the area where there is the most nuance in the surgeon's approach and decisions.

The mature eye's refractive state is not expected to change much during the years following surgery, whereas the very young eye is highly likely to undergo considerable change as part of normal growth and development. This creates a situation where the final postoperative refractive error can be unexpected and unsatisfactory. While myopic shifts are anticipated, how much and how quickly are tremendously variable. Some patients do not reach emmetropia at all, remaining hyperopic. Others quickly become myopic and may even require an IOL exchange (see Chap. 18: IOL exchange).

In a Delphi process, pediatric cataract surgeons reached a consensus on the following targeted postoperative refractions according to age: <6 months, +6-10D; 6–12 months, +4-6D; 1–3 years, +4D; 3–4 years, +3D; 4–6 years, +2-3D; 6–8 years, +1-2D; and >8 years, 0-1D [1]. In the Infant Aphakia Treatment Study, targeted hyperopia for infants (+8 for those 4–6 weeks of age, +6 for those 6 weeks to 6 months) was recommended [2]. Following these guidelines, most pediatric cataract surgeons elect for varying degrees of hyperopia for the pseudophakic child. The goal is gradual progress toward emmetropization, with refractive correction in the form of glasses and/or contact lenses along the way.

However, while adults may bristle at a need to wear spectacle correction after surgery, compliance is rarely a real problem. In early childhood, simply keeping glasses in place can be challenging or even impossible. This makes an unexpected or large refractive error more challenging to treat. A high degree of refractive error very early in life may contribute to amblyopia or impede its treatment, with a

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potentially major impact on the eye's ultimate vision. The young pseudophakic eye's lack of accommodation greatly amplifies the cost of uncorrected hyperopic refractive error, particularly in unilateral cases with a normally accommodating fellow eye. For this reason, when targeting hyperopia, the importance of spectacle compliance must be emphasized with caregivers and, when possible, the patient.

Another unique consideration when determining the refractive target for a child is intraocular lens availability. It is an infrequent occurrence for adults to require an IOL outside of the normal range available in most surgery centers. However, when preoperative lens calculations suggest a high plus or a low plus (or even a myopic) implant is required, this can be obtained prior to surgery date. However, the IOL power required to achieve emmetropia or desired hyperopia in very young eyes may be over +30 and unavailable in some implant models. Even if commercially available, a particular lens power may not be stocked in a surgery center and since lens calculations are frequently performed during an exam under anesthesia, the need would not be known.

One advantage of cataract surgery in childhood is neural plasticity. The adult patient's capacity to adapt to an abrupt change in refractive status is much less than a child's, the former situation creating potential for significant patient dissatisfaction with an outcome that differs significantly from preoperative refractive status, even if such a change could be viewed as advantageous; no such concern exists before maturity.

Because an important goal of most pediatric IOL implantations is optimizing adult refractive status, surgeons, starting during the first years of the procedure in the 1990s, have focused on choosing a lens power that will result in the most desirable refraction in maturity. Generally, this is thought to be emmetropia or low minus power requirement, with less concern about refraction during the short- and mid-term postoperative periods. Ample evidence of overall trend in the myopic direction (Table 14.1) [3–8] led to the establishment of a recommendation for targeting an early refraction on the plus side, more so in younger patients (Table 14.2).

**Table 14.1** Refractive change after IOL surgery

| Author (year) | Number eyes | Age years (mean or range) | F/U years (mean) | Shift diopters/ year (mean) | Shift diopters total (range) | Shift SD/ mean |
|---|---|---|---|---|---|---|
| Brady (1995) | 45 | 7.2 | 1.5 | −0.45 | +4.25 to −4.00 | |
| Hutchinson (1997) | 21 | 6.3 | 3.2 | −0.31 | +0.38 to −3.25 | |
| Dahan (1997) | 68 | 0–1.5 | 6.9 | −0.92 | | |
| | 36 | 1.5–3 | 3.5 | −0.79 | | |
| | 52 | 3–8 | 3.8 | −0.68 | | |
| Enyedi (1998) | 12 | 0–2 | 2.5 | −0.9 | +0 to −10 | 0.9 |
| | 23 | 2–4 | 2.2 | −1.8 | +5 to −10 | 1.8 |
| | 16 | 4–6 | 1.9 | −1.5 | +1 to −5 | 1.5 |
| | 9 | 6–8 | 3.0 | −1.6 | +2 to −6 | 1.6 |

*F/U* follow-up, *SD* standard deviation

**Table 14.2** Target refraction recommendations (Enyedi, 1998)

| Age years | Target diopters |
|---|---|
| 1 | +6 |
| 2 | +5 |
| 3 | +4 |
| 4 | +3 |
| 5 | +2 |
| 6 | +1 |

This approach does have two potential drawbacks. The lack of pseudophakic accommodation makes it imperative that refractive correction, generally in the form of spectacles, be provided immediately and consistently from the earliest postoperative days. Failure to consistently wear glasses results in poorly focused images, especially for viewing at near, where the young child's vision is mostly directed. This creates an amblyogenic situation, more harmful with younger age and higher degrees of "pseudohyperopia." This is especially true if one eye remains phakic.

"Pseudomyopia," on the other hand, like naturally occurring myopia, is less likely to contribute as significantly to amblyopia, particularly if it develops, as is more likely, later in childhood [9]. While refractive shift in the direction of myopia occurs most often after pediatric cataract surgery, variability among eyes is very large, as indicated by Table 14.1. Some progress to substantial myopia even from a starting point well on the plus side, while others remain stubbornly pseudohyperopic or even shift in the plus direction, necessitating lifelong low plus correction that may result in significant dissatisfaction for the family and ultimately the patient.

Based on these considerations, it has been the author's practice to target early post-op emmetropia for most eyes undergoing IOL surgery in childhood, regardless of age [10]. Inevitably this results in many eyes that become significantly myopic by maturity. The impact of such acquired myopia is mitigated by a number of circumstances. The uncorrected refractive state of the involved eye continuously permits exposure to optically sharp images at some distance that is easily achievable in the real world, minimizing amblyogenic stress. Very young children with uncorrected myopia, even bilateral, are generally not particularly bothered by the condition. They typically pay limited attention to distant parts of the world and are usually happy to approach any object of interest for close inspection. Most often by the time myopia develops after IOL surgery (typically years), the child is at an age when spectacle wear is reasonably well tolerated and considered socially acceptable. Contact lens correction for myopia of any degree poses fewer problems than in cases of low plus power requirement and can usually be achieved without much difficulty by the age at which high minus power may be needed. Finally, keratorefractive surgery is a very reasonable solution for the young adult who desires permanent correction. However, it is important to consider that the axial length elongation in the first 24 months can give rise to rapid myopia if emmetropia is targeted in this young age range.

A recent retrospective comparative clinical study from two institutions using different targeting strategies, with surgery performed age 2–6 years and mean follow-up 6 years, showed no significant difference in final best corrected visual acuity between two groups of 12 patients each with mean initial refractions of −0.1 D and + 3.3 D [11]. Final refraction ranged from −4.5 to +1.1 D (mean − 2.0, standard deviation 1.7) in the near-emmetropia targeted group and −1.8 to +3.5 D (mean + 1.3, standard deviation 1.6) in the plus targeted group.

The counter perspective, held by many surgeons, is to prefer a refractive target other than emmetropia [12]. A number of tables exist to assist the surgeon is selecting targeted hyperopia (see Chap. 13: Primary Intraocular Lens Placement). If the fellow eye is myopic and either already pseudophakic or unlikely to require lens surgery, it may be appropriate to aim for an early refraction within about 3D of that eye and similar or less net refractive error if possible. When surgery is planned for both eyes at the outset, risk of amblyopia from symmetrical bilateral pseudohyperopia is much less than in the unilateral case, and use of glasses at a young age is likely to be less problematic than if only one eye is affected. In these situations, starting more hyperopic in hope of reducing the ultimate degree of myopia is reasonable.

With surgery in infancy, particularly before age 6 months, considerable myopic shift is highly probable, but ability to predict ultimate refraction is also very poor [13]. Infants who qualify for an implant are likely to lose most of their pseudohyperopia within a few months if less than a +6 to +8 is set as the target.

## Case 1

A healthy 12-month-old girl with no significant family ocular history was referred by her pediatrician for “dull reflex right eye”; previous evaluations by the same doctor had shown no abnormality, and the parents had noted no disturbance of vision or eye appearance. Eye examination showed good fixation with each eye, but a left eye (OS) preference. Grating acuity measured with Teller cards was markedly reduced in the right eye (OD). Pupils, alignment, and motility were normal. Retinoscopy reflex OD was poor secondary to a posterior cortical lens opacity; no significant refractive error was noted OS.

Anterior segment findings under general anesthesia 2 weeks later included normal symmetrical corneal diameter (11.0–11.5 mm both eyes) and keratometry (mean 46.0 D both eyes). Intraocular pressure was normal bilaterally. Findings with handheld slit lamp included normal left eye and normal anterior segment in the right except for the lens, which showed dense opacification of the central 2.5 mm of posterior cortex and partial nuclear opacification with diameter 4–5 mm; no retrolental plaque or vessels were present. Fundus appearance was normal and symmetric in both eyes.

Retinoscopy with full cycloplegia was estimated to be -12D OD, plano OS. Axial length measured by A-scan biometry was 22.1 mm OD, 19.2 mm OS. Intraocular lens power calculation for emmetropia OD was 21.0 (SRK-II formula) to 21.5 (SRK-T formula).

Lensectomy was performed in standard fashion, including removal of the central 2.5 mm of posterior capsule, which remained opaque but was otherwise unremarkable after cortical aspiration, and limited anterior vitrectomy. A +21 power one-piece PMMA lens was placed in the capsular bag.

One month after surgery, refraction in the pseudophakic eye was +1.00 + 1.00 x 90. Visual fixation was good, and alignment normal. Teller card grating acuity was improved but remained considerably reduced. Five months after surgery (age 17 months) refraction was unchanged. Single vision glasses were prescribed to correct the full astigmatic error in both eyes and full hyperopic error in the right. Compliance with glasses and patching (up to 6–8 hours/day) was excellent.

At age 3 years, refraction remained the same in both eyes. Visual acuity measured 20/60 OD, 20/25 OS with best distance correction. A 25 prism diopter intermittent exotropia was present, with only small exophoria and fusion for near. At age 5 years, refraction was −1.00 + 1.00 × 90 OD, plano +1.50 × 90 OS; corrected VA 20/30 OD, 20/20 OS; and motility unchanged, with stereo 200 seconds. First bifocal lens was prescribed for the right eye, with +2.50 add.

At age 12 years, both eyes had undergone myopic shifts and corrected to 20/25 OD, 20/20 OS. In 2019, at age 21 years, refraction was −5.00 + 2.00 × 65 OD, −5.50 + 1.50 × 90 OS; VA with glasses was 20/20- OD, 20/20 OS. The lens implant was well positioned, with a small central posterior capsular opening. IOP and fundus appearance were normal and similar in both eyes. Having had no further procedures since her original surgery, the patient was orthophoric for distance and about to enter law school.

**Comment** The above case is from the author's personal experience, chosen due to 20 years of continuous follow-up. Though not necessarily typical, this case provides an example of how targeting near emmetropia can succeed over the long term. When diagnosed with unilateral cataract secondary to congenital central posterior capsule abnormality, this patient already had unilateral axial myopia, attributed to the effect of visual deprivation. Her unaffected eye was plano, notably not hyperopic as expected in this age range. Lensectomy and IOL implantation at age 12 months resulted in low hyperopia for her pseudophakic eye; then refraction did not budge for nearly 4 years. With conscientious refractive correction and patching for amblyopia from infancy, she achieved a remarkably good visual outcome. Theoretically if an early postoperative refraction of +6.00 had been targeted, her refractive journey may have included far more anisometropia, which complicates amblyopia treatment.

## Case 2

A 15-month-old girl was referred for an intermittent exotropia of her right eye. On exam, she was central, steady, unmaintained in the right eye, and central, steady, maintained in the left. She had a constant exotropia of 30 prism diopters at distance and an intermittent deviation of 15 at near. Exam was notable for a patchy posterior cortical opacity obscuring 4 mm of the red reflex OD. Anterior segment exam was otherwise normal in both eyes. It was possible to view the posterior pole in the right eye, which appeared grossly normal but view was poor. Cycloplegic refraction was challenging in the right and +1.50 sphere OS.

Parents had initiated patching for 2 hours/day OS prior to consultation. They were having moderate success but were highly motivated. After extensive conversation, including need for amblyopia treatment and glasses use after surgery, cataract extraction with IOL placement and anterior vitrectomy was planned. Target for the surgical eye was +5.0.

Exam under anesthesia confirmed normal intraocular pressures in both eyes. Portable slit lamp evaluation confirmed the right lens had a 4 mm posterior cortical opacification and a dense posterior plaque measuring 2 mm centrally. Axial length measurements were 19.55 mm OD and 20.12 mm OS. Cataract extraction, implantation of a SA60AT 26.0 diopter lens (Alcon, USA), and pars plana posterior capsulotomy and vitrectomy were performed.

The child did well in the immediate postoperative period. She obtained glasses at postoperative week 3, when refraction was judged to be stable from previous week. Her refraction at that time was +5.00 + 0.75 × 90. She was given glasses with a prescription of +7.00 + 0.75 × 90 OD and plano OS. She was tolerating 4 hours of patching a day.

She did well over the ensuing 6 months, tolerating glasses and patching. Distance exotropia remained constant and eye preference testing improved to intermittent maintain on the right. She received updated glasses 12 months following surgery. At this point, her cycloplegic refraction was +4.50 + 0.75 × 90 OD and + 1.00 OS. Her glasses prescription was +4.50 + 0.75 × 90 OD, plano OS. Bilateral bifocal add of +3.00 was introduced.

Six months later, her visual acuity could be tested using HOTV matching. She was 20/150 OD and 20/25 OS. Parents continued to patch 4 hours a day. Distance exotropia had improved with the glasses change.

At last follow-up at age 4, she was 20/80 best-corrected OD and 20/20 OS with a cycloplegic refraction of +3.25 + 1.25 × 80 OD and + 0.25 + 0.25 × 110 OS. She was wearing glasses full time, with full cycloplegic refraction on the right, plano on the left, and a bifocal add.

**Comment** This case is from the editor's practice, illustrating the clinical course of a patient with intentional hyperopic postoperative refractive error and the necessary resultant spectacle dependency. In this example, the young girl did very well with glasses correction. She was initially prescribed glasses with overcorrection to focus her world at near. As she aged, her glasses were changed to bifocals. Of note, she was given a bifocal add in her phakic eye as well. This encourages the child to engage the near add in both eyes and facilitates the use of the amblyopic eye at near. With time, she has undergone an expected reduction in her hyperopic refractive error. Her visual acuity likely reflects the later presentation with a unilateral cataract, but diligent patching history.

## References

1. Serafino M, Trivedi RH, Levin AV, Wilson ME, Nucci P, Lambert SR, Nischal KK, Plager DA, Bremond-Gignac D, Kekunnaya R, Nishina S, Tehrani NN, Ventura MC. Use of the Delphi process in paediatric cataract management. Br J Ophthalmol. 2016;100(5):611–5.
2. The Infant Aphakia Treatment Study Group. The infant Aphakia treatment study: design and clinical measures at enrollment. Arch Ophthalmol. 2010;128(1):21–7.
3. Brady KM, Atkinson CS, Kilty LA, Hiles DA. Cataract surgery and intraocular lens implantation in children. Am J Ophthalmol. 1995;120:1–9.
4. Hutchinson AK, Drews-Botsch C, Lambert SR. Myopic shift after intraocular lens implantation during childhood. Ophthalmology. 1997;104:1752–7.
5. Dahan E, Drusedau MU. Choice of lens and dioptric power in pediatric pseudophakia. J Cataract Refract Surg. 1997;23(Suppl 1):618–23.
6. McClatchey SK, Parks MM. Myopic shift after cataract removal in childhood. J Pediatr Ophthalmol Strabismus. 1997;34:88–95.
7. Enyedi LB, Peterseim MW, Freedman SF, Buckley EG. Refractive changes after pediatric intraocular lens implantation. Am J Ophthalmol. 1998;126:772–81.
8. Sachdeva V, Katukuri S, Kekunnaya R, Fernandes M, Hasnat Ali MH. Validation of guidelines for under-correction of intraocular lens power in children. Am J Ophthalmol. 2017;174:17–22.
9. Greenwald MJ, Parks MM. Amblyopia. In: Tasman W, Jaeger EA, editors. Duane's clinical ophthalmology. Philadelphia: Lippincott; 1990. (annual revision). Volume 1, section 1 (Parks MM, Mitchell PR, editors. Ocular motility and strabismus), chapter 10, p. 1–22.
10. Basti S, Jensen A, Greenwald MJ. Refractive changes after pediatric intraocular lens implantation. Am J Ophthalmol. 1999;127:394–5.
11. Lambert SR, Archer SM, Wilson ME, Trivedi RH, Del Monte MA, Lynn M. Long-term outcomes of undercorrection versus full correction after unilateral intraocular lens implantation in children. Am J Ophthalmol. 2012;153:602–8.
12. McClatchey SK, Parks MM. Theoretic refractive changes after lens implantation in childhood. Ophthalmology. 1997;104:1744–51.
13. Weakley DR, Lynn MJ, Dubois L, Cotsonis G, Wilson ME, Buckley EG, et al. Myopic shift 5 years after intraocular lens implantation in infant Aphakia treatment study. Ophthalmology. 2017;124:822–7.