Original Article

Refractive surgery to correct visual impairments in 267 children with autism spectrum and related neuro-developmental disorders: improvements in vision and behavior

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ABSTRACT

Background: Children with autism spectrum disorder (ASD) may have impaired vision owing to high refractive errors and aversion to spectacles or contact lenses. Visual blurring is caused by near-sighted myopia, far-sighted hyperopia, or astigmatism in one or both eyes. Refractive surgery can restore sharp vision and eliminate the need for spectacles and contact lenses. Restoration of sharp vision may improve ASD behavior. We aimed to determine the refractive outcomes in this cohort using ophthalmic measures and behavioral and school performance alterations after refractive surgery by employing parent–proxy reports.

Methods: This interventional, retrospective case series included data from 267 children with refractive errors and neurodevelopmental disorders (NDDs) diagnosed as ASD alone or NDD with ASD-like behaviors over a 15-year period. One of three refractive surgery methods was employed, with the choice of method uniquely tailored to the child's eye anatomy. Laser photorefractive keratectomy (PRK) was performed in 131 children, implantation of a phakic intraocular lens (pIOL) in 115 children, and removal of the crystalline lens and implantation of an intraocular lens (refractive lens exchange, RLE) in 21 children. All procedures were performed under brief general anesthesia, with the child returning home on the same day.

Results: The median age at surgery was 10.9 years and the median follow-up period was 3.1 years. Pre-operative refractive errors ranged from a mean (standard deviation) +7.5 (0.09) D to -14.3 (4.8) D. Surgery corrected 87% of the children to normal focal length (± 1 D). Visual acuity improved an average of 0.6 logarithm of the minimum angle of resolution, the equivalent of 6 lines on a standard eye chart. Change in visual acuity was significant (all $P < 0.01$) between baseline and the most recent follow-up examination in each of subgroups. Change in spherical equivalent refractive error at 3, 12, 24, 36, 60, and > 60 months post-operatively were significant (all $P < 0.01$) between baseline and each follow-up visit in each of subgroups. Social interactions and ASD behaviors improved in 72% (192) of the treated children ($P < 0.01$). The incidence of sight-threatening complications was low.

Conclusions: Refractive surgery improves both visual function and behavior in most children with ASD and major myopia, hyperopia, or astigmatism. The PRK, pIOL, and RLE procedures appear to be effective and reasonably safe methods for improving refractive error, visual acuity, and behavior in many ametropic children with ASD and ASD-like NDDs.

KEYWORDS

autism spectrum disorder, child development disorders, neurodevelopmental disorders, refractive surgical procedures, myopia, hyperopia, pediatrics, amblyopia, strabismus, nystagmus, prematurity retinopathy, optic atrophy, dissociated vertical deviation, optic nerve hypoplasia

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INTRODUCTION

Uncorrected refractive errors in young children can cause substantial visual impairment [1, 2]. Spectacles or contact lenses are typically sufficient to correct refractive errors; however, a subset of children with autism spectrum disorder (ASD) and ASD-like neurodevelopmental disorders (NDDs) refuse to wear glasses and are poorly suited for contact lens wear. Their vision may be degraded bilaterally – by isoametropia – to the level of legal blindness [3], or their vision may be degraded in one eye – by anisometropia – causing amblyopia [4]. Uncorrected refractive errors may also promote strabismus [5] and aggravate the visual degradation caused by nystagmus [6]. We have performed refractive surgery in children with ASD and these visual disorders to improve their visual function.

One may reasonably assume that children with uncorrected high myopia or hyperopia who are aversive to spectacles or contact lens wear have decreased quality of life (QoL). Pediatric patients with impaired visual acuity have reported difficulties in activities of daily living, dependency, psychosocial interactions, and school [7-9]. The current study posited that ASD phenotypes are exacerbated by ametropic blurring. The working hypothesis was that refractive surgery would improve both visual behavior and QoL.

In this study, we analyzed a large cohort of children with refractive errors and NDDs diagnosed as ASD alone or ASD-like behavior. We aimed to determine refractive outcomes using ophthalmic measures and behavioral and school performance alterations after refractive surgery by employing parent–proxy reports.

METHODS

In this interventional, retrospective case series, data were collated retrospectively for 267 children, adolescents, and young adults (444 eyes, hereinafter referred to as children) from the pediatric refractive surgery database at St. Louis Children's Hospital, St. Louis, MO, USA, from January 1, 2000, to January 1, 2015. Of the 267 patients in the treated cohort, 256 (96%) were < 18 years of age with diagnosis of ASD or NDD with ASD-like associated behaviors, including Down syndrome, Angelman syndrome, Cornelia de Lange syndrome, fetal alcohol syndrome, Rhett syndrome, or self-injurious behavior. ASD diagnosis was established in most cases using the Social Responsiveness Scale and in a minority using alternative ASD measures [10, 11].

The study protocol was approved by the Washington University St. Louis Institutional Review Board. Written informed consent was obtained from the parent(s) and the child, when possible. The consent document itemized the rationale for the procedure and the potential risks, benefits, alternatives to pediatric refractive surgery, and importance of follow-up ophthalmic examinations. The consent form also explained the need for continuous monitoring and possible need for additional eye surgery. A diagnosis of ASD or an ASD-like disorder was the leading inclusion criterion for this study. Additional indications were spherical equivalent refractive error (SEQRE) > 3 diopters (D), myopia, hyperopia, or astigmatism; noncompliance, aversion to, or chronic difficulties with the wearing of spectacles in children also ill-suited for the use of contact lenses; and good rapport with the child's parent(s). The exclusion criteria were the presence of corneal dystrophy, endothelial dysfunction, corneal scarring, keratitis or systemic inflammatory disease, glaucoma, uveitis, recurrent conjunctivitis, tear film insufficiency, untreated lattice degeneration, or a family history of retinal detachment.

The pre-operative and post-operative examination techniques and refractive surgery methods used have been described in detail in our prior reports [12-17]. Briefly, all children underwent at least two office examinations before surgery, as well as examination under anesthesia (EUA) during the primary procedure. The examinations included age-appropriate testing of uncorrected (UDVA) and corrected (CDVA) distance visual acuity in each eye (ETDRS, HOTV, Allen figure acuity, Cardiff figure acuity, or Teller grating acuity) [18]; pupillary examination for afferent defects, diameter, and dyscoria/corectopia; sensorimotor examination for strabismus, nystagmus, gaze apraxia, binocular fusion, and stereopsis; at least 2 manual and, when feasible, automated cycloplegic refractions; slit-lamp biomicroscopy of the anterior segment for corneal clarity; assessment of tear film, crystalline lens clarity, and absence of inflammation; indirect ophthalmoscopy; and measurement of intraocular pressure with a Tonopen (Minter O&O, Norwell, MA) or iCare (iCare, USA) tonometer. Spatial sweep visually evoked potential measurements of acuity were also obtained in children who did not cooperate during optotype or acuity card testing. Additional measurements obtained under anesthesia, before the surgical procedure, included central corneal thickness ultrasound pachymetry, Righton Retinomax auto-keratometry, digital caliper corneal diameter, portable slit-lamp biomicroscopy with gonioscopy, A-scan ultrasonographic axial length (Echoscan, model U3300, Nidek Inc., Tokyo, Japan or Eye Cubed, Ellex, Adelaide, Australia) anterior chamber depth, lens thickness measurement, repeated indirect ophthalmoscopy using scleral depression, and, when indicated, Retcam II digital imaging of the fundi [12-17].

Children were treated using the least invasive surgical method. The first choice was photorefractive keratectomy (PRK); if PRK was not suitable, phakic intraocular lens (pIOL) implantation was performed; and if PRK and pIOL implantation were not suitable, refractive lensectomy/refractive lens exchange (RLE) was performed. PRK was performed for SEQRE +5 to -5 D, with astigmatism < 3 D, pachymetry exceeding 450 μm, a normal tear film, and absence of blepharitis. pIOL implantation was employed for children whose SEQRE exceeded the PRK range, with anterior chamber depth ≥ 3.2 mm, corneal diameter > 10.8 mm, and normal crystalline lens clarity. RLE was performed in children whose refractive error exceeded the PRK range and who failed to meet the anterior chamber depth, corneal diameter, and crystalline lens clarity criteria for safe pIOL implantation.

An IOLMaster (Carl Zeiss Meditec, Jena, Germany) or AL-Scan Optical Biometer (Nidek Inc., USA) was used to record the corneal curvature radius (mm/D/meridian degrees), axial length (mm), anterior chamber depth (mm), central corneal thickness (μm), white-to-white diameter (mm), and pupil size (mm). Children unable to cooperate in awake testing underwent these measurements during the pre-operative EUA. The power of the pIOL (Artisan-Ophtec or Visian) was calculated using the manufacturer-designated software. For RLE, after removing the crystalline lens, a standard posterior chamber IOL (Alcon SA 60AT or MA 60AC) was implanted into the capsular bag or sulcus to achieve target refraction. PRK, pIOL, and RLE corrections were planned to achieve the target refraction of emmetropia, with some adjustment for patient age and anticipated refractive regression and/or axial length elongation, i.e., 1 D under (hyperopia) or over (myopia) correction. The major outcome measures were the uncorrected visual acuities and the post-operative refractive error. The reported post-operative acuities (fractional visual acuity using Snellen notation) were uncorrected and converted to the logarithm of the minimum angle of resolution (logMAR) notation for the calculation of geometric means [19, 20]. Visual acuity measures include potential improvements during the follow-up interval attributable to increased performance with advancing maturity. However, these measures also incorporate any visual decline that occurs due to refractive regression or other confounding factors. Measurements were obtained at follow-up visits at 3, 12, 24, 36, 60, and > 60 months post-operatively.

The secondary outcome measure was parent, proxy, or caregiver reports of behavioral changes during the entire follow-up period. The parents were asked a series of questions that addressed any changes, for better or worse, in the child's overall visual and behavioral function, in particular (a) detection, recognition, visual awareness, attentiveness, or social interactions, and (b) observations or reports of these behaviors from those outside the child's home, including teachers, therapists, or other caregivers.

Statistical analyses were conducted using IBM SPSS Statistics for Windows, version 29.0 (IBM Corp., Armonk, NY, USA). Outcome measures were collected throughout the follow-up period. The visual acuity outcomes reported are those obtained at the most recent follow-up examination. The collected data were tested for normality of distribution. The means of parametric measures between baseline and each follow-up visit were compared using two-tailed, paired *t*-tests. Categorical variables were compared using the chi-squared goodness-of-fit test. Statistical significance was defined as $P < 0.05$.

RESULTS

For the 267 children, median (range) age at surgery was 10.9 (1.3 – 25.8) years and median (range) follow-up duration was 3.1 (0.04 – 15.1) years. Patient characteristics are listed in Table 1. The percentages of children having ASD alone and NDD subtypes with associated ASD behaviors are shown in Figure 1. The percentages of children affected by ocular comorbidities are shown in Figure 2.

Myopic PRK was performed for 68 (25%) children (116 [26%] eyes), hyperopic PRK on 63 (24%) children (107 [24%] eyes), myopic pIOL implantation on 101 (38%) children (161 [36%] eyes), hyperopic pIOL implantation on 14 (5%) children (26 [6%] eyes), and RLE on 21 (8%) children (34 [8%] eyes). Treatment was bilateral in 68% (181 children) (358 [81%] eyes) for isoametropia and unilateral in 32% (86 children) (86 [19%] eyes) for anisometropia (Table 1).

The mean (standard deviation [SD]) SEQRE in the myopic PRK-treated children (Figure 3A) improved from - 4.4 (2.9) to 0.0 (1.2) D, in the hyperopic PRK group (Figure 3B) from + 4.0 (1.5) to + 0.75 (1.0) D, in the myopic pIOL children (Figure 3C) from - 12.0 (6.1) to 0.0 (1.0) D, in the hyperopic pIOL group from + 7.5 (0.09) to - 1.1 (1.0) D, and in the RLE-treated group (Figure 3D) from - 14.3 (4.8) to - 2.8 (0.7) D. At a median 3-year follow-up, 87% were corrected to within ± 1 D emmetropia, and 95% to within ± 2 D.

For the entire cohort of 267 children (444 eyes; Figure 4A), UDVA improved an average of 0.6 logMAR, from mean (SD) 0.9 (0.6) to 0.3 (0.3) logMAR. For myopic PRK patients (Figure 4B), UDVA improved from 0.92 (0.4) to 0.27 (1.0) logMAR; for hyperopic PRK patients (Figure 4C), from 0.45 (0.33) to 0.21 (0.22) logMAR; for myopic pIOL patients (Figure 4D), from 1.50 (0.41) to 0.45 (0.36) logMAR; for hyperopic pIOL patients (Figure 4E), from 1.1 (0.5) to 0.5 (0.5) logMAR; and for RLE patients (Figure 4F), from 1.48 (0.61) to 0.61 (0.35) logMAR. Changes in both SEQRE and UDVA were significant (all $P < 0.01$) in each of these subgroups.

Parents and caregivers reported improvements in visual and/or social behaviors in 192 (72%) of the treated children ($P < 0.01$). Recorded gains included one or more of the following: visual recognition, eye contact and tracking, motor skills, and school performance. Ten percent (n = 27, 10%) of the total cohort of children with NDDs had a specific ASD diagnosis. Improvements were reported in 19 (70%) of the children with ASD. No instances of decreased QoL or exacerbations of NDD behavior were reported.

Complications encountered during follow-up are displayed in Table 2. Each complication prompted a return to the operating room for a secondary procedure. Among all eyes treated using RLE, 17.6% (6 eyes) required either Nd:YAG laser capsulotomy or vitrector membranectomy for posterior capsule phimosis and/or opacification. Of all eyes implanted with a pIOL, 5 (3%) required re-enclavation to repair traumatic de-enclavation of one haptic. Two eyes (1%) implanted with a pIOL developed a cataract, requiring pIOL explantation and pediatric cataract/IOL surgery an average 4.2 years after pIOL implantation. Two eyes (1%) implanted with a pIOL required a return to the operating room to restore patency to the peripheral iridotomy after an episode of pupillary block ocular hypertension. Two eyes (0.9%) treated using PRK had a persistent epithelial defect in the first 30 days after surgery, requiring lateral tarsorrhaphy (released 60 – 90 days later).

Table 1. Characteristics of 267 children (444 eyes) with ASD or ASD-like neurodevelopmental disorders treated using refractive surgery

Variables	Value
Age at surgery (y), Median (Range)	10.9 (1.3 to 25.8)
Length of follow-up (y), Median (Range)	3.1 (0.04 to 15.1)
Sex (Male / Female), n (%)	161 (60) / 106 (40)
Method of refractive surgery, n (%)	
PRK myopic	68 (25) children (116 [26] eyes)
PRK hyperopic	63 (24) children (107 [24] eyes)
pIOL myopic	101 (38) children (161 [36] eyes)
pIOL hyperopic	14 (5) children (26 [6] eyes)
RLE myopic	21 (8) children (34 [8] eyes)
Laterality surgery, n (%)	
Bilateral: isometropia	181 (68) children (358 [81] eyes)
Unilateral: anisometropia	86 (32)children (86 [19] eyes)

Abbreviations: ASD, autism spectrum disorder; y, years; n, numbers; %, percentage; PRK, photo-refractive keratectomy; pIOL, phakic intra ocular lens; RLE, refractive lens exchange.

Table 2. Complication rate for each method of refractive surgery in 267 children (444 eyes)

Method of refractive surgery	Type of complications	Frequency of complications, n (%)
PRK (n = 223 eyes)	Persistent epithelial defect	2 (0.9)
pIOL (n = 187 eyes)	De-enclavation dislocation	5 (3.0)
	Pupillary block	2 (1.0)
	Cataract	2 (1.0)
RLE (n = 34 eyes)	Capsular phimosis/opacification	6 (17.6)

Abbreviations: n, number of eyes; %, percentage; PRK, photo-refractive keratectomy; pIOL, phakic intra ocular lens; RLE, refractive lens exchange.

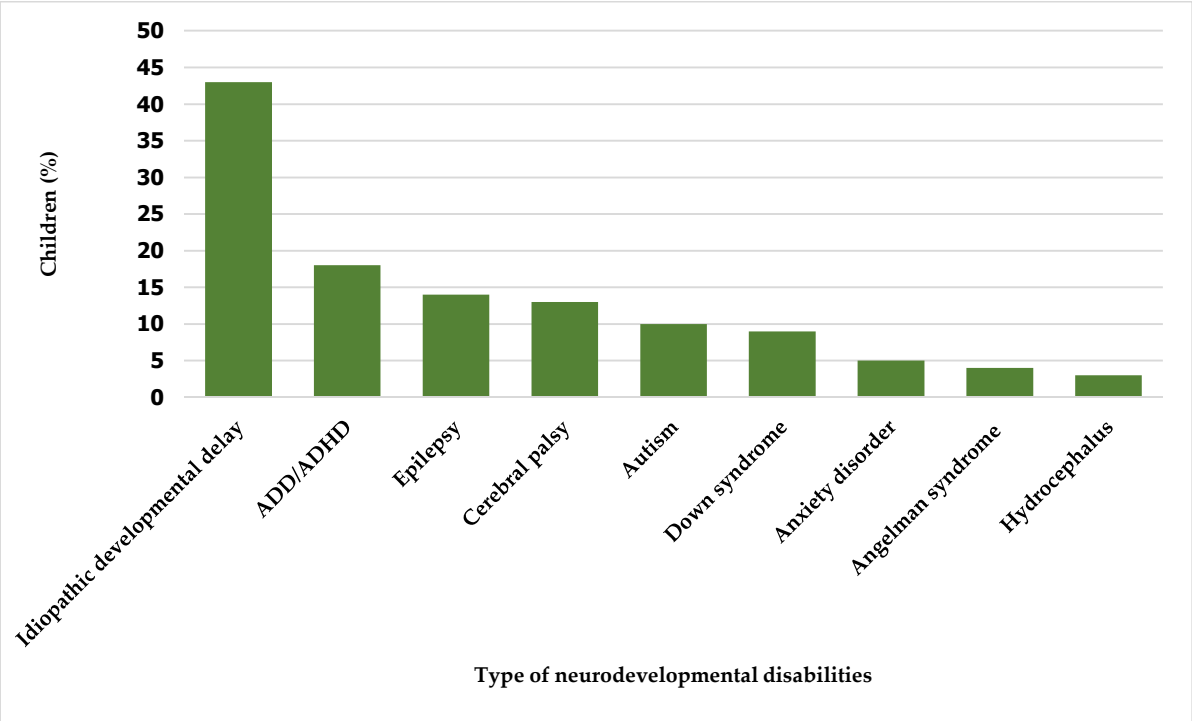

Figure 1. Neurodevelopmental disabilities (NDD) in the 267 children: percentages and subtypes. Idiopathic developmental delay in 43%; attention deficit disorder (ADD) / attention deficit hyperactivity disorder (ADHD) in 18%; epilepsy in 14%, cerebral palsy in 13%; autism in 10%; Down syndrome in 9%; anxiety disorder in 5%; Angelman syndrome in 4%; and hydrocephalus 3%. Children could have more than one subtype of NDD, the sum of the percentage from this variable exceeds 100%.

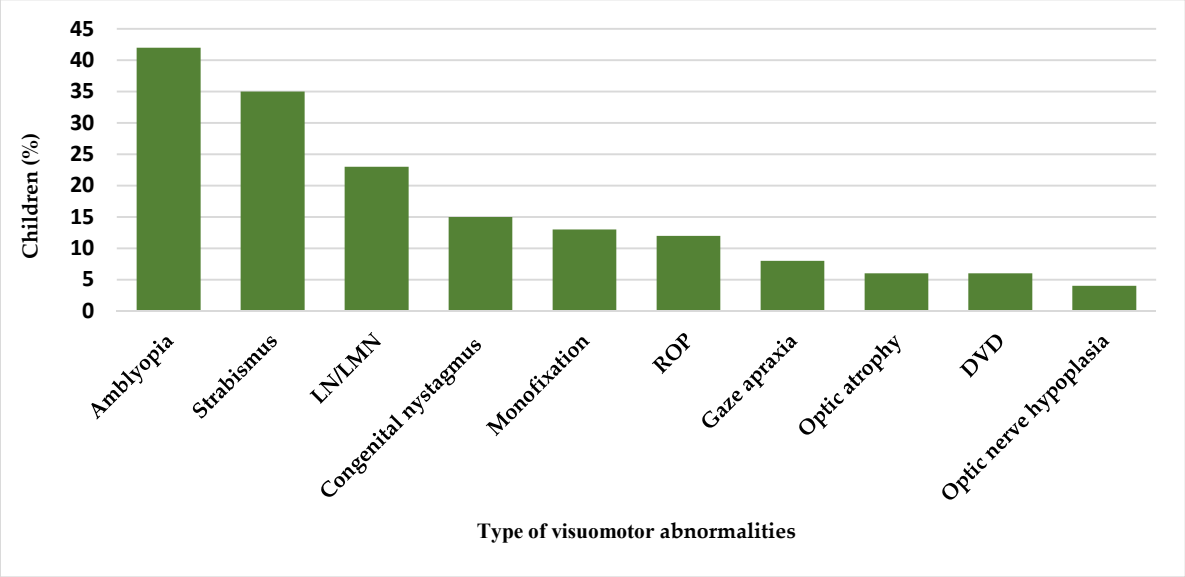

Figure 2. Visuomotor abnormalities in the 267 children: percentages and subtypes. Amblyopia (strabismic and/or anisometropic) in 42%; strabismus in 35%; fusion maldevelopment/latent nystagmus (LN/LMN) in 23%; idiopathic infantile ("congenital") nystagmus in 15%; microtropia/monofixation syndrome in 13%; retinopathy of prematurity (ROP) in 12%; gaze apraxia in 8%; optic atrophy in 6%; dissociated vertical deviation (DVD) in 6%; and optic nerve hypoplasia in 4%. Children could have more than one ocular disorder, the sum of the percentage from this variable exceeds 100%.

DISCUSSION

Our group performed refractive surgeries in children with NDDs for the past 20 years. Most of the treated children had substantially improved visual acuity [12-14]. However, the benefits of refractive surgery are not limited to correction of ametropia. Children with ASD and ASD-like NDD behaviors treated with these procedures may achieve improved visual attention, school performance, and QoL, as observed in the current study.

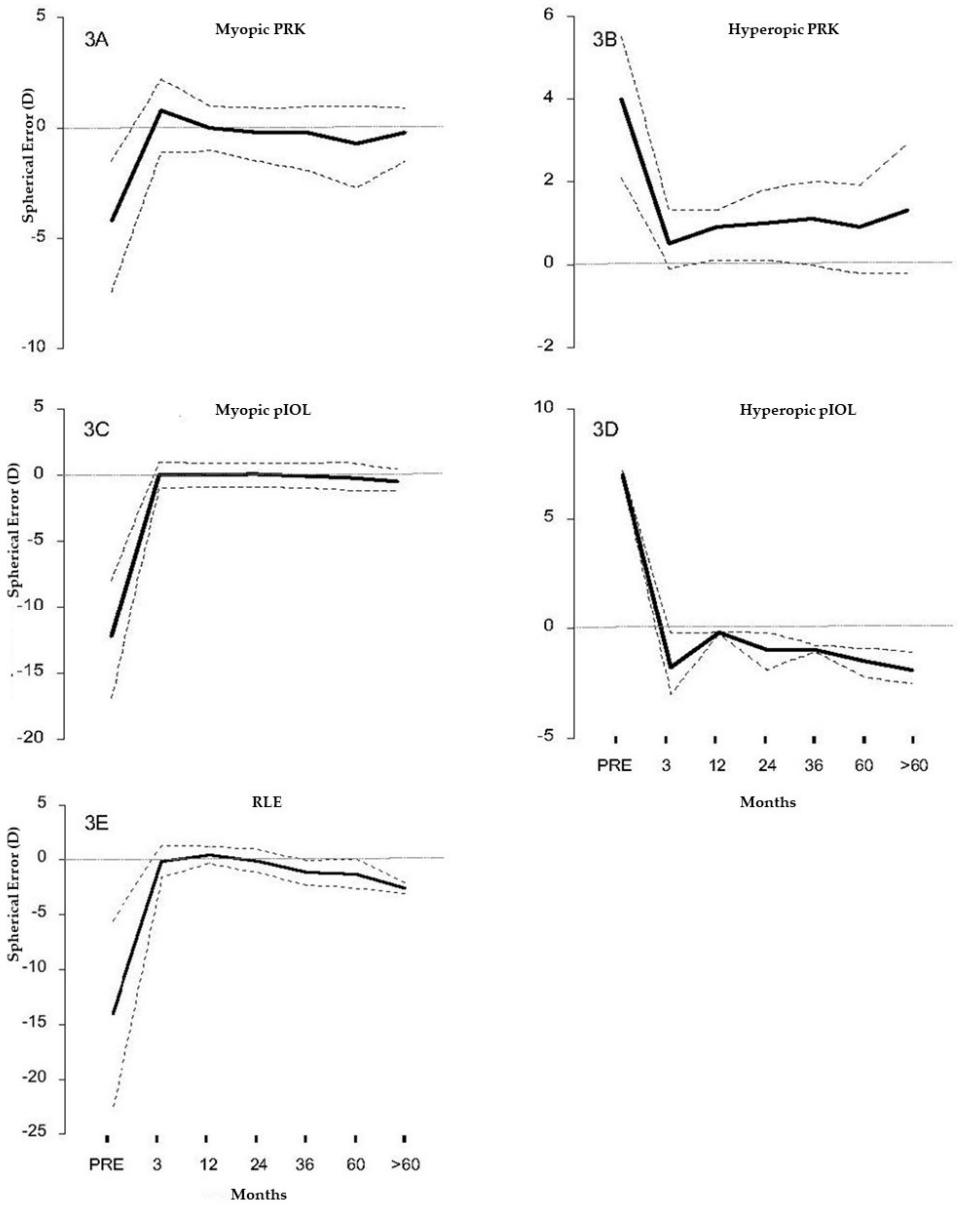

Figure 3. Refractive error before and after surgery in the 267 children. Abbreviations: D, diopters; PRE, pre-operative, PRK, photorefractive keratectomy; pIOL, phakic IOL; RLE, refractive lens exchange. Note: Mean, bold line; dotted lines, standard deviation.

One may reasonably assume that children with uncorrected high myopia or hyperopia who are aversive to spectacles or contact lens wear have a decreased QoL. Pediatric patients with impaired visual acuity have reported difficulties in activities of daily living, dependency, psychosocial interactions, and school [7-9]. Congenitally blind children have an increased likelihood of ASD or autistic-type features [21-24]. Therefore, it is reasonable to posit that the ASD phenotypes are exacerbated by ametropic blurring.

Enhanced QoL is common in adults after refractive surgery [25]. After LASIK [26] and ICL surgery to correct myopia [27], 95% of patients and 88% of adults, respectively, reported improved QoL. In a previous study, our group reported improved QoL after pediatric refractive surgery in a smaller cohort of children with ASD and NDDs. Among children with NDDs who underwent PRK, 15 of 17 (88%) displayed improved visual behaviors [15]. Similar gains were observed in children with NDDs treated with Artisan-Ophtec pIOL surgery [17], Visian pIOL surgery [12], and RLE [16]. In each of these smaller case series [12, 15-17], children were noted by observers other than their parents to have enhanced visual awareness, attentiveness, or social interactions. Lesueur and Arne also reported an improvement in QoL in four children treated with pIOL implantation for anisometropic myopic amblyopia [28]. In the current study, two patients with NDDs and ASD behaviors who had not previously walked started walking after RLE. One patient first walked at the age of 8 years and the other at 22 years. Another patient went from reading braille to reading books and watching movies. Determining which patients may benefit to this dramatic degree would be helpful. Further research is needed to determine how decreased visual acuity contributes to disability in children with ASD and NDDs.

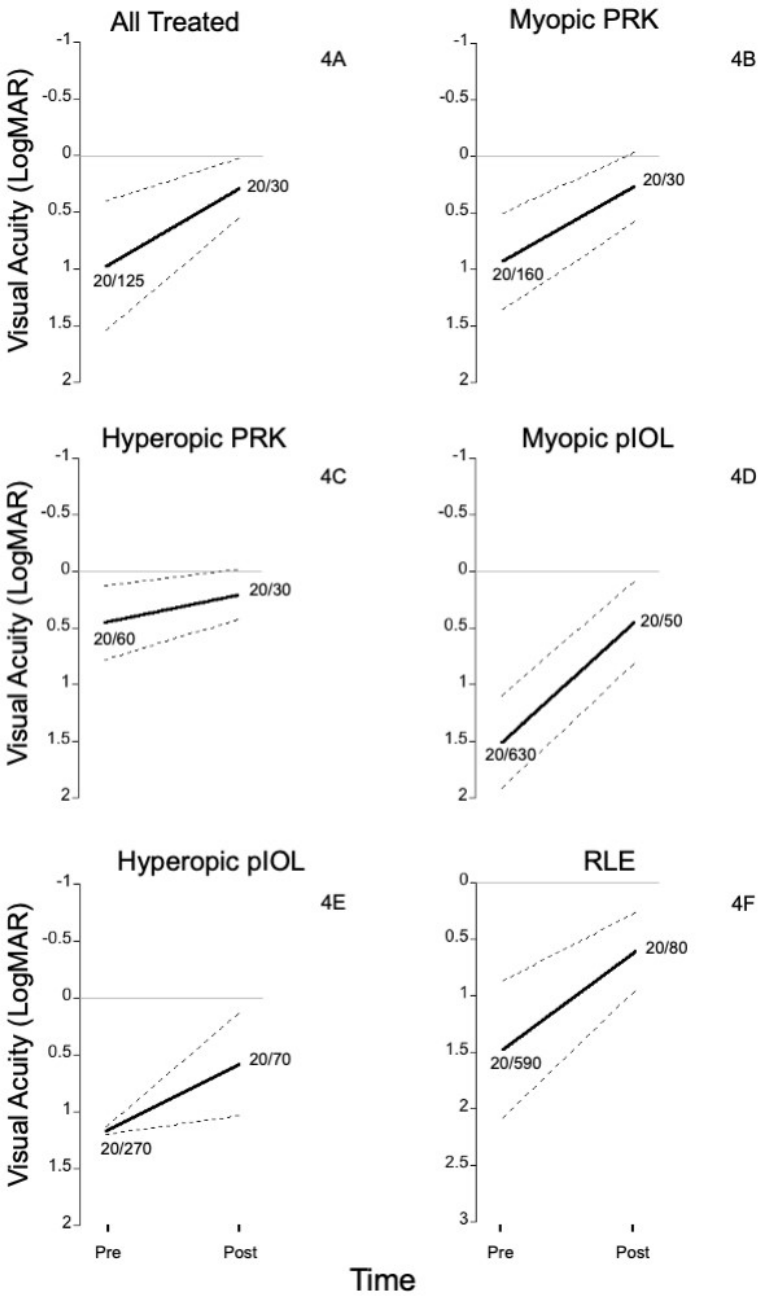

Figure 4. Visual acuity (UDVA) in the 267 children before and after surgery. Abbreviations: UCDVA, uncorrected distance visual acuity; logMAR, the logarithm of the minimum angle of resolution; Pre, pre-operative UCDVA, Post, post-operative UCDVA obtained at the most recent follow-up examination; PRK, photorefractive keratectomy; pIOL, phakic IOL; RLE, refractive lens exchange. Note: Mean, bold line; dotted lines, standard deviation.

Adaptations are required when employing refractive surgery methods to treat any child, particularly one with ASD. Children with ASD may be less cooperative and require more time, energy, and expertise than neurotypical children during peri-operative care [29]. Therefore, it is useful to review adaptations that can optimize the efficacy and safety of PRK, pIOL implantation, and RLE procedures in this population of children.

For PRK, at the conclusion of laser ablation, a plano-bandage contact lens is applied to the operated eye(s), and disposable goggles are fitted. As in adults, the corneal epithelium heals in 3–6 days [13, 30]. Topical drops are instilled from the first post-operative day. Children with ASD tend to better tolerate post-PRK discomfort and photophobia than adults, and they resume normal playing activities sooner. Approximately 10% may require oral narcotic analgesics for the first 48 hours. For post-operative awake examinations in the office, an adequate view of the healing cornea(s) often requires restraint and the use of a portable slit lamp. Despite the best efforts of parents, approximately 20% of children can be expected to dislodge the goggles, rub and poke their eyes, and lose contact lenses. These behaviors are distressing to the child's parents but do not impede – with rare exceptions – timely healing. The lost contact lens is replaced and reinserted in the office by the surgeon's staff. Fewer than 1% of the children we have treated using PRK have had a persistent corneal epithelial defect. To avoid sight-threatening subepithelial scarring, it is advisable to return these patients to the operating room for surgical tarsorrhaphy [31].

For pIOLs, the implant we have preferred for the last seven years is the foldable, sulcus-positioned intraocular collamer lens (Visian ICL; Staar Surgical, Monrovia, CA, USA) [12]. During the 10 years before the introduction of the Visian ICL, we used the PMMA iris-enclaved myopic lens (Verisyse; Ophtec, Boca Raton, FL, USA) [17]. Precise sizing of the ICL requires accurate white-to-white measurements of the corneal diameters [32]. In cooperative children, this can be achieved using a Nidek IOL Biometer or IOL Master. Alternatively, the measurement can be performed using digital calipers during the planning EUA. Proper vaulting of the ICL in the posterior chamber – between the anterior surface of the crystalline lens and posterior surface of the iris – and minimizing the long-term risk for corneal endothelial cell loss requires a corneal diameter ≥ 10.8 mm and an anterior chamber depth ≥ 3.2 mm [33]. The previous version of the ICL required an iridotomy, created during the procedure, to circumvent pupillary block ocular hypertension. The current EVO model of the ICL has an aperture in the optic, allowing aqueous flow and obviating the need for iridotomy and the concerns of pupillary block [33]. In cases of high bilateral ametropia, the eyes are implanted sequentially, with several days to one week elapsing before operation on the second eye. Because children's eyes heal rapidly, a superior 3.0-mm clear corneal incision can be employed, which achieves the therapeutic effect of a relaxing limbal incision [33]. Common with-the-rule, pre-operative astigmatism is reduced by approximately 40%. If pre-operative astigmatism exceeds 2.5 D, a myopic toric ICL is implanted. Absorbable 9-0 polyglactin sutures are used to close the corneal incision to avoid re-anesthetization of the child for suture removal. Leaving the incision unsutured is inadvisable in children. In some children, to prevent eye rubbing, arm restraints should be applied for the first several post-operative days or weeks [33].

RLE is useful for children when myopia exceeds 16 to 24 D (the upper limits for ICL and Ophtec phakic IOL power, respectively), corneal diameter is < 10.8 mm, or anterior chamber depth is < 3.2 mm [16, 34]. Standard pediatric lensectomy, posterior capsulectomy, and pars plana vitrectomy techniques are employed using a high-speed 25-gauge vitrector and separate anterior chamber infusion. If required to achieve emmetropia, a foldable acrylic IOL (Alcon SA60AT or MA60AC) is injected into the capsular bag depending on the axial length and lens power calculations. Primary capsulectomy/anterior vitrectomy is advisable because of the high rate of dense, posterior capsule fibrosis in pediatric eyes when the capsule is preserved [35]. We perform an EUA a few weeks to one month prior to the planned lensectomy. The peripheral retina is examined in detail by depression. Accurate immersion axial length measurements are obtained. If the axial length exceeds approximately 29 mm, barrier diode laser therapy may be used to reduce the risk (estimated at 2%) of future aphakic/pseudophakic retinal detachment [33, 36-38].

This study revealed the feasibility and suitability of refractive surgery to correct visual impairments in children with difficult-to-manage ASD and NDD, with a resultant improvement in UCDVA, SEQRE, and subjective QoL over a long follow-up period. The principal limitations of this study were its retrospective design and the lack of a more rigorous QoL questionnaire to measure behavioral improvements. Parents' verbal reports to the medical team may differ from written analytical reports. We are currently engaged in a prospective study employing ASD-specific QoL parent-proxy questionnaires.

CONCLUSIONS

Refractive errors and visual acuity substantially improved in this cohort of difficult-to-treat children with ASD and NDDs. The PRK, pIOL, and RLE procedures appear to be effective and reasonably safe methods for improving behavior in many ametropic children with ASD and ASD-like NDDs.

ETHICAL DECLARATIONS

Ethical approval: The study protocol was approved by the Washington University St. Louis Institutional Review Board. Written informed consent was obtained from the parent(s) and the child, when possible. The consent document itemized the rationale for the procedure and the potential risks, benefits, alternatives to pediatric refractive surgery, and importance of follow-up ophthalmic examinations. The consent form also explained the need for continuous monitoring and possible need for additional eye surgery.
Conflict of interest: None.

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