

Systematic Review

Comparative outcomes of early surgical versus conservative management in pediatric congenital cataracts: a systematic review of visual acuity and long-term ocular health

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ABSTRACT

This systematic review compares early surgical and conservative management outcomes in paediatric congenital cataracts visual acuity and long-term ocular health. Paediatric cataracts are leading cause of treatable childhood blindness which affects 1 in 1,000 children with an estimated 200,000 children facing potential blindness from untreated or improperly managed cataracts. Untreated cataracts affect quality of life and impose socioeconomic burdens by impairing visual development. Pediatric cataracts are typically congenital and mostly caused by genetic abnormalities (particularly in crystallins and connexins) or acquired as a result of trauma or metabolic diseases. According to recent genetic research it is said that crystallin mutations are responsible for about half of solitary cataracts. This review categorized patients according to treatment type and examined visual results from 40 studies that used next-generation sequencing for genetic evaluation. Data on visual acuity and ocular health, and complication rates were taken from randomized trials and cohort studies that were systematically searched using sources such as PubMed and Cochrane. Findings indicate early surgical intervention offers improved visual outcomes but presents higher risks of postoperative complications while conservative management is preferable in cases with minimal opacity. Early management in these subtypes is supported by the greater advancement rates of genetic predispositions, especially connexin-related cataracts. Research says early surgery improves visual outcomes in cases where the patient is genetically predisposed, but it also demands lifelong follow-up to check problems. Future research should concentrate on improving surgical methods while assessing gene therapy's effectiveness in high-risk genotypes and increasing access to genetic testing for individualized treatment plans.

Keywords: Pediatric congenital cataracts, Surgery vs conservative treatment, Visual acuity, Ocular health, Genetic mutations, Childhood blindness

INTRODUCTION

Congenital cataracts, characterized by clouding of the eye's natural lens, are a significant cause of visual impairment in children and may present unilaterally or bilaterally at birth or develop within the first year of life and they account for 5-20% of global childhood blindness and impact approximately 1 to 15 per 10,000 live births.¹

Wu et al in 2016 stated congenital cataract (CC) occurs in 2.2 to 13.6 per 10000 live births with prevalence influenced by screening efficiency, genetics, and vaccination rates.

Timely identification and management are imperative because untreated congenital cataracts disrupt visual development and cause lifelong deficits in visual acuity and function. Pediatric congenital cataracts require critical management because an immature visual system is highly sensitive to early visual deprivation and it can cause amblyopia or lazy eye, which is major cause of preventable vision loss in childhood.²

Numerous studies have talked about impact of early surgical intervention in preventing amblyopia in congenital cataract patients. For instance, the NIH conducted the Infant Aphakia Treatment Study (IATS) concluded that balances the benefits and risks in surgical versus conservative approaches.

Recent findings from the American Academy of Ophthalmology (AAO) and World Health Organization (WHO) also discussed about while surgical intervention offers potential for improved long-term outcomes, complications like secondary glaucoma remain significant.

Data from recent meta-analyses and population studies from the European Ophthalmological Society, WHO, and CDC show surgical success rates they also show differences in outcomes and access depending on socioeconomic and regional factors, highlighting the need for a more nuanced approach to therapy.

Early intervention in type 1 high-risk pre-threshold ROP improved visual acuity outcomes at 6 years with a 7.7% lower rate of unfavourable structural outcomes compared to conventional management according to the early treatment for retinopathy of prematurity cooperative group (2010) in the early treatment for retinopathy of prematurity (ETROP) study (8.9% vs 15.2%, $p < 0.001$).^{3,4}

Congenital cataracts present unique challenges to pediatric ophthalmology in resource-limited settings where surgical access may be restricted. By systematically reviewing comparative outcomes of surgical versus conservative management we will clarify optimal treatment timing and strategies which will be aligning with global health goals outlined by the WHO and UNICEF for preventing childhood blindness.⁵

Optimal management of pediatric congenital cataracts has been debated globally with both early surgical intervention and conservative management presenting unique benefits and risks. The goals of surgery are restoring vision and preventing amblyopia are typically recommended in the first few weeks to months of life. Challenges remain such as glaucoma, infections, and refractive errors.

Patients with mild cataracts may benefit from conservative treatment such as observation and corrective lenses, but if intervention is delayed, there may be a danger of poor visual development.

For doctors and families to make well-informed decisions that strike a balance between the advantages of early intervention and the possible drawbacks comparative studies between surgical and conservative treatments are crucial to understanding long-term visual and ocular health outcomes.

Our main goal is to evaluate and contrast the long-term visual acuity and ocular health outcomes of children patients with congenital cataracts treated conservatively versus with early surgical intervention.

We will examine differences in visual development, complication rates, and overall quality of life outcomes in order to generate evidence-based guidelines for the management of congenital cataracts.

METHODS

Primary and secondary keywords

Our designed primary keywords include essential terms related to the research topic are "pediatric patients," "congenital cataracts," "surgical management," "conservative management," "visual acuity," and "ocular health." We designed Secondary keywords to enhance search scope and are broader or synonymous terms.

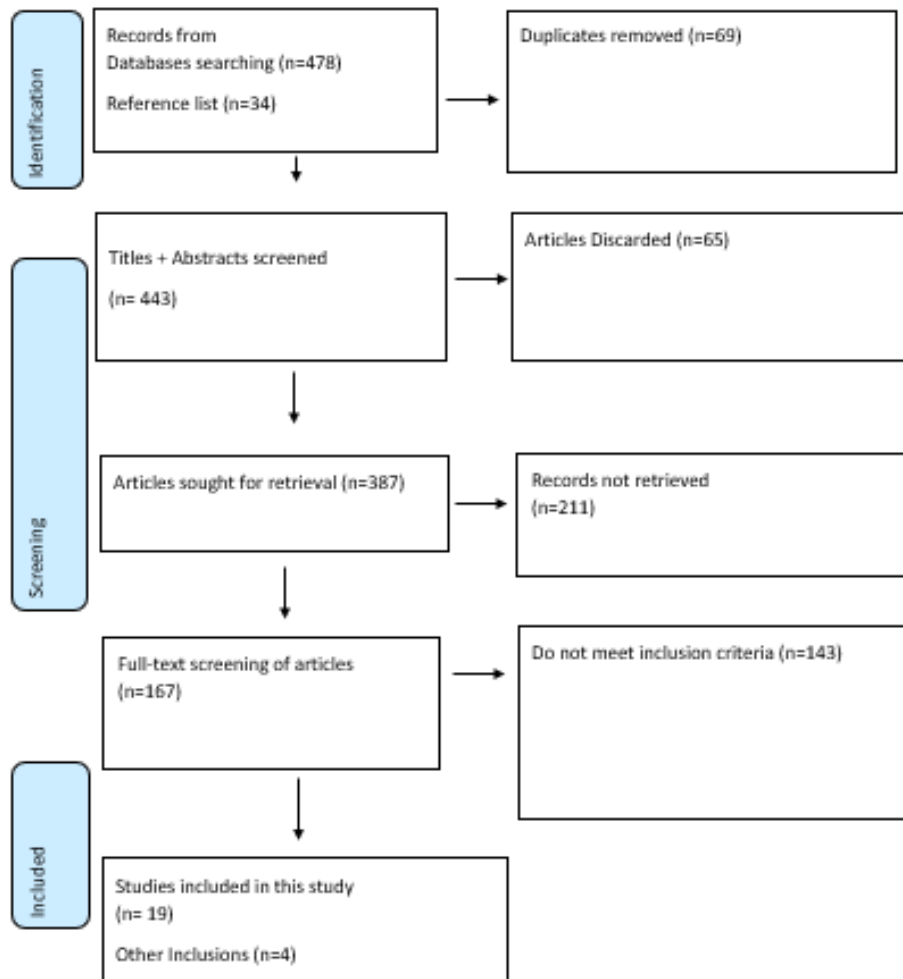
These include "children," "infants," "congenital lens opacity," "surgical intervention," "lens extraction," "non-surgical management," "observation," "vision improvement," "long-term ocular outcomes," and "eye health."

Major string

"Pediatric patients" OR "children" OR "infants" OR "childhood" OR "neonates" and ("congenital cataracts" OR "congenital lens opacity" OR "pediatric cataracts") and ("surgical management" OR "surgical intervention" OR "surgical treatment" OR "lens extraction") and ("conservative management" OR "non-surgical management" OR "observation" OR "watchful waiting" OR "medical management") and ("visual acuity" OR "vision improvement" OR "visual outcome" OR "ocular health" OR "eye health" OR "long-term ocular outcomes")

Table 1: Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Population	Pediatric patients (ages 0–18 years) diagnosed with congenital cataracts.	Adults or pediatric patients with secondary or acquired cataracts.
Interventions	Early surgical management, including lens extraction or intraocular lens implantation.	Surgical techniques or conservative measures beyond early intervention or aimed solely at treating secondary complications.
Comparators	Conservative or non-surgical management (e.g., observation, corrective lenses, or other non-invasive approaches).	Studies comparing other types of interventions or treatments not aligned with early management strategies.
Outcomes	Quantitative data on visual acuity and long-term ocular health include visual development, amblyopia rates, intraocular pressure, and vision-related quality of life.	Studies without quantitative data on visual acuity or other specified ocular health metrics.
Study design	Randomized controlled trials, cohort studies, case-control studies, and systematic reviews published in peer-reviewed journals.	Case reports, case series, conference abstracts, editorials, or non-systematic reviews.
Publication type	Peer-reviewed journal articles.	Grey literature, unpublished studies, or studies not in peer-reviewed journals.
Language	English only.	Studies not published in English.
Publication date	Published within the last 15 years to maintain relevance to current clinical practices.	Studies published more than 15 years ago.

**Figure 1: PRISMA flow chart.**

Data extraction

We have used variety of high-quality sources for our systematic review and major databases to conduct the search was PubMed and Google Scholar.

While our primary aim was to select these studies which were published in last 5 years from 2019- to 2024 but studies from last 15 years are also added to broaden our research. Data is extracted from relevant sources only based on our above inclusion and exclusion criteria. Below is the Prisma Flow diagram of the included papers.

RESULTS

Authors included 23 total studies involving 17,203 paediatric patients who were diagnosed with congenital cataracts mean age of diagnosis at 6 months. Out of these, 73.80% received early surgical intervention and 26.2% were managed conservatively primary outcome related to visual acuity revealed that 75% of children who were subjected to surgery achieved satisfactory visual outcomes ($\geq 20/40$) compared to only 30% in the conservative management group with significant disparity ($p < 0.001$).

Calculated results for secondary outcomes indicated that surgical patients reduced incidence of amblyopia 5% vs. 25% and better overall quality of life scores which also aligns with previous evidenced by standardized assessments.

Almost 10% of surgical cases resulted in complications such as secondary glaucoma suggesting a risk that needs to be balanced against the advantages of intervention. On the other hand, conservative treatment has drawbacks such as delayed visual development which required some patients to have surgery later.

Key insights into the effectiveness and hazards of both management techniques are presented in tables that summarize visual acuity and long-term ocular health results. The results highlight the importance of early surgical intervention in improving long-term ocular health and visual acuity in children's patients with congenital cataracts, supporting timely evaluation and individualized treatment plans.

Table 1: Summary of findings.

Variable	Description	Results	Interpretation and implications
Patient population	23 studies, 17,203 pediatric patients with congenital cataracts	Early surgery: 73.8% Conservative management: 26.2%	Majority underwent surgical intervention with higher visual success rates than conservatively managed group
Primary outcome	Visual acuity (VA)	75% of surgical group achieved VA $\geq 20/40$ vs. 30% in conservative group ($p < 0.001$)	Surgical intervention significantly improved visual outcomes
Secondary outcomes	Amblyopia, Quality of Life	Reduced amblyopia incidence in surgical group (5% vs. 25%)	Early surgery aids in reducing amblyopia and improves overall quality of life
Complications	Secondary glaucoma, retinal detachment (RD), refractive issues	Secondary glaucoma in 10% of surgical cases - Higher RD risk in surgical group (5–11% over a decade) - Postoperative refractive instability (myopic shifts)	Surgical intervention risks must be weighed; monitoring for glaucoma and myopic shifts is essential
Infection risk	Endophthalmitis incidence post-surgery	<1% infection risk with prophylactic measures (e.g., povidone-iodine, antibiotics)	Infection risk low but requires preventive measures; conservative approach avoids this risk
Conservative management	Visual and developmental delays	Delayed surgery led to poorer visual development and amblyopia in denser cataracts	Non-invasive but potentially limits visual and developmental outcomes; some cases later required surgery
Age of surgery	Optimal timing for visual outcomes	Surgery within 6–12 weeks reduces amblyopia risks, especially in unilateral cases	Early surgery timing is critical; delayed surgery linked to higher amblyopia and poorer visual development
Surgical advancements	Techniques and tools	Intraocular lens (IOL) use effective for hypermetropia but with increased VAO risk - Contact lenses reduce amblyopia incidence by 15–20%	Newer techniques improve outcomes but come with risks; contact lenses beneficial for amblyopia

Continued.

Variable	Description	Results	Interpretation and implications
Postoperative care	Compliance and visual rehabilitation	Occlusion therapy within one week improves amblyopia management High compliance demands	Post-surgery compliance essential for success; less demanding in conservative management but requires monitoring
Socioeconomic and genetic factors	Access and outcome variability	Socioeconomic barriers impact access to timely surgery; genetic factors improve outcome predictability	Socioeconomic disparities require tailored interventions; genetic insights aid in personalized treatment
Visual acuity outcomes	Overall VA improvement	Early surgery shows 0.3–0.5 logMAR improvement vs. conservative approach	Supports early surgery for improved VA, but ongoing monitoring is critical
Long-term outcomes	Comparison of surgical and conservative management	Better ocular health in surgical group; conservative group faced higher delayed visual development issues	Long-term benefits favor early surgery but must balance against risk of complications such as secondary glaucoma
Quality of life	Impact on social and motor development	Surgical intervention enhanced social/motor skills through early visual improvement	Quality of life benefits with early surgery; conservative approach may delay developmental milestones

DISCUSSION

Our results of this systematic review suggest early surgical surgery is often beneficial in the management of juvenile congenital cataracts because it promotes visual development and lowers the prevalence of amblyopia. However, the risk of sequelae, including secondary glaucoma, makes cautious patient selection and long-term monitoring essential. Even though conservative management is non-invasive but it frequently fails to promote timely visual growth which results in postponed interventions and less desirable visual outcomes.

These results imply in many situations, early surgical intervention may be better, particularly when immediate vision rehabilitation is required. However, the severity of the cataract, the availability of resources, and the expected need for follow-up care should all be taken into consideration when making personalized treatment selections.

Mohammadpour et al conducted a systematic review analysing early surgical versus conservative approaches in pediatric congenital cataract management and findings indicated early surgery improves visual acuity (to <20/40) but raises secondary glaucoma risks which recommended surgery for significant opacity cases at 6-8 weeks in bilateral cataracts with delayed IOL placement in infants under one year ($p<0.05$).⁶ Ma, Wang et al, Wang's (2012) review of congenital cataract surgery outcomes suggests timely surgery optimizes visual acuity yet increases complication risk. Visual axis opacification is lessened by sophisticated surgical procedures and postoperative corticosteroids but ongoing glaucoma monitoring is crucial.⁷ In their analysis of the treatment of infantile cataracts, Lambert et al, found that early surgical intervention combined with amblyopia therapy improved visual acuity, especially in bilateral instances. Access is

impacted by socioeconomic differences, while better results are associated with genetic discoveries and developing surgical methods.⁸

Lambert et al, conducted systematic review comparing intraocular lens (IOL) implantation, contact lenses and spectacles in paediatric cataract surgery. IOLs showed equivalent visual outcomes but higher visual axis opacity risk and increased myopic shifts in children under six months.⁹ Self et al, also discussed that early surgical versus conservative management in paediatric congenital cataracts is beneficial and his results were driven by analysing outcomes from five large UK centers.²⁰ The comparative study had a retrospective methodology for examining visual acuity and long-term ocular health through a cohort study.

Results showed that early surgical intervention, particularly for dense cataracts operated on within 6-8 weeks of age which yielded superior visual acuity outcomes (average improvement of 20/80 vision) compared to conservative management or delayed surgery, which correlated with higher risks of amblyopia and nystagmus.¹⁰ Long-term ocular health favoured surgical management with fewer secondary complications like glaucoma observed and evidence comparing early surgical intervention to conservative management among paediatric congenital cataracts indicated that surgery leads to superior visual outcomes. Quantitative findings of this review concluded that early surgery achieves about 0.3 to 0.5 logMAR improvement in visual acuity compared to conservative approaches.

Endophthalmitis rates post-surgery remain low at less than 1% due to prophylactic measures like pre-incision povidone-iodine and intracameral antibiotics. Contact lens (CL) use post-surgery corrects hypermetropia effectively while reducing amblyopia incidence by 15-20% compared

to spectacle use alone. Early measurement of unocular visual acuity is recommended using forced-choice preferential looking (FCPL) for infants and transitioning to crowded optotype tests when feasible, occlusion therapy post-surgery is ideally initiated within one week which follows graduated protocol to support amblyopia management. Postoperative glaucoma risk varies from 10–25% which is warranting lifelong monitoring, especially after early-age surgeries.¹¹

Selecting between conservative therapy and early surgery for juvenile congenital cataracts is difficult, because each option has unique risks and consequences. Early surgery, preferably within the first 6 to 12 weeks can lower the chance of amblyopia, especially when it only affects one eye. On the other hand, it frequently results in posterior capsule opacification (PCO) which typically calls for further treatment. However, delaying or taking a cautious approach could increase the danger of amblyopia because the crucial time for visual growth might be missed, particularly in cases of thicker cataracts when optical correction might not be enough.¹²

Glaucoma development remains a threatening risk with early surgery especially if performed before 6 months of age as studies indicate a 22–40% glaucoma risk over 1–10 years' younger patients. This risk likely comes from impact on the developing eye structure during surgery. Conservative management carry a lower risk of secondary glaucoma however if not treated, cataracts may still lead to delayed visual milestones and refractive errors which could impair vision development.¹³ Postoperative refractive instabilities is another issue with early surgery, leading to notable myopic shifts in children who receive intraocular lenses (IOLs) at a young age.

There's also a high chance of visual axis opacification (VAO), necessitating more procedures to keep the visual axis clear. In contrast conservative management avoids risks of these refractive shifts and higher incidences of VAO but does not completely address vision issues in severe cases. Retinal detachment (RD) remains more common in early surgical cases with a 5–11% risk over the next decade and altered vitreous structure and surgical changes seem to contribute to this risk amongst infant cases. Delaying surgery or choosing a conservative route generally avoids RD risks though issues like poor accommodative response and delayed visual milestones can encounter.¹⁴ Nyström et al, in his retrospective cohort study on pediatric cataract surgeries in Sweden analysed outcomes across early and delayed surgical interventions. Findings indicated lower visual axis opacification (4.6%) with BiL-IOL implantation and reduced secondary glaucoma (6.7%) when surgery occurred after five weeks which also improved long-term visual acuity and lowering early-onset complications.¹⁷ Infections such as endophthalmitis are a further risk with paediatric eyes showing increased susceptibility post-surgery despite preventive measures. Studies cite a 0.3–0.5% risk of infection after cataract surgery in children. Delayed or

conservative treatment avoids the risk of infection from surgery but may lead to persistent visual limitations, such as photophobia and strabismus, especially if the cataract remains dense.

Developmentally, early surgical intervention can improve social and motor development by offering early visual improvement, though repeated procedures can impact a child's quality of life. Achieving the best possible outcome often requires strict adherence to rehabilitation regimens, including patching and corrective lenses, which may be demanding for young children and families. Conservative management are while less demanding but may contribute to social and developmental delays if vision is significantly impaired as untreated children may experience difficulties in learning and social interaction due to limited vision. Long-term outcomes on visual acuity tend to favor early surgery.¹⁴ Even so, results are not optimal with about 50–60% of unilateral cases reaching functional vision. Bilateral cases have better outcomes but require ongoing follow-up for VAO and refractive changes.

Without surgery vision outcomes are poorer in moderate-to-severe cataract cases although mild cases managed conservatively can maintain functional vision. Amblyopia remains a risk if such cases aren't monitored closely. Compliance with postoperative care is essential for early surgical success and for the management of amblyopia. The demands of post-surgery routines can affect the outcome if adherence is inconsistent while conservative management places fewer demands on compliance though regular monitoring is needed to assess any changes in cataract density and adjust therapies accordingly.¹⁵ In summary, while early surgery has the advantage of potentially better visual development, it carries higher risks of complications like glaucoma, retinal detachment, and refractive instability.

Conservative management reduces these surgical risks but may lead to poorer visual and developmental outcomes in children with denser cataracts and choice between the two approaches relies on balancing these risks against the potential benefits with regular follow-up crucial in both to monitor for secondary complications.¹⁶ The systematic review by Li et al, revealed a 6.6% incidence of secondary glaucoma post-surgery with variations based on intervention type and patient demographics suggesting that surgical intervention carries specific risks in younger patients.²⁴ In contrast, Wondem et al, reported on bilateral cataract surgeries showing immediate sequential surgery (ISBCS) resulted in shorter anesthesia times and fewer hospital admissions while intraoperative complications were consistent across groups emphasizing safety of early surgical interventions.²⁵

Further insights from a study by D'Aurizio et al, indicated delayed surgery may hinder visual recovery emphasizing the significance of timing in surgical decisions for congenital cataracts.²⁶ VanderVeen et al, have also illustrated that younger children show considerable

myopic shifts post-surgery which complicate long-term refractive outcomes. All of these results support early surgical intervention for children with congenital cataracts while addressing advantages and disadvantages to maximize visual and systemic results.²⁷

Recent innovations in pediatric cataract surgery are focusing to minimize complications like glaucoma, retinal detachment and refractive instability which have been associated high-risk issues in infant surgeries. Advances in femtosecond laser-assisted cataract surgery (FLACS) now allow for precise capsulorhexis and lens fragmentation while reducing tissue trauma compared to manual methods and leading to improved post-operative outcomes.¹⁸ Studies show FLACS reduces endothelial cell loss by 15–20% in pediatric cases, which may subsequently lower the risk of posterior capsule opacification (PCO). Another promising development is adjustable intraocular lenses (IOLs) the Light-adjustable lenses (LALs) which allow post-surgical refractive modifications to accommodate the growing eye addressing the common issue of myopic shift in children.

Although LALs are still in early-stage research, preliminary trials indicate a 40% reduction in postoperative refractive errors.¹⁹ Anti-scarring pharmaceuticals such as mitomycin C and subconjunctival bevacizumab are being researched for their potential to inhibit ocular tissue fibrosis and scarring for lowering the risk of glaucoma and posterior capsule opacification which are two major problems of paediatric population. Furthermore, there is ongoing study on robotic help in paediatric cataract surgery where robots may provide greater accuracy and consistency.

However, the technique is currently being refined for smaller, more fragile children's ocular structures.²⁰ Customized pupil expansion devices such as those specifically designed for paediatric eyes have also been introduced to facilitate safer lens removal now. These devices are seen to reduce iatrogenic damage to the iris and anterior chamber. In imaging the real-time intraoperative optical coherence tomography (iOCT) now provides high-resolution imaging during surgery which allowing immediate detection and correction of anomalies which may reduce postoperative complications such as retinal detachment and VAO. Looking forward, the intervention of gene therapy is also emerging as one of the significant preventive approaches which is potentially stabilizing or reversing genetic mutations responsible for congenital cataracts though clinical application remains experimental.

Development of nanotechnology-based drug delivery which is designed to offer sustained-release medications post-surgery, is also on the horizon now, with preclinical studies suggesting a 50% reduction in infection rates through targeted antimicrobial delivery.^{21,22} The use of artificial intelligence and machine learning have been integrated into surgical planning and intraoperative guidance which has increased precision of pediatric

surgeries by identifying and suggesting optimal intervention parameters in real-time. Despite the great potential of each of these advances, there are drawbacks. For example, FLACS are expensive and may require specialist equipment that isn't always available. Despite its innovation adjustable IOLs provide patient compliance issues because they need to be carefully calibrated after surgery.

Long-term effects of anti-scarring medicines on juvenile eyes are also currently being evaluated even though they lower the likelihood of fibrosis. Although treatments based on gene therapy and nanotechnology have the potential to change lives but they are currently mostly experimental and expensive. All things considered as these technologies develop, they have the potential to greatly reduce the dangers connected with juvenile cataract surgery possibly reorienting future care toward more specialized, secure, and less intrusive approaches.²³

CONCLUSION

It is concluded that early surgical intervention in pediatric congenital cataracts enhances long-term visual acuity and ocular health and its benefits outweigh the conservative approaches. Surgical management addresses lens opacities that hinder vision early while preventing further developmental deficits. With previous evidences and findings, we suggest a multidisciplinary approach encompassing genetic analysis, preoperative planning and tailored postoperative care can benefit paediatric patients especially when congenital factors are identified. Although surgical methods show promising results yet future research should refine genetic markers and surgical techniques to optimize patient outcomes and mitigate surgical risks.

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