Optical Coherence Tomography Findings After Childhood Lensectomy

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Summary

Cataract is now the leading cause of treatable blindness in children in some developing countries,1,2 and one of the three main leading causes worldwide.3 Early lensectomy can rescue visual development, but despite early intervention, visual outcomes are often poor. Children who have undergone cataract surgery before 7 weeks of age often achieve a visual acuity approximately 0.50 logMAR only, and those who had lensectomy before 7 weeks of age, 1.10 logMAR.4 Outcomes are often poor: children who have undergone lensectomy after this age, 1.0 logMAR.5

Several factors contribute to poor visual outcome. Lack of visual stimulation in the first weeks of life may cause an irreparable defect in the development of afferent and efferent pathways, reflected in poor acuity (amblyopia), poor fixation stability, and nystagmus.6,7 Post-lensectomy glaucoma and corneal thickening are additional significant factors.8

In children, removal of the crystalline lens may have a mechanical effect on ciliary muscle and choroidal dynamics and disrupt the feedback loops between retina/fovea, visual cortex, ciliary muscle and choroid required for normal visual development.

Little is known about the development of fovea and posterior choroid after lensectomy for childhood cataract. One study reported normal macular structure, with central optical coherence tomography (OCT)-subfield thickening.9 The aim of this study was to test the hypothesis that lensectomy in children disrupts normal posterior segment development and is associated with an arrest in foveal and subfoveal choroidal development.

METHODS

This cross-sectional study was approved by the National Research Ethics Committee London - Stanmore (16/LO/0327). The study adhered to the tenets of the Declaration of Helsinki.

Participants

We included children aged 4 to 16 years with healthy eyes (visual acuity normal for age, normal IOP) and children who had undergone lensectomy, excluding those with other developmental eye defects, such as persistent fetal vasculature and optic nerve and/or retinal coloboma, and those unable to cooperate with the study procedures. We screened the notes of all children attending our pediatric clinics in advance to identify those who met the inclusion criteria. A research fellow (MCD)
Optical Coherence Tomography After Childhood Lensectomy

approached families, provided age-appropriate written infor-
mation material, and addressed any questions before obtaining
written consent and assent. Between May 16, 2016, and April
27, 2017, we enrolled 45 children with healthy eyes and 40
who had undergone lensectomy.

We recorded the mean thicknesses of the following layers/retinal
segments: retina, inner retinal layers, outer nuclear layer,
macular RNFL, peripapillary RNFL and choroid. We summa-
ized the values for the ETDRS grid inner ring as the mean of
subfields two, three, four, and five, and the outer ring as the
mean of subfields six, seven, eight, and nine. Similarly, we
summarized the superior sectors of the peripapillary grid as
the mean of subfields one and six, and the inferior sectors as
the mean of subfields three and four.

Additional Measurements of the Foveal Region and
Qualitative Parameters

MCD measured the foveal pit depth by calculating the
difference between the retinal layer thickness at the foveal
center and the mean retinal thickness of the adjoining
subfields. Using the caliper tool in Heidelberg Eye Explorer,
we measured the distance from the center of the foveal pit to
the inner border of the ellipsoid zone (EZ) as well as the
distance from the outer border of the ellipsoid zone to Bruch’s
membrane (both measured in triplicate). Furthermore, we
quantitatively and qualitatively described the foveal region
using the following parameters: persistence of inner retinal
layers at the foveal center, number of retinal layers at/below
the foveal pit, presence of cystoid macular edema (within the
foveal region and/or beyond).

Statistics

MCD entered data onto a spreadsheet in Excel (Microsoft,
Redmond, WA, USA) and calculated the means of the triplicate
measurements. Using SPSS24 (IBM, Armonk, NY, USA) we
inspected the data distribution using QQ plots. Where data
were normally distributed, we calculated cohort means and
SDs; where data were not normally distributed, we calculated
medians and interquartile range (IQR). We used the two-tailed
independent samples t-test to compare means of measure-
ments in healthy versus post-lensectomy eyes, and the two-
tailed paired samples t-test for interocular, intra-individual
analysis; statistical significance was set at the 5% level.
Similarly, we used the Mann-Whitney U test to test differences
between medians of nonparametric data. Presented here is the
analysis of data from the right eye of healthy volunteers and
bilateral lensectomy cases, and the operated eye of unilateral
cases. Analysis of left eyes/unilateral cases is available as online
supplement (Supplementary Tables S1-S3).

RESULTS

We enrolled 45 children with healthy eyes and 38 post-
lensectomy (Supplementary Fig. S2). Table 1 summarizes
demographic and clinical characteristics. There was no
statistically significant difference between groups with regard
to age (P = 0.9) and spherical equivalent in the study eye (P =
0.35). BCVA was significantly lower in eyes that had undergone
lensectomy than in unoperated eyes. Post-lensectomy gluco-
ma affected 24 (42%) of 57 operated eyes (Table 1); of these, 14
had undergone glaucoma surgery.

Foveal Pit Depth and Subfoveal CT

Foveal pit depth and subfoveal CT are significantly reduced in
eyes that have undergone lensectomy (Table 2). Figure 1 shows
two typical cases of interocular differences in foveal appear-
ance after unilateral lensectomy.

There is a significant association of foveal pit depth with age
at lensectomy (Spearman’s rho correlation coefficient SRCC
0.448, P = 0.028), but not with BCVA or spherical equivalent
(SE) (P = 0.108 and P = 0.955, respectively). There was no

significant association of subfoveal CT with any of these parameters.

**Macular CT**

Following lensectomy, CT is reduced in most subfields, including the summary fields of inner and outer ring and the mean of all subfields (Table 3).

**Other Foveal Parameters**

Mean distance from the center of the foveal pit to the inner border of the EZ and mean distance from the outer border of the EZ to Bruch’s membrane are not different in eyes that have undergone lensectomy from those in unoperated eyes (Table 2). In two eyes, we observed a persistence of inner retinal layers at the foveal center. The foveal inner retinal layer thickness is higher in eyes that have undergone lensectomy (Table 4). Cystoid macular edema (within the foveal region and/or beyond) was seen in one eye only.

**Other Retinal Parameters**

Including only eyes without a diagnosis of glaucoma, there was no statistically significant difference in peripapillary RNFL thickness between post-lensectomy eyes and eyes of healthy volunteers. Mean inner ring and all subfield macular RNFL was reduced in eyes post-lensectomy in the analysis of right eye of bilateral and all unilateral cases, but not in the analysis of left eye of bilateral and all unilateral cases (Table 4; Supplementary Table S3a–d).

There was no difference in central retinal and photoreceptor layer thickness between healthy and post-lensectomy eyes (Table 4 and Supplementary Table S3a–d), with the exception of the foveal zone. There was no correlation between outer retinal layer thickness or central macular thickness and BCVA ($P = 0.086$ and $0.461$, respectively).

**Interocular Differences**

Children who have undergone unilateral lensectomy have reduced foveal pit depth in the operated eye only; in bilateral cases and healthy volunteers, there is no significant interocular difference in foveal parameters (Table 5).

Results were similar for left eyes of healthy volunteers and bilateral lensectomy cases plus the operated eye of unilateral cases and are available as supplementary material.

**Discussion**

The principal finding of this study is that childhood lensectomy is associated with reduced foveal pit depth and subfoveal CT. Associated defects are a generalized reduction in macular CT and peripapillary RNFL thickness.

This study has some limitations, inherent to a cross-sectional observational study design. We attempted to minimize selection bias by consecutively approaching all families with eligible children; bias from self-selection appears small, as the demographic characteristics of our study population reflect our general patient population. Missing data occurred when children were tired of participating in multiple imaging assessments, or families felt they did not have sufficient time to complete assessments. Foveal imaging was sometimes limited by fixation instability. The high prevalence of glaucoma in the post-lensectomy eyes ($45\%$) may have affected RNFL thickness measurements, but we did not detect a statistically significant difference between eyes with and without glaucoma. We omitted measurements of the axial length (AL) to
FIGURE 1. Posterior segment OCT of two typical cases of unilateral lensectomy. Left: unoperated eye. Right: operated eye. Note the reduction in foveal depth following lensectomy.

TABLE 2. Foveal Pit Depth and Subfoveal CT Are Significantly Reduced in the Right Eye of Children Who Have Undergone Lensectomy

| OCT Parameter                          | Healthy Eyes | Eyes After Lensectomy | Sig. (2-tailed) | 95% Confidence Interval of the Difference |
|----------------------------------------|--------------|------------------------|-----------------|------------------------------------------|
|                                        | n | Mean | SD | n | Mean | SD |              |                          |                          |
| Foveal pit depth, μm                   | 44 | 72.6 | 14.3 | 27 | 58.9 | 24.4 | <0.01 | -22.8 | -4.5 |
| Subfoveal CT, μm                       | 42 | 353.7 | 88.4 | 26 | 287.9 | 95.0 | 0.01 | -111.1 | -20.5 |
| Mean distance fovea to EZ              | 44 | 140.8 | 15.4 | 26 | 152.0 | 31.9 | 0.05 | -0.2 | 22.4 |
| Mean distance EZ to Bruch’s membrane   | 44 | 69.6 | 8.8 | 25 | 66.8 | 9.8 | 0.22 | -7.4 | 1.7 |

Values in bold indicate *P* < 0.05. sig., significance.

TABLE 3. Following Lensectomy, CT Is Reduced in Most Subfields, Indicating a Lack of Physiological Thickness Increase During Childhood Years

| CT                                      | Healthy Eyes | Eyes After Lensectomy | Sig. (2-tailed) | 95% Confidence Interval of the Difference |
|-----------------------------------------|--------------|------------------------|-----------------|------------------------------------------|
|                                        | n | Mean | SD | n | Mean | SD |              |                          |                          |
| 2 - inner ring, superior                | 43 | 357.7 | 85.0 | 26 | 258.7 | 94.2 | 0.00 | -122.2 | -35.6 |
| 3 - inner ring, temporal                | 43 | 320.8 | 88.0 | 26 | 280.9 | 93.3 | 0.08 | -84.6 | 4.7 |
| 4 - inner ring, inferior                | 43 | 363.6 | 86.6 | 26 | 296.0 | 94.9 | 0.00 | -112.1 | -23.0 |
| 5 - inner ring, nasal                   | 43 | 355.6 | 80.7 | 26 | 280.6 | 94.4 | 0.00 | -115.6 | -30.3 |
| 6 - outer ring, superior                | 43 | 314.8 | 75.3 | 26 | 219.3 | 90.7 | 0.00 | -135.9 | -55.2 |
| 7 - outer ring, temporal                | 43 | 254.0 | 85.4 | 26 | 250.4 | 90.9 | 0.87 | -47.0 | 39.8 |
| 8 - outer ring, inferior                | 43 | 347.9 | 75.9 | 26 | 285.3 | 91.5 | 0.00 | -103.4 | -22.0 |
| 9 - outer ring, nasal                   | 43 | 335.2 | 71.3 | 26 | 258.3 | 84.6 | 0.00 | -114.9 | -38.9 |
| Mean inner ring                         | 43 | 343.9 | 81.7 | 26 | 279.1 | 90.5 | 0.00 | -107.0 | -22.6 |
| Mean outer ring                         | 43 | 313.0 | 71.6 | 26 | 253.3 | 80.1 | 0.00 | -96.8 | -22.5 |
| Mean all 9 subfields                    | 43 | 331.4 | 77.2 | 26 | 268.6 | 85.5 | 0.00 | -102.7 | -23.0 |

Values in bold indicate *P* < 0.05. sig., significance.
### Table 4. Excluding Eyes With Glaucoma From the Analysis, Peripapillary RNFL Thickness (Top), Central Retinal and Photoreceptor Layer Thickness (Bottom) Are Not Affected by Lensectomy

|                        | Healthy Eyes | Eyes After Lensectomy | 95% Confidence Interval of the Difference | Eyes After Lensectomy Without Glaucoma | 95% Confidence Interval of the Difference |
|------------------------|--------------|-----------------------|------------------------------------------|---------------------------------------|------------------------------------------|
|                        | n Mean SD    | n Mean SD             | Sig. (2-tailed)                          | n Mean SD                             | Sig. (2-tailed)                          |
| RNFL thickness         |              |                       |                                          |                                       |                                          |
| Macular RNFL           |              |                       |                                          |                                       |                                          |
| Mean inner ring        | 44 34.9 4.9 27 24.2 5.1 | 0.00 1.1 4.4 23 24.1 5.4 | 0.02 2.9 0.3                        |                                       |                                          |
| Mean outer ring        | 44 21.4 1.8 27 39.6 9.9 | 0.01 1.1 8.1 23 39.2 10.6 | 0.05 5.8 0.0                        |                                       |                                          |
| Mean all 9 subfields   | 44 26.4 2.7 27 29.7 6.8 | 0.01 1.1 5.6 23 29.6 7.1 | 0.03 3.8 0.2                        |                                       |                                          |
| Peripapillary RNFL     |              |                       |                                          |                                       |                                          |
| Mean superior RNFL     | 43 125.5 16.4 26 113.2 23.5 | 0.01 21.9 2.7 20 115.4 24.2 | 0.18 3.3 17.3                        |                                       |                                          |
| Mean inferior RNFL     | 43 128.3 17.3 25 112.3 18.6 | 0.00 25.0 7.1 19 115.1 12.2 | 0.18 3.1 15.7                        |                                       |                                          |
| Retinal thickness      |              |                       |                                          |                                       |                                          |
| Central retinal thickness |          |                       |                                          |                                       |                                          |
| Mean inner ring        | 44 339.6 13.0 27 336.5 23.2 | 0.48 11.6 5.5 23 331.2 34.3 | 0.44 5.1 11.4                        |                                       |                                          |
| Mean outer ring        | 44 299.2 15.9 27 292.3 24.0 | 0.15 16.3 2.6 23 290.2 26.7 | 0.22 3.5 14.9                        |                                       |                                          |
| Mean all 9 subfields   | 44 313.6 13.3 27 310.6 21.2 | 0.47 11.1 5.2 23 306.9 27.9 | 0.44 4.8 10.7                        |                                       |                                          |
| Inner retinal layers   |              |                       |                                          |                                       |                                          |
| Foveal                 | 44 177.2 16.7 27 192.5 23.2 | 0.00 5.8 24.7 23 189.5 27.8 | 0.03 19.6 0.8                        |                                       |                                          |
| Mean inner ring        | 44 258.2 11.9 27 257.4 20.6 | 0.83 8.5 6.9 23 252.9 31.0 | 0.76 6.1 8.3                        |                                       |                                          |
| Mean outer ring        | 44 220.4 14.9 27 215.3 21.4 | 0.25 13.7 3.6 23 215.7 24.2 | 0.35 4.4 12.2                        |                                       |                                          |
| Mean all 9 subfields   | 44 232.4 12.1 27 231.6 18.7 | 0.84 8.0 6.6 23 228.7 25.1 | 0.79 5.8 7.7                        |                                       |                                          |
| Outer nuclear layer    |              |                       |                                          |                                       |                                          |
| Mean inner ring        | 43 68.9 7.8 27 68.8 11.6 | 0.97 4.7 4.5 23 66.6 13.3 | 0.71 3.8 5.6                        |                                       |                                          |
| Mean outer ring        | 43 59.7 6.7 27 56.4 8.9 | 0.09 7.0 0.5 23 55.0 9.1 | 0.05 0.1 7.5                        |                                       |                                          |
| Mean all 9 subfields   | 43 66.8 7.0 27 65.3 10.1 | 0.47 5.6 2.6 23 63.4 11.6 | 0.38 2.3 5.9                        |                                       |                                          |

sig., significance.

|                        |               |                       |                                          |                                       |                                          |
|                        |               |                       |                                          |                                       |                                          |
| Table 5. Following Unilateral Lensectomy, Foveal Pit Depth Is Reduced in the Operated Eye Only; in Bilateral Cases and Healthy Volunteers, There Is No Significant Difference in Foveal Parameters

|                        | Operated Eye | Nonoperated Eye | Paired Differences | 95% Confidence Interval of the Difference | Sig. (2-tailed) |
|------------------------|--------------|-----------------|--------------------|------------------------------------------|-----------------|
|                        | n Mean SD    | n Mean SD       | Mean Diff.         | Lower Upper                              | Sig. (2-tailed) |
| Unilateral lensectomy  |              |                 |                    |                                          |                 |
| Foveal pit depth, μm   | 15 58.6 27.8 | 20 77.3 16.0     | 18.1               | −19.9 25.0 0.01                          | 4.2             |
| Subfoveal CT, μm        | 16 278.9 115.5 | 19 324.8 68.8 | −37.2              | −96.4 22.0 0.20                          | 22.0            |
| Mean distance fovea to EZ, μm | 13 154.9 32.6 | 20 136.5 14.5 | 19.2               | −0.6 27.8 0.03                           | 36.0            |
| Mean distance EZ to Bruch’s membrane, μm | 13 64.9 6.9 | 20 67.4 4.8 | −3.0               | −6.3 5.5 0.07                           | 0.3             |

|                        | Right Eye | Left Eye | Paired Differences | 95% Confidence Interval of the Difference | Sig. (2-tailed) |
|------------------------|-----------|---------|--------------------|------------------------------------------|-----------------|
|                        | n Mean SD | n Mean SD | Mean Diff.         | Lower Upper                              | Sig. (2-tailed) |
| Healthy volunteers     |           |         |                    |                                          |                 |
| Foveal pit depth, μm   | 44 72.6 14.3 | 44 73.1 13.9 | −0.5               | 4.4 0.9 0.47                            |                 |
| Subfoveal CT, μm        | 42 355.7 88.4 | 43 356.4 76.9 | 19.3               | 45.1 5.7 0.01                           | 55.0            |
| Mean distance fovea to EZ, μm | 44 140.8 15.4 | 44 137.7 16.0 | 3.2                | 12.3 0.10                              |                 |
| Mean distance EZ to Bruch’s membrane, μm | 44 69.6 8.8 | 44 69.7 6.1 | −0.1               | 8.2 0.25                               |                 |

|                        |          |               |                    |                                          |                 |
| Bilateral lensectomy   |           |               |                    |                                          |                 |
| Foveal pit depth, μm   | 13 56.4 22.4 | 12 53.8 20.5 | 3.9                | 10.8 −3.3 0.25                          | 0.25            |
| Subfoveal CT, μm        | 11 290.1 67.2 | 11 286.3 79.1 | −11.5              | 44.5 −43.3 0.44                         | 20.4            |
| Mean distance fovea to EZ, μm | 13 149.1 32.2 | 12 153.2 30.3 | −3.8               | 8.0 −9.2 0.15                           | 1.6             |
| Mean distance EZ to Bruch’s membrane, μm | 12 68.8 12.2 | 12 69.5 5.1 | 0.9                | 9.9 5.7 0.77                           |                 |

Values in bold indicate \( P < 0.05 \), sig., significance.
reduce the burden of research to children, as this would have required an additional test. Some authors suggest formulas including AL to correct RNFL thickness measurements for optical magnification arising from refractive errors, but these formulas are not universally accepted and may not take into account all refractive components of the eye. Coexisting wider developmental eye defects could have affected foveal development, but to our knowledge this series did not include children with microphthalmia or persistent fetal vasculature. Last, association is not causation, and although our findings may reflect structural changes induced by biomechanical changes in the ciliary muscle-choroid-retina complex, a longitudinal study would be required to confirm causality. Future work should also include dynamic choroidal imaging with and without accommodative effort, to directly visualize choroidal accommodation. It is possible that the foveal underdevelopment we observe correlates with the presence of cataract rather than lensectomy. Prenatal foveal development is thought to be promoted principally by orthogonal forces exerted onto the foveal avascular zone by IOP, and to a lesser degree by tangential retinal stretch during ocular growth. It is possible that the same developmental defect that caused childhood cataract also caused foveal underdevelopment. Our group of children with unilateral lensectomy included only two children with unoperated cataract in the fellow eye. In both cases, subfoveal CT was reduced in the operated eye, compared with the unoperated eye, and foveal pit depth was reduced on the operated side in one case. Both children had good visual acuity in the unoperated eye, and poor acuity in the operated eye (0.7 and 0.94 logMAR), indicating that the lens opacity in the unoperated eye was not visually significant. It is not possible to explore the possibility of patterning defects causing cataract and foveal underdevelopment based on this very low number of cases.

An alternative possibility is that in eyes that have undergone removal of the crystalline lens in early childhood, the fovea and subfoveal choroid remain in an immature state. During physiological postnatal development, the fovea undergoes remodeling, changing shape from a narrow and deep pit toward a wider and more shallow depression. During this phase, tangential retinal stretch during ocular growth is considered to be the leading force driving foveal development. How lensectomy might affect this postnatal development is speculative, but we propose the following mechanism, in which visual experience, accommodation, and choroid play a central role (Fig. 2).

Three cues trigger accommodation to maintain the image on the fovea in sharp focus: blur, change-in-size ("proximity"), and binocular disparity. In the first 14 weeks of life, change-in-size is the leading stimulus to induce accommodation. During this early phase, blur cues may be less available, due to retinal, cortical, and optical immaturity; disparity detection is immature, as stereopsis only emerges at the age of 12 to 16 weeks. Between 12 and 28 weeks of age, blur, change-in-size, and disparity all induce accommodation, and by the age of 5 to 9 years, stimulus responsiveness is similar to that observed in adults, with disparity now mature and inducing the greatest changes in accommodative state.

This visual experience guides postnatal development of the eye, which includes axial elongation and emmetropization (reviewed in Refs. 18–20). The choroid plays a central part in this process: modulation of CT adjusts the retinal plane to the focal plane of the eye ("choroidal accommodation"), and release of growth factors by the choroid regulates extracellular matrix remodeling in the sclera, inducing scleral growth. In addition, the subfoveal choroid itself undergoes maturation changes, increasing in thickness over the first years of life, then thinning during adulthood. After childhood lensectomy, axial elongation is highly variable; implantation of a primary IOL implant may facilitate a more physiological development than...
aphakia. However, variability in postoperative development complicates the calculation of IOL power, and eyes are often intentionally left hypermetropic, anticipating axial elongation in the first years of life; residual hypermetropia is corrected with contact lenses or glasses (reviewed in Ref. 24). Foveal maturation is also guided by visual experience, but proceeds at a slower pace. Although eye growth (axial elongation) is greatest in the first 24 months of life, rapid changes in optics and focusing ability, retinal and choroidal accommodation, and ganglion cell layer development continue throughout childhood. Disruption of developmental processes can affect foveal development and subfoveal CT.

Genetic conditions such as albinism and aniridia can arrest foveal pit formation during fetal development and maturation after birth. Sporadic developmental defects such as fovea plana similarly affect foveal pit morphology, often without impact on visual acuity. Premature birth has also been associated with reduced foveal depth and increased inner and outer retinal layer thickness persisting into childhood, as well as an increase in the distance from fovea to EZ, with normal height from EZ to Bruch’s membrane at the foveal center. Our observations on foveal development after childhood lensectomy are similar to these reports, with reduced foveal pit depth, reduced subfoveal CT, increased fovea-EZ distance (although not statistically significant) and normal EZ-Bruch’s membrane height. The lack of correlation between foveal parameters and BCVA in our study may be due to the presence of amblyopia and, to a lesser degree, variability in cooperation during acuity testing. In albinism, a similar lack of correlation between foveal pit depth and BCVA has been reported. In our study population, we did not observe a correlation between outer retinal layer thickness or central macular thickness and BCVA, as previously reported in normal visual development. Without direct visualization of the photoreceptors it is also difficult to know how many cells are present, but there is also a large range of foveal shapes with normal acuity.

Ultimately, foveal development is a carefully choreographed series of events leading to the development of a pit, increased cone density, and high-resolution visual acuity. It could be argued that the foveal changes we observe may have been caused by postoperative CME. In infants who have undergone lensectomy and anterior vitrectomy, the reported incidence of CME varies widely, from 0 to 37%. We observed CME in only one eye, but a longitudinal study including the early postoperative period would be required to explore the potential impact of CME on foveal development.

Despite the hypermetropic mean SE of post-lensectomy eyes in our study, our OCT findings are markedly different from previous reports of increased subfoveal CT in eyes with hypermetropic/short AL and in hypermetropic anisometropic amblyopia, where the greater hypermetropic eye displays a greater subfoveal CT compared to the fellow eye.

Contrary to our finding of reduced macular and peripapillary RNFL thickness, several studies have reported that these do not differ significantly between amblyopic and fellow or healthy control eyes. In our study, RNFL thickness was reduced, even in eyes without coexisting glaucoma. Last, visual experience guides the maintenance and connections of cortical neurons. Cellular architecture of the visual cortex and neural sensitivity reach relative maturity early (reviewed in Ref. 31). Disruption of visual experience leads to cortical remodeling, such as in amblyopia. Preference for the unoperated eye is common in unilateral cataract management, and unsuccessful amblyopia treatment often results in profound reduction in vision despite technically successful surgery.

Lensectomy disrupts both the biomechanical accommodative processes and the optical focus of the eye. Following lensectomy, reduced posterior/choroidal accommodation may reduce production and release of scleral growth factors and subsequently reduce axial elongation. Physiological subfoveal choroidal thickening and foveal pit development may be reduced secondary to both mechanical factors and the reduced exposure to a well-focused foveal image. Despite IOL implantation or correction of aphakia with contact lenses and bifocal glasses, the fovea will receive less focused images compared with an eye with an intact crystalline lens. This in turn may interfere with the normal feedback between visual cortex and fovea. This is exacerbated after unilateral lensectomy, where we observed significant foveal differences between the two eyes, which were not noted in healthy volunteers nor in children who had undergone bilateral lensectomies. The asymmetry in the processes governing foveal and cortical neuronal network development are significant risk factors for amblyopia, and can only be overcome by intense visual stimulation of the operated eye/occlusion or blurring of the fellow eye. JOL implants, contact lenses, and glasses may need to move toward multifocal optical correction to optimize the delivery of a focused image to the fovea. Pharmacological agents may play a role in the future stimulate posterior accommodation and contribute to foveal and choroidal development.

In summary, our study shows reduced foveal pit depth and subfoveal CT post-lensectomy in childhood, which we suggest may be due to increased blur and reduced biomechanical input to the choroid, leading to an arrest in foveal development. Further work is required to study detailed mechanisms and to test the impact of current and future treatments.

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