Original Article

Central macular thickness and subfoveal choroidal thickness changes on spectral domain optical coherence tomography after cataract surgery in pediatric population

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Purpose: To evaluate the central macular thickness (CMT) and subfoveal choroidal thickness (SFCT) changes on spectral domain optical coherence tomography (SD-OCT) after cataract surgery with intraocular lens (IOL) implantation in a pediatric population. **Methods:** This was a longitudinal, prospective, interventional study which included 90 pediatric patients who underwent cataract extraction with IOL implantation. Serial SD-OCT scans were done at postoperative day 1, 1-month, and 3-month follow-up. CMT and SFCT were measured at each visit. **Results:** A statistically significant increase in CMT was noted at 1 month (from 199.3 µm to 210.04 µm) post surgery, which declined over a 3-month period (202.70 µm, $P = 0.0001$). In case of SFCT, a constant increase was observed for over 3 months of follow-up (baseline: 296.52 µm; 1 month: 309.04 µm; and 3 months: 319.03 µm, $P = 0.0001$). The traumatic cataract group showed more pronounced changes in CMT and SFCT than the non-traumatic cataract group. No significant difference was observed regarding these parameters between those who underwent primary posterior capsulotomy (PPC) versus those who did not. None of the patients in the study group developed cystoid macular edema. These posterior segment–related anatomical changes did not affect the final visual outcomes. **Conclusion:** Cataract surgery induces potential inflammatory changes in the macula and choroid in pediatric patients. Such changes are more pronounced in trauma-related cases; however, they are not significant enough to affect the visual outcomes. Similarly, the additional surgical step of PPC does not induce significant anatomical or functional changes.

Key words: Central macular thickness, CME, pediatric cataract, post cataract inflammation, SD-OCT, sub foveal choroidal thickness

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The standard surgical technique in managing pediatric cataract is phacoaspiration and in-the-bag intraocular lens (IOL) implantation with or without primary posterior capsulotomy (PPC) with anterior vitrectomy (AV).[1] Any ocular surgery may disturb the stable state of the eye and cause an inflammatory insult. Such inflammation is more pronounced in the younger age groups as compared to the adults. This inflammation can be easily appreciated in the anterior segment of the eye in the form of cells and flare. But it is very difficult to visualize inflammation of the posterior segment.

It is proposed that pro-inflammatory cytokines and prostaglandins are released after ocular surgery.[2,3] This impairs the blood–aqueous and blood– retina barrier which may cause posterior segment inflammation and cystoid macular edema (CME).[4] Fortunately, the rate of CME in children is very low compared to older age groups—around 0% to 4%.[5–11] However, this does not rule out the possibility of inflammatory changes at a microscopic level.

Such subtle inflammatory changes can be picked up by fundus fluorescein angiography (FFA) and optical coherence tomography (OCT). FFA is an invasive procedure with difficulties to perform in children with known potential adverse effects. The cross-sectional examination of the retinal layers to study parameters like central macular thickness (CMT) is only possible using OCT. OCT helps in studying thickness changes accurately as it evaluates biological tissues by *in vivo* imaging.[12] Along with the macula, the choroid may also show changes in its thickness post cataract surgery with a change in the biochemical environment.[13] Being a vascular coat, a change in choroidal thickness may be considered a good marker to measure the response to inflammatory process.[14]

In spite of all of these advancements in technology, there is not much literature on posterior segment inflammation after cataract surgery in the pediatric age group. Hence, the purpose of this study was to evaluate the posterior segment inflammation by studying macular and choroidal thickness

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changes using spectral domain (SD)-OCT after cataract surgery in the pediatric population and to correlate it with the postoperative visual outcome.

Methods

This was a longitudinal, prospective, interventional study conducted from August 2017 to January 2019 at a tertiary eye care institute. The study was performed after obtaining approval from the Institutional Review Board. The study adhered to the tenets of the Declaration of Helsinki. Written and informed consent was obtained from the parents of the children prior to all diagnostic work-up and therapeutic interventions.

Consecutive pediatric patients (aged 4–18 years) undergoing cataract extraction and IOL implantation were recruited. Only developmental, congenital, or uncomplicated traumatic cataracts (post close globe injury) which underwent uneventful surgery were considered for the inclusion in this study. In bilateral cases, only the first operated eye was included in this study. Patients uncooperative on OCT, having significant corneal edema, those lost to follow-up, with intraoperative complications, a pre-existing posterior segment or macular pathology like macular scar, macular dystrophy, and those with poor fixation and nystagmus were excluded.

All the patients underwent a complete ophthalmological examination including medical history, best-corrected visual acuity (BCVA), intraocular pressure (IOP) measurement using a non-contact tonometer, slit-lamp examination, and dilated fundus biomicroscopy using a 90-Diopter (D) lens. Preoperative B-scan ultrasonography was done, if necessary, to rule out any posterior segment pathology. Visual acuity in Snellen equivalents was converted to logarithm of the minimum angle of resolution (logMAR) for statistical analysis.

All cataract surgeries were performed by a single experienced pediatric ophthalmic surgeon using Alcon Infiniti System (Alcon Labs Inc. Fort Worth, TX, USA). Two clear corneal side ports of 1-mm size were made 120° apart at 2 and 10 o'clock positions. After staining the anterior capsule with 0.06% trypan blue dye, a cohesive viscoelastic substance was used to fill the anterior chamber. The tri-planer keratome entry was made at 12 o'clock using a 2.8-mm keratome. Anterior capsulorhexis was initiated using a bent cystotome and completed using Utrata forceps. Hydrodissection was performed at multiple quadrants. Lens matter aspiration was done using phaco probe and bimanual irrigation-aspiration cannula followed by in-the-bag implantation of hydrophobic acrylic single piece IOL. Posterior capsulotomy of 4–5 mm in size was created using vitrector, along with anterior vitrectomy in all patients under 8 years of age. Preservative-free moxifloxacin was injected intracamerally. All the ports were sealed by stromal hydration (hydroclosure) or interrupted 10-0 polyglactin suture. Topical eye drops were prescribed postoperatively, moxifloxacin (0.5%, QID) for 15 days, homatropine (2%, TDS) for 15 days, and prednisolone acetate (1%, 8 times in tapering doses) for 4–6 weeks.

In addition to the routine postoperative examination, serial SD-OCT scans were done after the cataract surgery on postoperative day 1 (POD 1), and at 1-month (±1 week) and 3-month (±1 week) follow-up. Values of the first scan (POD 1) were considered baseline values. On the SD-OCT (OptovueRTVue XR Avanti; Optovue, Inc., Fremont, CA, USA) scan, CMT and subfoveal choroidal thickness (SFCT) were measured. All the scans were carried out and evaluated by the same experienced technician to minimize bias. A signal strength of at least 6 was necessary to ensure quality of images. The technician neither was aware of the study protocols nor had access to prior values. We also evaluated intraobserver variation in the first 10 patients. Intraclass correlation was 0.963 and 0.985 for CMT and SFCT, respectively, which was excellent.

Measurement technique on OCT and definitions

A horizontal raster SD-OCT scan of 12 × 12 mm length was taken through the foveal center after dilating the patient's pupils [Figs. 1 and 2].

- CMT was measured manually at the fovea as the distance between the inner limiting membrane and the outer boundary of the retinal pigment epithelium (RPE)–Bruch's complex using the calliper tool of the OCT.[15]
- SFCT was measured using the same calliper tool as the vertical distance between the RPE and the choroidal-scleral interface, that is, the hyper reflective line of the inner scleral border.[15]
- CME was defined as the presence of intraretinal cystoid changes at macula.[16] In the absence of preoperative finding, we had to rely on both clinical appearance and cystoid changes in OCT to diagnose CME.

Statistical analysis

The sample size of 90 was calculated, providing 90% power for detecting 7% difference in mean thickness pre and post surgery at 3 months at an alpha level of 0.05. The study was continued till the desired sample size with follow-up scans were achieved. The data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 20.0. The difference between two means was calculated using unpaired *t*-test and in the same group at intervals by paired *t*-test or repeated measure analysis of variance (ANOVA). The correlation between two independent variables was done using the Pearson correlation coefficient. A P value of <0.05 was considered statistically significant.

Results

The study included 90 eyes of 90 patients and significant male preponderance was noticed. The detailed information of the cohort and study-related parameters are mentioned in Tables 1 and 2.

CMT: Mean baseline value of 199.3 ± 18.9 μm was increased significantly (210 ± 19.1 μm, +5.4%) at 1-month postoperative visit. At the 3-month visit, again significant change was observed (−3.5%) and it was reduced to 202.7 ± 17.5 μm. Still, it remained higher than the baseline values.

SFCT: Unlike CMT, this parameter showed statistically significant rise at every follow-up visit. Increase of SFCT was 4.2% and 3.2% (overall +7.5%) at 1-month (309 ± 47.8 μm) and 3-month (319 ± 45.0 μm) follow-up, respectively. The thickness changes were more pronounced and persistent in the choroid compared to the retina but there was no correlation between the two.

During the study duration, CME was not observed in any patient. Statistically significant improvement was noticed in the BCVA (from 0.593 ± 0.59 to 0.316 ± 0.53 logMAR) at every follow-up visit. None of the abovementioned thickness changes affected the final visual outcome of the patients.

A subgroup analysis was done to compare the impact of trauma and PPC + AV. No significant difference was observed

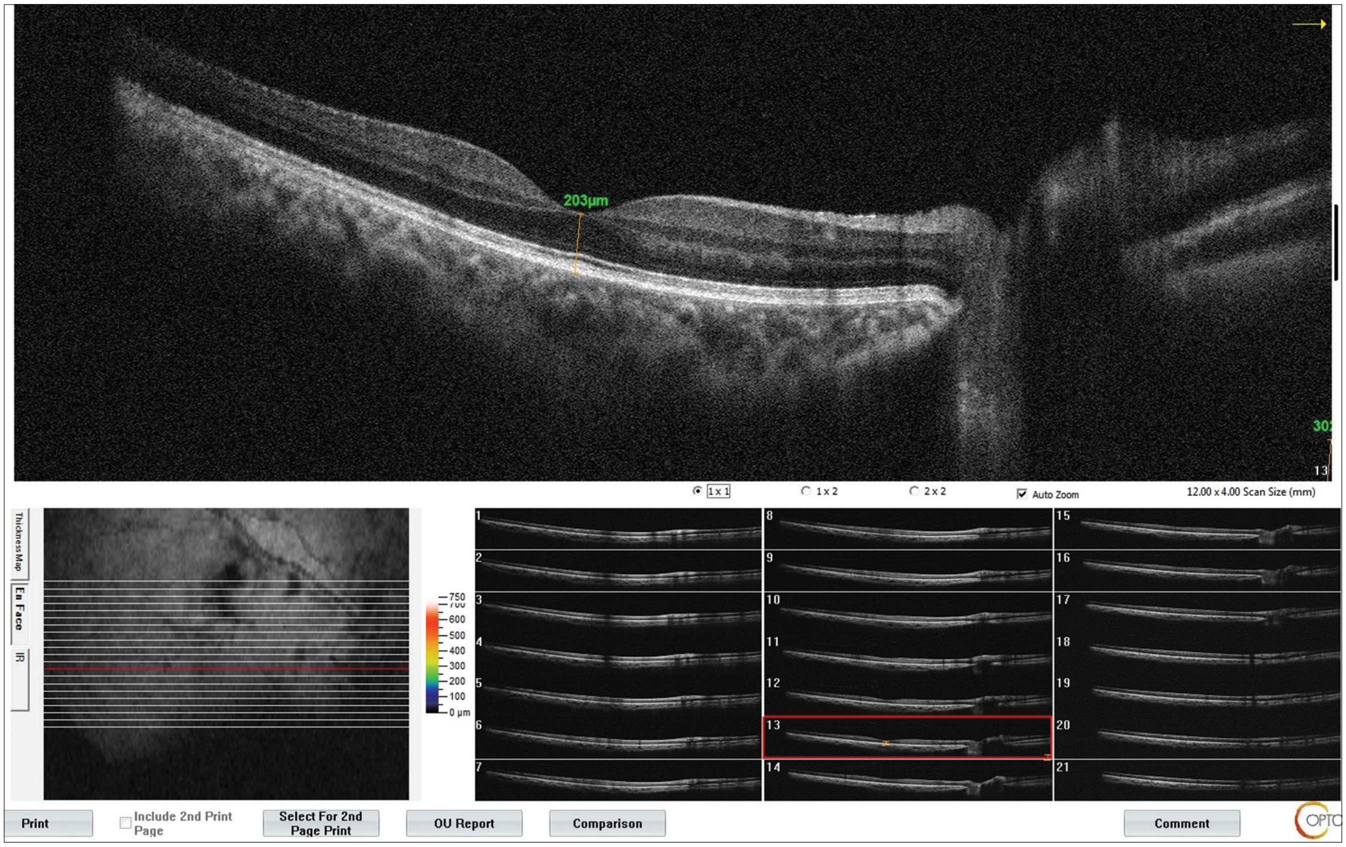

Figure 1: Measurement of central macular thickness from inner limiting membrane to retinal pigment epithelium–Bruch's complex

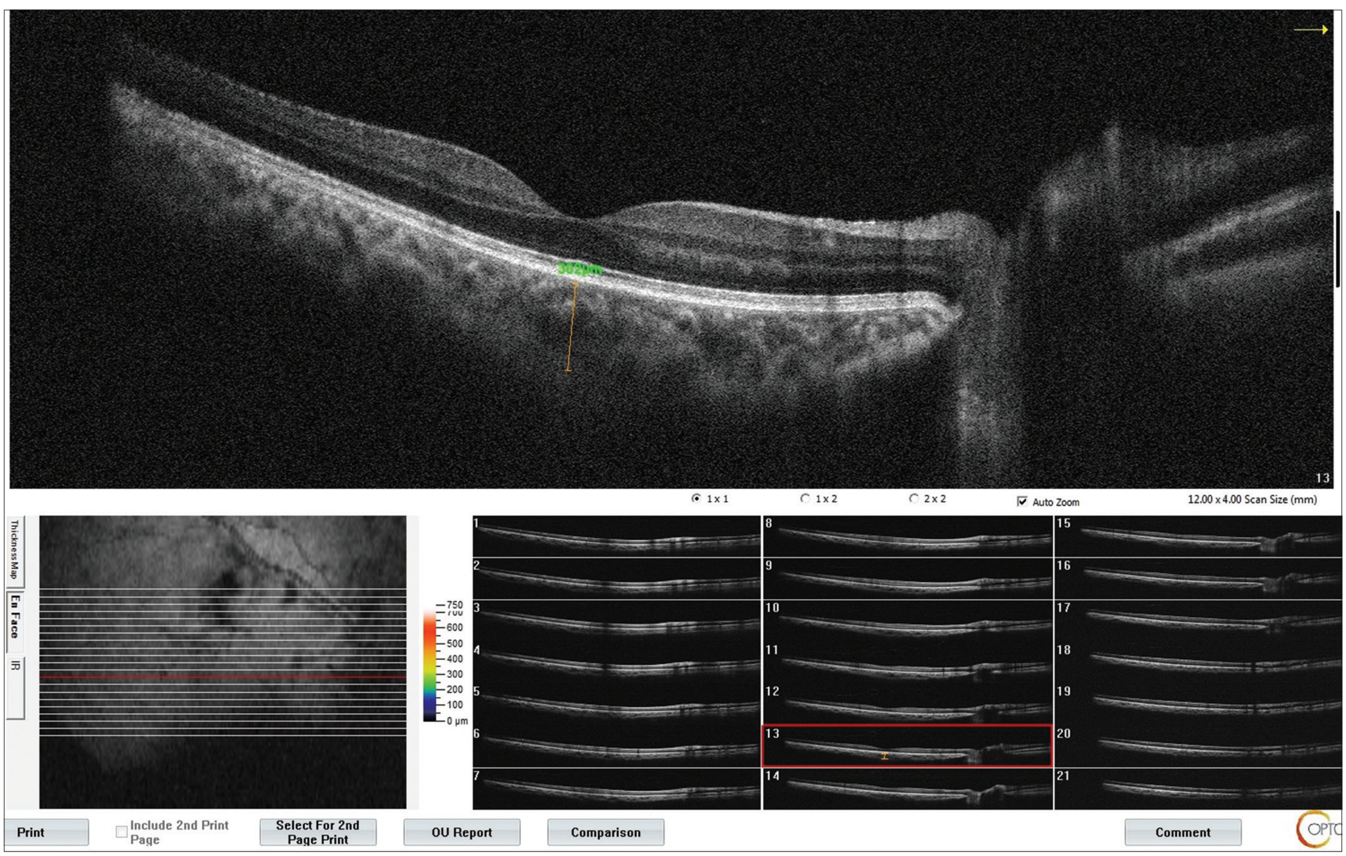

Figure 2: Measurement of subfoveal choroidal thickness from retinal pigment epithelium to choroidal-scleral interface

in thickness changes at any point of time for CMT amongst the eyes with or without PPV + AV. Overall SFCT values in the PPC + AV group showed 8.7% rise and without PPC + AV had 6.9% rise [Fig. 3]. All the baseline thickness parameters were higher in the traumatic group. On consecutive follow-ups, both groups showed similar trends of thickness changes as seen in the total study population, although the values at each visit were higher in the traumatic group. Moreover, SFCT values showed a 9.4% increase from the baseline, whereas the same was increased by only 6.7% in the non-traumatic group [Fig. 4]

Table 1: Demography and other relevant details of the study cohort

Parameter	*n* (%)
Total patients	90 eyes of 90 patients
Gender	
Male	60 (66.6)
Female	30 (33.3)
Age: mean (years) ± SD	10.48±3.46
Age group (years)	
4-8	31 (34.4)
9-13	39 (43.3)
14-18	20 (22.2)
Etiology	
Developmental	59 (65.6)
Congenital	4 (4.4)
Traumatic	27 (30)
Surgery: Additional PPC+AV	
Yes	35 (38.9)
No	55 (61.1)

PPC: Primary posterior capsulotomy; AV: Anterior vitrectomy

Table 2: Comparison of study parameters in follow-up visits

Parameters	Day 1	1 month	3 Months	*P*
Mean BCVA (logMAR)	0.59±0.59	0.37±0.54	0.32±0.53	0.0001
Mean CMT (μm)	199.3±18.9	210.0±19.1	202.7±17.5	0.001
Mean SFCT (μm)	296.5±49.0	309.0±47.8	319.0±45.0	0.027

BCVA: Best-corrected visual acuity, CMT: Central macular thickness; SFCT: Subfoveal choroidal thickness

In any of these subgroups, no statistically significant difference was noted regarding interim or final visual acuities. Traumatic cataract subgroup, however, achieved slightly better vision, the probable reason being the absence of detrimental effects of amblyopia due to a recent nature of trauma [Fig. 5].

Discussion

In this study, we aimed at studying the macular and choroidal thickness changes on SD-OCT after cataract surgery in the pediatric population. The CMT showed an initial rise in thickness at 1 month after surgery, followed by a decline over a 3-month period. However, a constant rise was observed for over 3 months for the SFCT. All these changes, however, were not associated with differences in visual acuity.

In our study, the preoperative OCT evaluation could not be performed due to media opacity and poor vision leading to difficulty in fixating accurately. However, several studies have observed that significant differences in SFCT values were not seen between preoperative and POD 1 values.[17–21] This indicates that such posterior segment inflammatory changes may become evident after a few days of surgery. Thus, POD 1 values may closely resemble preoperative ones and can be taken as baseline.

Siddique *et al.*[22] measured macular and retinal nerve fiber layer thickness in adolescent patients undergoing cataract surgery (phacoaspiration versus small-incision cataract surgery [SICS]). Mean baseline macular thickness was 192.4 μm and 203.9 μm in SICS and phacoaspiration group, respectively. Maximum rise was seen at 6 weeks follow-up visit, following which the values started declining, similar to what we noted. It took 24 weeks for the values to come down to baseline levels.[22] However, in our study the CMT values almost reached baseline at the 3-month follow-up. Sacchi *et al.*[16] measured macular thickness in 11 eyes of 11 children. They observed a significant increase in the mean macular thickness at 1 month (273.7 ± 26.8 μm) and 3 months (266.0 ± 22.8 μm) after cataract surgery from the baseline (244.8 ± 19.5 μm). Values returned to baseline after 6 months of the surgery and remained stable thereafter. In their study,[16] value continued to

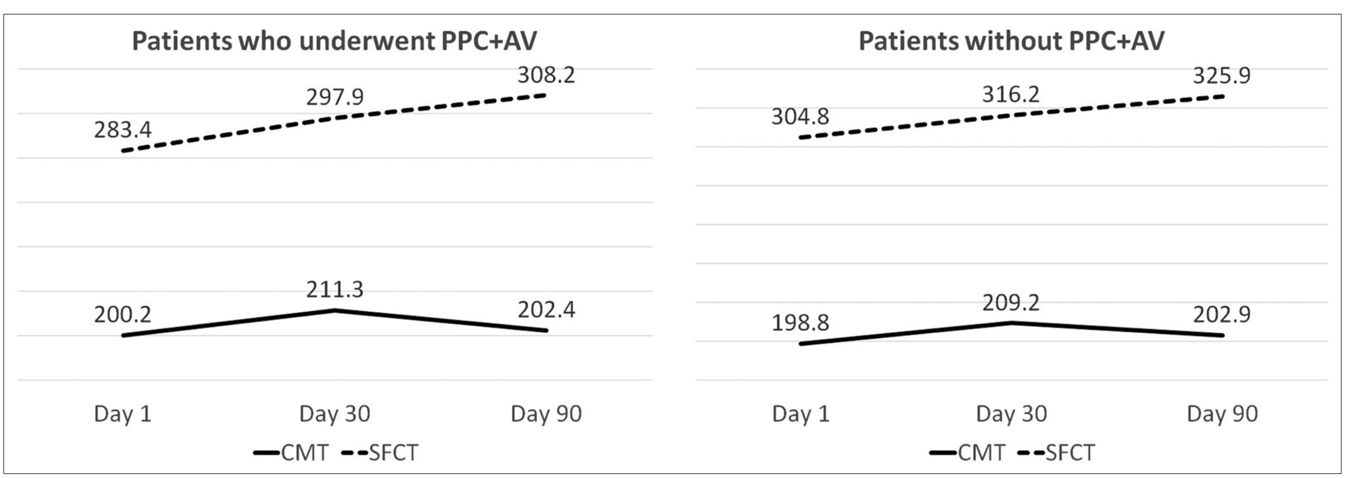

Figure 3: Line chart comparing SD-OCT parameters between patients who underwent PPC + AV versus those who did not. PPC: Primary posterior capsulotomy; AV: Anterior vitrectomy; CMT: Central macular thickness; SFCT: Subfoveal choroidal thickness

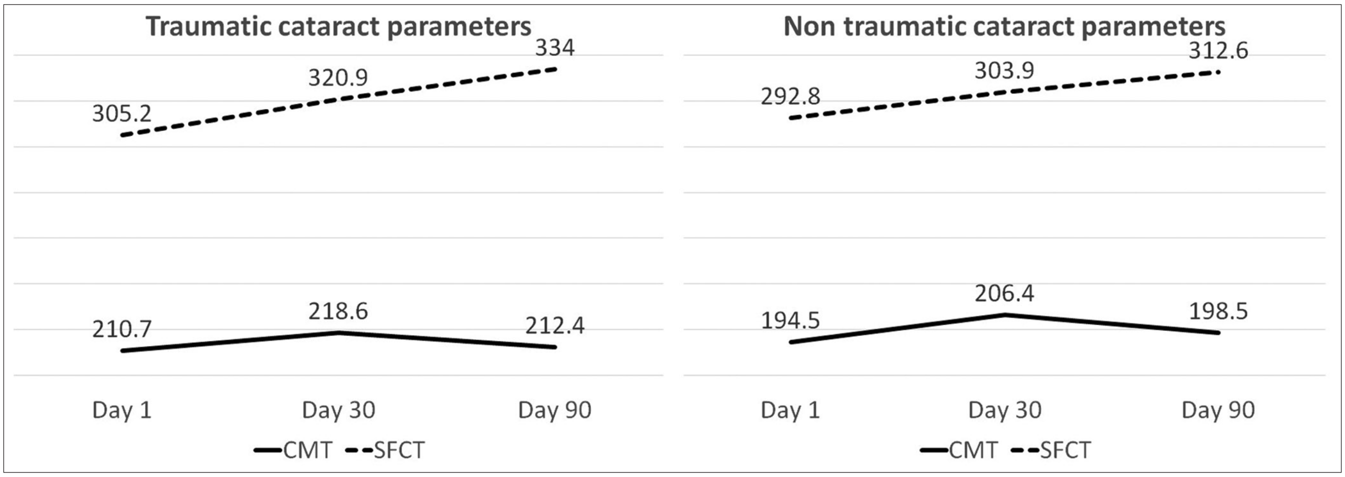

Figure 4: Line chart comparing SD-OCT parameters between trauma and non-trauma patients. CMT: Central macular thickness; SFCT: Subfoveal choroidal thickness

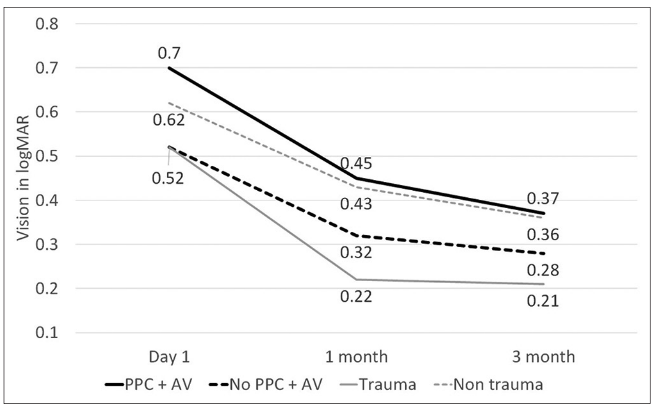

Figure 5: Line chart showing progressive vision improvement in different subgroups

rise till 3 months which was not found in our study as well as in that by Siddique *et al*.[22] Mean age of the patients was much younger (5.8 years) in the study conducted by Sacchi *et al*.[16] Wang *et al*.[23] also noted a persistently thick retina 6 months after pediatric cataract surgery (mean age of 5 years), which returned to preoperative values after 12 months. Younger age may be the reason for persistent rise of macular thickness, indirectly indicating prolonged inflammation in younger eyes.

To the best of our knowledge, there was no study conducted in pediatric patients comparing SFCT. So we have compared our results with adult studies. Zeng *et al*.[24] incorporated data from 13 studies involving 802 eyes. They found a statistical increase of SFCT at 1 week, 1 month, and 3 months. A recent article also noted a significant increase in SFCT 3 months after uncomplicated phacoemulsification.[25] This observation matches with our report as well. A prospective study done by Ohsugi *et al*.[21] in the adult population, with a longer follow-up (6 months) showed a constant increase in SFCT on all follow-ups till 6 months, suggesting a persistent inflammatory process. This could be attributed to the fact that choroid being a highly vascular structure, more inflammatory mediators might have been released here.

Such thickness changes are important to study as they may represent the active inflammatory process in the posterior segment of the eye post surgery.[26] It is worth noting that despite the thickness changes at the level of the retina and choroid, exposure to trauma, and surgical procedure of PPC + AV, none of the eyes in our study developed CME. Gilbard *et al*.[5] carried out FFA on 25 eyes after pars plicata lensectomy and vitrectomy for congenital cataract. With the exception of one questionable result, no CME was detected. Rao *et al*.[27] also did not find even a single case of CME in their study involving 28 eyes of 18 children. The lower incidence of CME in pediatric eyes post cataract surgeries is attributable to factors like young and healthy choroidal vasculature with gel homogenous vitreous. Kim *et al*.[28] in their study of adult patients who underwent uncomplicated cataract surgery stated that a baseline increase of ≥40% from the preoperative value, or alternatively a minimum cut-off of 240 μm when baseline CMT is not available can be considered clinically relevant to be labelled as macular edema. According to this criteria, the changes seen in our study were not clinically significant.

The baseline and postoperative macular and choroidal thickness values were higher in the traumatic cataract group compared to the non-traumatic group. All these values showed a similar trend on subsequent follow-ups, though SFCT values increased much more in the traumatic group. This difference might be due to the pre-existing inflammatory changes in the traumatic cases. Regarding surgical procedures, SFCT increased more in patients who underwent PPC + AV. Since the creation of PPC destroys the naturally present anatomical barrier between the anterior and posterior segment of the eye, it may expose the posterior segment to the inflammatory mediators of the anterior segment. However, no statistically significant difference in thickness changes or functional outcomes was observed at any point of time between the two groups.

The strengths of the study were its prospective nature, inclusion of cataracts of varying etiologies, especially trauma and evaluation of effect of two different surgical techniques, that is, cataract extraction with and without PPC + AV on CMT and SFCT. There was uniformity of procedure as all surgeries were performed by a single skilled pediatric surgeon and all measurements were done by a single observer. The thickness changes were observed under the cover of postoperative anti-inflammatory therapy, which gives a more realistic picture of the postoperative inflammatory status of the posterior segment.

This study had a few limitations. Long-term changes in thickness were not assessed. As SFCT continues to show an upward trend even after 3 months of surgery, it would be interesting to conduct a long-term study to detect when such changes revert to preoperative values. The thickness changes were manually measured on SD-OCT; hence, the possibility of some manual error cannot be disregarded. Multiple measurements and averaging by two independent observers may have helped us reduce the errors. However, we found it difficult to obtain multiple images in small children, and that too postoperatively. So we focused on obtaining a single but good quality image every time. Automated programs like MM5 and MM6 are highly accurate for measuring retinal thickness. They, however, measure CMT as a mean thickness of central 1 mm of macular region. We instead preferred a manual approach where measurement was done through the thinnest part of the fovea directly. Unlike CMT, reliable automated software for measuring SFCT is still lacking. Researchers in many recent studies had to rely upon manual measurements with calliper tool, similar to what we did.[29–31] The nature of the disease and the age group prevented us from taking controls, as it would not have been a fair comparison considering anatomical differences.

Conclusion

In conclusion, there is definitive evidence of posterior segment inflammation in the immediate postoperative period in the pediatric population which can be evaluated in terms of macular and choroidal thickness changes. These thickness changes are more pronounced in cases of traumatic cataract but are not visually significant. Additional steps of PPC + AV do increase the extent of SFCT changes but do not affect vision. Macular thickness changes start reverting after a month of cataract surgery but the SFCT continues to increase at least till 3 months.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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