SCIENTIFIC REPORT

Glaucoma and increased central corneal thickness in aphakic and pseudophakic patients after congenital cataract surgery

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Aim: To compare the mean central corneal thickness (CCT) among aphakic and pseudophakic patients following congenital cataract surgery with age matched controls.

Methods: This study included 43 eyes of 43 aphakic and pseudophakic patients following congenital cataract surgery. 44 healthy, age and sex matched volunteers were recruited for comparison with the patients. After a complete eye examination, corneal thickness and intraocular pressure were measured.

Results: In the study group, 33 eyes were aphakic, and the remaining 10 eyes were pseudophakic. The median CCT was 556.0 μm (range 490–640 μm) in the control group and 626 μm (range 523–870 μm) in the study group ($p < 0.05$). There was a significant difference in CCT between aphakic and pseudophakic eyes in which an intraocular lens (IOL) had been implanted at the time of congenital cataract surgery ($p = 0.011$). The same difference was not observed between aphakic and pseudophakic eyes in which an IOL had been implanted secondarily ($p = 0.835$). The median age of the patients at the time of lensectomy was 24 months (range 1 week to 120 months). There was a negative correlation between the age at lensectomy and CCT ($r = -0.485$, $p = 0.001$).

Conclusion: Aphakic and pseudophakic patients have significantly thicker corneas than age matched controls. This difference can have an important effect on interpreting intraocular pressures in these patients. It is also important to assess the effects of early surgery for congenital cataracts, as well as those of primary and secondary IOL implantation, on CCT.

Aphakic glaucoma continues to be one of the most common complications of successful congenital cataract surgery. The reported prevalence of postoperative glaucoma varies between 5% and 32%.^{1,2} The diagnosis of glaucoma in aphakic children is a challenging problem because of difficulties in measuring intraocular pressure (IOP) and in conducting gonioscopy, fundus examination, and visual field tests.³ As IOP is the key parameter for diagnosing glaucoma, any variable that can affect the measurement of IOP could lead to an incorrect diagnosis of glaucoma.

Central corneal thickness (CCT) influences IOP measurements using Goldmann applanation tonometry. When the CCT is low, the true IOP may be underestimated, and the converse is true when the CCT is high.⁴ Overestimation or underestimation of IOP in patients with glaucoma can have a significant impact on their treatment and overall prognosis. CCT has been studied extensively in patients with primary

open angle glaucoma, ocular hypertension, normotensive glaucoma and congenital glaucoma.^{5–8} By contrast, there is little information on CCT in aphakic glaucoma following congenital cataract surgery. This study compared CCT measurements of aphakic and pseudophakic patients after such surgery with those of age matched normal subjects.

METHODS

Forty three aphakic or pseudophakic patients were included in a prospective, comparative, randomised clinical study. Forty four healthy volunteers matched for age and sex were also recruited. All 44 control subjects were examined carefully and were found to have normal ophthalmic findings in all clinical respects, including retinoscopy, anterior segment examination, and dilated fundus examination.

Glaucoma was defined as the presence of optic nerve damage with an IOP greater than 22 mm Hg. Patients with an IOP greater than 22 mm Hg and without any optic nerve damage were defined as having ocular hypertension (OHT).³ If both eyes were eligible for the study, one eye of the patient was selected randomly. Patients were excluded if they had a history of ocular trauma, chronic uveitis, a history of glaucoma drainage device surgery, central corneal opacity or scarring, corneal oedema, refractive surgery, or penetrating keratoplasty.

All patients underwent routine ophthalmic examination, including CCT measurement. Visual field and gonioscopic examinations were performed only in cooperative children at least 7 years of age. CCT was measured using an ultrasonic pachymeter by an experienced ophthalmic technician who was unaware of the patient's diagnosis. In all cases, CCT was measured using an ultrasonic pachymeter before applanation tonometry. Measurements were made under topical anaesthesia. Uncooperative children were examined under general anaesthesia. The mean value of five consecutive readings was used for the evaluation. IOP was measured in a standard manner with a calibrated Goldmann applanation tonometer. At least two measurements were recorded, and the mean IOP was defined as the average of two or three IOP measurements.

The study followed the tenets of the declaration of Helsinki. Written informed consent was obtained from either parent of all the children participating in the study, or from adult subjects. The study protocol was approved by the institutional ethics committee.

Statistical analysis was performed using the SPSS 11.0 software package. The normality of the data distribution was checked using the Shapiro-Wilk test. The data were not distributed normally, and thus non-parametric Mann-Whitney U and Wilcoxon signed rank tests were used to

Abbreviations: CCT, central corneal thickness; IOL, intraocular lens; OHT, ocular hypertension

Table 1 Demographic characteristics of the study and control groups

Demographic characteristics	Study group	Control group	p Value
Median age (range) (years)	9.0 (4.0–41.0)	12.5 (6.0–21.0)	0.143
Sex, n (%)			0.458
Male	20 (46.5)	17 (38.6)	
Female	23 (53.5)	27 (61.4)	
Central corneal thickness (range) (μm)	626 (523–870)	556 (490–640)	<0.05

compare the data. Spearman's correlation (two tailed) analysis was used to examine the relation between the CCT, IOP, and demographic characteristics. Pearson correlation analysis was used to determine any relation between CCT and age at cataract surgery. CCT values were compared using the Kruskal-Wallis test in aphakic and pseudophakic patients. Given the large number of tests, simultaneous inference using the Bonferroni correction was also applied.

RESULTS

Forty three eyes of 43 aphakic/pseudophakic patients and 44 eyes of 44 healthy subjects were enrolled in this study. Thirty three eyes were aphakic, and the remaining 10 eyes were pseudophakic. Five of the 33 patients had unilateral aphakia and 28 patients had bilateral aphakia. There were no significant differences in age ($p = 0.143$) or sex ($p = 0.458$) between the study and control groups. The demographic characteristics of the study and control groups are presented in table 1.

The median CCT was 556 μm (range 490–640 μm) in the control group and 626 μm (range 523–870 μm) in the study group. The median CCT was significantly greater in the study group than in the controls ($p < 0.05$) (fig 1). There was an inverse correlation between age and CCT in the control group ($r = -0.341$, $p = 0.024$). The same correlation was not observed in the study group ($r = -0.204$, $p = 0.189$). CCT was similar between males and females in both groups (control group, $p = 0.247$; study group, $p = 0.312$). The median CCT values for the right and left eyes of the bilateral aphakic or pseudophakic patients were 632 μm and 616 μm , respectively, and were not significantly different ($p = 0.627$).

Figure 1 Median central corneal thickness of the study and control groups.

The clinical characteristics of the study group are given in table 2. Intraocular lens (IOL) implantation was performed in five eyes at the time of congenital cataract surgery and secondarily in five eyes. There was a statistically significant difference in the CCT values between the aphakic and pseudophakic eyes in which an IOL had been implanted at the time of congenital cataract surgery ($p = 0.011$). The same difference was not observed between aphakic and pseudophakic eyes in which the IOL had been implanted secondarily ($p = 0.835$). The median age of the patients at the time of cataract surgery was 24 months (range 1 week to 120 months). There was a negative correlation between the age at lensectomy and CCT ($r = -0.485$, $p = 0.001$).

The median IOP was 23 mm Hg (range 11–57 mm Hg) in the study group and 14.5 mm Hg (range 10–26 mm Hg) in the control group. There was a positive correlation between corneal thickness and IOP in both the study ($r = 0.643$, $p < 0.001$) and control groups ($r = 0.596$, $p < 0.001$) (fig 2). Using the reported correction formula for corneal thickness,^{5,9} 19 (68%) of the eyes with OHT were reclassified as having a normal IOP. Of the 12 eyes with glaucoma, four (33%) had a change with antiglaucoma eyedrop therapy and three (25%) had a change in the recommendation of glaucoma surgery.

DISCUSSION

In this study, a median CCT of 626 μm was found in patients with aphakia or pseudophakia and was significantly greater than that in the group of age matched controls. This finding supports an earlier report that found a significantly increased average CCT of 660 μm in a group of 28 aphakic patients.¹⁰ In that report, the CCT was compared with that of phakic eyes within patients, instead of with the eyes of healthy subjects. As only five patients had unilateral aphakia in our study, we could not compare aphakic and phakic eyes within patients. Consequently, we chose age matched healthy subjects for comparison. An important limitation of the previous study was the inclusion of both eyes of bilateral aphakic patients. In our study, only one eye of a bilateral aphakic patient was included. We did not find any statistically significant difference in CCT between the right and left eyes of bilateral aphakic and pseudophakic patients.

A new finding in this study was the inverse correlation between the age of the patients at the time of cataract surgery and CCT. We could not explain the exact mechanism producing a thick CCT when cataract surgery is performed in the early months of life. The central cornea is thicker at birth, and corneal thickness decreases rapidly during the first few months of life.¹¹ The rapid decrease in corneal thickness occurring in the first months of life might be explained by the mechanism that regulates hydration, evaporation, and transparency.¹² Surgical trauma to the cornea during the first months of life might impair these regulatory mechanisms, interrupting normal corneal development. Simon *et al*¹⁰ found normal CCT values in the phakic fellow eyes of patients with unilateral aphakia. Based on our data and previous results, we postulate that surgical trauma is an important factor for increasing CCT. Kugelberg *et al*¹³ found no

Table 2 Clinical characteristics of the study group

	Aphakia	Pseudophakia (primary)	Pseudophakia (secondary)	Total
	No (%)	No (%)	No (%)	No (%)
OHT	18 (55)	1 (10)	3 (30)	22 (51)
Glaucoma	10 (30)	–	2 (20)	12 (28)
Normal	5 (15)	4 (40)	–	9 (21)
Total	33	5	5	43 (100)

significant difference in IOP and corneal thickness between the aphakic and normal eyes of unilaterally lensectomised newborn rabbits with 3 months of follow up. Rabbit corneas may respond differently to surgical trauma. It also takes time to observe the effects of surgical trauma on the cornea. Those factors may have an effect on the results of the previous study.

Magnusson *et al*¹⁴ found that surgery for a congenital cataract during the first month of life was associated with increased risk of aphakic glaucoma compared with surgery performed later. Later studies also found an increased risk of developing aphakic glaucoma with early surgery.^{15–17} It is questionable whether the patients in previous reports had glaucoma, because the diagnostic criteria for aphakic glaucoma were not described clearly in those studies. Lens remnants and a small pupil often led to difficulty in evaluating the optic nerve head. Small children cannot perform the visual field test, and the results can be affected by factors such as amblyopia and nystagmus, even in cooperative patients. Therefore, IOP measurements are the only diagnostic criterion for the diagnosis of glaucoma in the paediatric age group. Patients might be misdiagnosed because of the absence of CCT determinations and subsequent adjustment of the IOP. Based on the manometric data of Ehlers *et al*,³ recent studies found that as many as 56–65% of patients with OHT could be reclassified as having normal IOP.^{6–7,18} According the linear correction formula, in our study, 68% of the eyes with OHT would be reclassified as normal. Of the 12 eyes with glaucoma, four (33%) had a

change with antiglaucoma eyedrop therapy, and three (25%) had a change in the recommendation of glaucoma surgery.

It was also interesting to find a difference in CCT between aphakic and pseudophakic eyes in which an IOL had been implanted primarily. The same difference was not found in pseudophakic eyes in which an IOL had been implanted secondarily. To our best knowledge, this has not been studied previously. Asrani *et al*¹⁹ reported that primary posterior chamber IOL implantation can decrease the incidence of open angle glaucoma in congenital cataracts. Primary posterior capsulectomy and anterior vitrectomy may increase the risk of late onset open angle glaucoma in paediatric aphakic glaucoma.²⁰ We speculate that vitreous factors alter the microstructure of the anterior segment and might even impair the normal maturation of the cornea. An IOL might serve as a barrier between the cornea and vitreous and, consequently, corneal and anterior segment changes do not occur when an IOL is implanted primarily. Larger controlled clinical trials may clarify the effects of vitreous factors on CCT in aphakic patients following congenital cataract surgery.

In conclusion, knowledge of corneal thickness in aphakic glaucoma is important for accurate IOP readings. It is important to assess the effects of early surgery as well as those of primary and secondary IOL implantation on CCT, to clarify whether they induce an increase in CCT.

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Figure 2 Positive correlation between central corneal thickness and intraocular pressure.

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