

# Central Corneal Thickness in Juvenile Glaucoma

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## Abstract

**Purpose:** To evaluate central corneal thickness (CCT) in patients with juvenile glaucoma and compare it with that of normal individuals

**Methods:** A prospective, case-control study was performed on 80 eyes with juvenile glaucoma who attended glaucoma clinic in Farabi eye hospital, Tehran, Iran and 107 clinically normal healthy eyes. Standard automated perimetry (SAP) was performed for all the participants. CCT was measured using ultrasonic pachymetry. Mean CCT and its correlations with juvenile glaucoma diagnosis, mean deviation (MD) in SAP, age and usage of topical carbonic anhydrase inhibitors (CAIs) was calculated.

**Results:** Mean CCT was 561.6±49.9 µm (range, 463-650 µm) and 531.5±29 µm (range 457-606 µm) in eyes with juvenile glaucoma and normal healthy eyes, respectively. The differences of mean CCT between the groups were highly significant (P<0.001). CCT did not correlate with age, MD and usage of topical CAIs.

**Conclusion:** CCT measurements in eyes with juvenile glaucoma were greater than those in normal healthy eyes. There might be no correlation between CCT and severity of the disease in juvenile glaucoma.

**Keywords:** Central Corneal Thickness, Visual Field, Juvenile Glaucoma

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## Introduction

Primary open angle glaucoma (POAG) is the most common form of glaucoma. The numbers of people who suffer from this disease are increasing and it is predicted that bilateral blindness will be present in 4.5 million people with POAG by the year 2010.<sup>1</sup>

Juvenile glaucoma is a form of disease which is diagnosed in individuals younger than age of 35. Because it is a much more severe

form of disease with high intraocular pressures (IOPs), early surgery to avoid loss of sight is often required.<sup>2</sup>

IOP is the key parameter for diagnosing glaucoma and any variable that cause overestimation or underestimation of IOP in patients with glaucoma can have a significant impact on their treatment and prognosis.

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Goldmann applanation tonometry (GAT) has been the gold standard for IOP measurement since its introduction in 1956.<sup>3</sup>

The effect of central corneal thickness (CCT) on IOP measurements using GAT has been studied extensively in patients with POAG,<sup>4</sup> ocular hypertension, normotensive glaucoma,<sup>5,6</sup> and congenital glaucoma.<sup>7</sup> CCT has also been identified as a substantial glaucoma risk factor for progression of disease in angle closure glaucoma,<sup>8</sup> open angle glaucoma<sup>9</sup> and normal tension glaucoma.<sup>10</sup>

However, to our knowledge no study has been described CCT in patients with juvenile glaucoma. We performed this study to evaluate CCT in eyes with juvenile glaucoma and its correlations with severity of glaucoma.

## Methods

Patients with juvenile glaucoma seeking treatment at glaucoma clinic of Farabi Eye Hospital were recruited to participate in this study. Written informed consent was obtained from all participants. The study followed the tenets of the declaration of Helsinki, and the Institutional Review Board of Tehran University of Medical Sciences approved the study.

Eyes defined as having juvenile glaucoma were those with IOP greater than 22 mmHg in the presence of typical glaucomatous disc, field changes, and an open angle on gonioscopy. In all patients onset of glaucoma was under the age of 35 with any cause of glaucoma including developmental glaucoma. Exclusion criteria were previous history of ocular trauma, intraocular laser, any systemic disease that influences CCT, chronic uveitis, central corneal opacity or scarring, corneal edema, refractive surgery or penetrating keratoplasty. Eyes with juvenile glaucoma which had an IOP of 30 mmHg or more and those which had clinically significant edema were also excluded. If both eyes were eligible for the study, one eye of the patient was selected randomly.

In healthy controls exclusion criteria were IOP>22 mmHg, typical glaucomatous disc, field changes, and those mentioned for our cases.

Data collected from all subjects included age, gender, medical therapy and history of surgery. The regular visit included best

corrected visual acuity (BCVA), slit-lamp biomicroscopy, GAT, and dilated pupil ophthalmoscopy were performed for patients and healthy controls. Visual field (VF) was evaluated with Humphrey VF analyzer (central 30-2 SITA standard program; Carl Zeiss Meditec Inc, Dublin, CA). VF reliability criteria were fixation loss, false-positive and false-negative rates of less than 25%. Severity of glaucoma determined based on perimetry by Hodapp, Parrish and Anderson's Classification.<sup>11</sup>

The corneal thickness was measured during the day (between 9 AM and 12 AM) by a masked examiner. After corneal anesthesia using topical tetracaine, the probe of the ultrasound pachymeter was perpendicularly touched to the center of the cornea and five measurements were recorded. The same pachymeter (Sonomed 200P+Micropach [Sonomed Inc., NY, USA]) was used for each measurement.

## Statistical analysis

Statistical analyses were performed with SPSS 13.0 (SPSS, Chicago, IL, USA) using the independent-samples t-test to evaluate normally distributed continuous variables. Differences were considered to be statistically significant when  $P \leq 0.05$ . Pearson correlations and multiple regression were used to examine the correlation between CCT with continuous variables, such as age.

## Results

### Description of study subjects

Eighty eyes of 80 subjects with juvenile glaucoma (44 males and 36 females) and 107 eyes of 107 healthy volunteers (59 males and 48 females) were included. The mean age of them was  $26.2 \pm 6.3$  years (range 13-36) and  $25.4 \pm 5.3$  years (range 12-36), respectively.

There was no statistically significant difference between groups in terms of sex ( $P=0.18$ ) and age ( $P=0.36$ ). All subjects had the same racial background. Mean duration since disease first diagnosed was  $6.2 \pm 6.0$  years (range 3 month to 20 years). Thirteen patients (%16.3) had history of trabeculectomy. The number of medications was  $1.5 \pm 1.3$  medications (range 0 to 4) from which 31 patients (38.8%) took carbonic anhydrase inhibitors (CAIs).

### Central corneal thickness analysis

The mean CCT in eyes with juvenile glaucoma;  $561.6 \pm 49.9 \mu\text{m}$  (range 463-650  $\mu\text{m}$ ) was statistically different from normal healthy eyes;  $531.5 \pm 29 \mu\text{m}$  (range 457-606  $\mu\text{m}$ ) ( $P < 0.001$ ). Mean CCT in eyes with a history of trabeculectomy surgery and in those without it was  $565.1 \pm 41.9 \mu\text{m}$  and  $543 \pm 30 \mu\text{m}$ , respectively ( $P = 0.07$ ). After exclusion of eyes with a history of trabeculectomy, CCT in the juvenile glaucoma group was still significantly higher than the control group ( $P < 0.001$ ).

In eyes with juvenile glaucoma mean CCT of females was significantly thinner ( $P = 0.05$ ) than CCT of males ( $555 \pm 34 \mu\text{m}$  and  $569 \pm 47 \mu\text{m}$ , respectively). No statistically significant correlation was found between CCT and age in eyes with glaucoma and in control subjects (Pearson  $r = 0.10$ ;  $P = 0.17$  and Pearson  $r = 0.03$ ;  $P = 0.7$ , respectively).

There was no statistically significant difference between CCT in glaucomatous eyes which received topical CAIs and those which didn't receive it ( $557.3 \pm 4 \mu\text{m}$ ,  $564.2 \pm 36.8 \mu\text{m}$ ;  $P = 0.46$ ). No significant correlation was found between CCT and number of topical glaucoma medications ( $P = 0.34$ ).

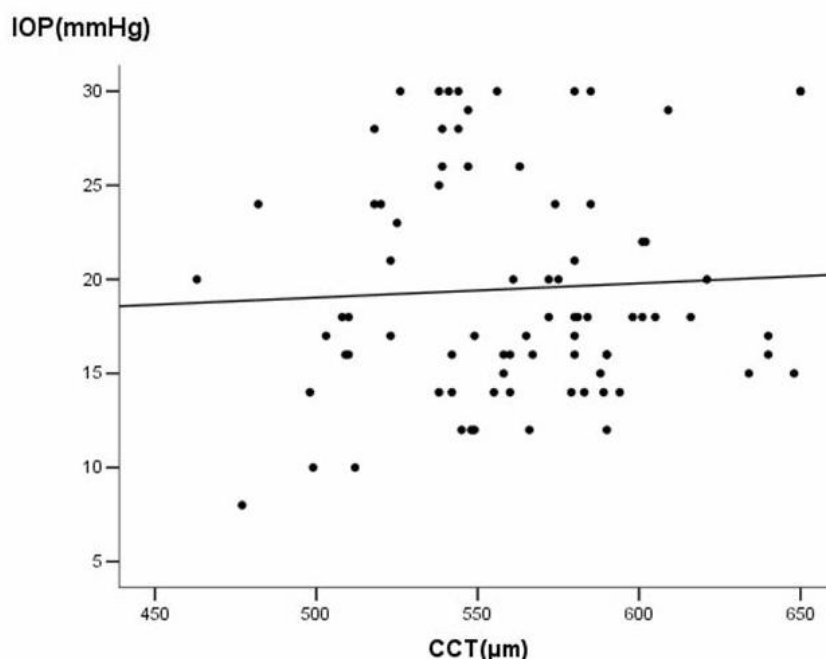
Mean IOP in eyes with juvenile glaucoma and normal eyes was  $18.5 \pm 5.9$  (range 8-30) and  $14.9 \pm 1.6$  (range 12-18). There was no

correlation between CCT and IOP in our patients (Pearson  $r^2 = 0.003$ ;  $P = 0.64$ ) (Figure 1).

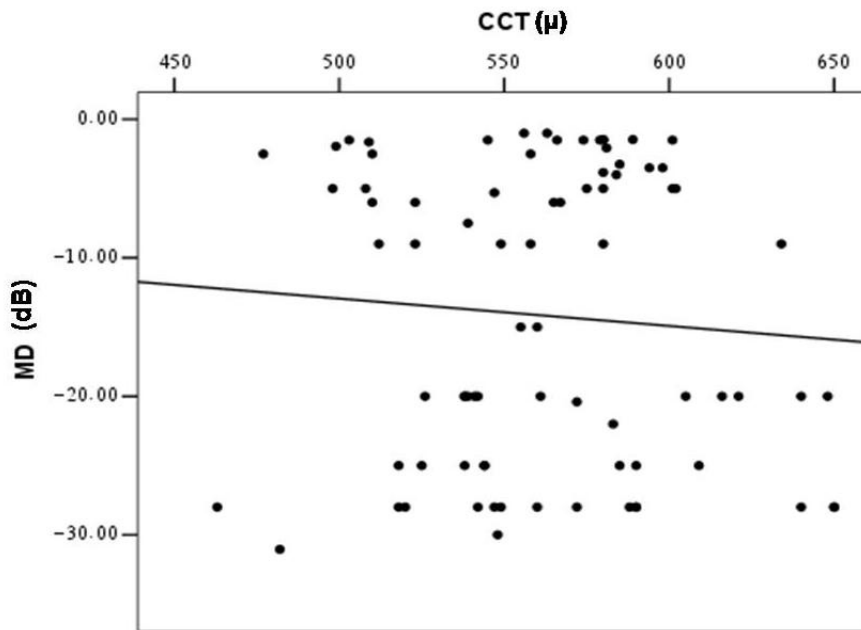
We divided the participants into 3 stages of glaucoma severity depending on their mean deviation (MD) score, as defined by Anderson and Patella's classification: the early stage ( $\text{MD} \leq -6 \text{ dB}$ ), the moderate stage ( $-12 \text{ dB} \leq \text{MD} < -6 \text{ dB}$ ), and the advanced stage ( $\text{MD} < -12 \text{ dB}$ ). Mean CCT in these groups were  $559.3 \pm 29 \mu\text{m}$ ,  $550.9 \pm 11 \mu\text{m}$  and  $566.1 \pm 40 \mu\text{m}$ , respectively ( $P = 0.5$ ). Mean MD in eyes with CCT less than  $535 \mu\text{m}$  and in eyes with CCT greater than it was  $-13.06 \pm 11.37$  and  $-14.48 \pm 10.48$ , respectively ( $P = 0.62$ ). No statistically significant correlation between CCT and MD in perimetry was present (Pearson  $r^2 = 0.006$ ;  $P = 0.5$ ) (Figure 2).

There was no statistically significant correlation between CCT and cup to disk ratio (C/D) in our study (Pearson  $r^2 = 0.007$ ;  $P = 0.4$ ). The mean spherical error of was  $-1.91 \pm 2.1$  diopters (0.5 to -6.0) with no correlation with CCT ( $r = 0.15$ ,  $P = 0.21$ ).

In multiple regression analysis, there was no significant correlation between sex, age, visual acuity (VA), topical CAIs usage, history of trabeculectomy, IOP, MD and CCT ( $P > 0.05$ ).



**Figure 1.** Scatter plots of the relationships between central corneal thickness and intraocular pressure in eyes with juvenile glaucoma



**Figure 2.** Scatter plots of the relationships between central corneal thickness and mean deviation in eyes with juvenile glaucoma

**Table 1.** Demographic and biometric data of patients with juvenile glaucoma and control group

	Juvenile glaucoma (n=80)	Control group (n=107)	P
Age (years) (Range)	26.2±6.3 (13-36)	25.4±5.3 (12-36)	0.36
Gender (M/F)	44/36	59/48	0.18
CCT(μm) (Range)	561.6±49.9 (463-650)	531.5±29 (457-606)	P<0.001
IOP(mmHg) (Range)	18.5±5.9 (8-30)	14.9±1.6 (12-18)	P<0.001
C/D <sup>§</sup> (Range)	0.79±0.15 (0.5-1)	0.3±0.06 (0.2-0.4)	P<0.001
MD <sup>†</sup> (Range)	-17.14±9.8 (-28.0 to -3.0)	-0.89±9.8 (+0.51 to -2.78)	P<0.001

<sup>§</sup>: Vertical cup to disc ratio.  
<sup>†</sup>: Mean deviation in standard perimetry.  
 CCT: Central corneal thickness, IOP: Intraocular pressure, C/D: Cup to disk ratio, SD: Standard deviation, MD: Mean deviation

## Discussion

IOP is the key parameter for diagnosing glaucoma. Since its introduction in 1956 GAT has been the gold standard for IOP measurement.<sup>3</sup> The effect of CCT on IOP measurement using GAT is well known. The device overestimates IOP in thick corneas and underestimates it in thin corneas.<sup>12,13</sup>

The relation of CCT and different types of glaucoma is thoroughly investigated. Many reports have noted that, eyes with normal

tension glaucoma have a significant less CCT compared with that of POAG and normal subjects.<sup>5,6</sup> Shah and coworkers<sup>14</sup> have reported that the corneal thickness of their patients with ocular hypertension was greater than that of glaucomatous or normal eyes, whereas those with normal-tension glaucoma and pseudoexfoliative glaucoma had thinner corneas. Wagnanski-Jaffe et al<sup>15</sup> have

reported less corneal thickness in congenital glaucoma compared with normal eyes.

To our knowledge this is the first report of CCT in patients with juvenile glaucoma. Our data showed a statistically significant higher CCT in the eyes with juvenile glaucoma than healthy control group. We found that when we excluded patients with a history of ocular surgery, mean CCT was still significantly higher.

In our study mean CCT of eyes with a history of trabeculectomy was higher than that of eyes without it; nevertheless the difference did not reach to statistical significance. This higher value may be because of endothelial cell damage sustained during surgery. Increased CCT beyond the normal values were reported after a range of intraocular surgeries such as cataract surgery and penetrating keratoplasty.<sup>4</sup> Previous studies have been described higher CCT in children with aphakic eyes compared with phakic eyes.<sup>7,16</sup> Muir and coworkers<sup>17</sup> showed that this difference in the CCT of aphakic and pseudophakic eyes versus normal eyes occurs after surgery and is due to decrease in endothelial cell count because of surgical trauma.

The average CCT of healthy eyes in our study,  $531.5 \pm 29 \mu\text{m}$ , was similar to mean CCT reported for similar age group ( $536 \pm 31 \mu\text{m}$ ).<sup>4</sup> We found no correlation between age and CCT among our patients and in normal control eyes. This is comparable with some of past reports. Dai and Gunderson<sup>18</sup> studied the CCT of subjects younger than 18 years and found no difference. Doughty et al<sup>19</sup> showed that there is no significant difference in the measurements of CCT in European children, adults, and elderly. In the other hand, Kotecha et al<sup>20</sup> found that in younger eyes, GAT readings shows less value than dynamic contour tonometry (DCT) readings, but this difference reverses in older eyes. They assumed that age related increase in corneal stiffness may induce an overestimation of IOP with GAT.

We didn't find any correlation between CCT

and IOP. A meta-analysis of possible association between CCT and IOP by Doughty et al<sup>4</sup> revealed a statistically significant correlation; a 10% difference in CCT would result in a  $3.4 \pm 0.9 \text{ mmHg}$  difference in IOP. The observed phenomenon was much smaller for healthy eyes.

Regarding glaucoma stage, our study didn't show any significant difference in CCT in different stages of glaucoma. This is in contrast with Kniestedt and coworkers<sup>22</sup> who reported that glaucoma patients with thin CCT are more likely to be found at an advanced stage of the disease. This is also in contrast to Hong et al<sup>8</sup> who found that patients with primary angle closure glaucoma (PACG) with a thinner cornea were at greater risk for VF progression. One reason might be that we did not exclude developmental cases so we had heterogeneous cases of juvenile glaucoma.

Konowal et al<sup>23</sup> reported that topical CAIs used to treat glaucoma are associated with corneal decompensation in some patients. CCT in our group of patients who received topical CAIs was not significantly higher than those who didn't received it.

This study is limited by a relatively small sample size. Although we excluded patients with clinically significant edema, we have not evaluated the number of corneal endothelial cells, and subclinical corneal edema may have interfered with the acquired measurements. Finally different IOP and different number of medication may affect some of our results.

## Conclusion

In conclusion, our findings show that, in juvenile glaucoma, there is a thicker CCT in compare with normal healthy eyes which may influence the IOP measurements, the diagnosis of glaucoma, follow-up and treatment. Corneal pachymetry has great value in the management of these patients and the IOPs need to be further adjusted for thickening of the cornea. We also found no correlation between CCT and severity of glaucoma in patients with juvenile glaucoma.

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