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ORIGINAL RESEARCH

Central corneal thickness and corneal endothelial characteristics in healthy, cataract, and glaucoma patients

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Purpose: The aim of this study was to describe and compare endothelial cell parameters and central corneal thickness (CCT) in four different groups of patients (patients with cataract, patients with glaucoma, elderly healthy subjects, and young healthy subjects) and identify correlations between these characteristics, patient age, and sex.

Methods: Before conducting invasive procedures, 104 patients were examined using a non-contact specular microscope. Parameters examined included endothelial cell density (ECD), percentage of regular hexagonal cells (6A), average size of endothelial cells (Ave), and CCT. Patients' ages and sexes were also noted.

Results: A total of 47 (45%) patients were men and 57 (55%) were women. CCT, ECD, 6A, and Ave in cataract group were 540 (±64) µm, 2633 (±430) cells/mm^2, 60 (±10)%, and 390 (±66) µm, respectively; these values in the glaucoma group were 553 (±32) µm, 2484 (±82) cells/mm^2, 60 (±10)%, and 397 (±58) µm. In the elderly group these figures were 545 (± 39) µm, 2394 (±416) cells/mm^2, 64 (±10)%, and 386 (±43) µm; and in young healthy subjects the values were 555 (±43) µm, 2940 (±345) cells/mm^2, 66 (±10)%, and 345 (±42) µm. A weak inverse correlation was observed between ECD and subject age ($r = -0.459$; $P < 0.05$) and between ECD and CCT ($r = 0.232$; $P < 0.05$). CCT was inversely correlated with patient age ($r = -0.13$; $P = 0.189$), but statistically significant data was observed only for the glaucoma group ($r = -0.572$; $P < 0.05$).

Conclusion: ECD in young subjects was higher than in elderly subjects in all groups; these patients have more endothelial cells and smaller, thicker corneas. The corneal endothelium cells in males have more regular hexagonal cells than do females. No difference in CCT and the ECD was observed between sexes. CCT and average size of endothelial cells do not differ between groups.

Keywords: cornea, endothelium, ECD, CCT

Introduction

A large number of population studies measuring central corneal thickness (CCT)[1] or endothelial cell density (ECD)[1–6] have recently been conducted. Some studies have examined the Lithuanian population, but these studies focused on CCT.[7,8]

Several studies have investigated the correlation between sex and corneal parameters, while others described the influence of age; however, the data is controversial. No studies have demonstrated how common ophthalmic diseases affect CCT and endothelial cells.

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Table 1 Comparison of central corneal thickness, endothelial cell parameters, and age in the four groups of subjects

Feature	Group 1 (n = 29)		Group 2 (n = 26)		Group 3 (n = 19)		Group 4 (n = 30)	
	M (±SD)	CI	M (±SD)	CI	M (±SD)	CI	M (±SD)	CI
Age (years)	72 (±6.7)	69.8–74.9	71 (±9)	68.3–75.4	77 (±8)	73.9–81.4	23.5 (±0.1)	23.2–23.7
CCT (μm)	540 (±64)	515.2–563.9	553 (±32)	540.5–566.7	545 (±39)	526.7–564.0	555 (±0.43)	539–571
ECD (cells/mm^2)	2633 (±430)	2469.1–2796.4	2484 (±482)	2289.6–2678.6	2394 (±416)	2194.8–2596.1	2940 (±0.345)	2811–3068
6A (%)	60 (±10)	56.6–64.4	60 (±10)	55.7–64.1	64 (±10)	59.4–69.3	66 (±0.10)	62–70
Ave (μm)	390 (±66)	364.9–415.2	397 (±58)	373.3–419.9	386 (±43)	385.2–480.9	345 (±0.42)	329–361

Notes: Group 1: cataract; Group 2: glaucoma; Group 3: elderly healthy eyes; Group 4: young healthy eyes.
Abbreviations: n, number of subjects; CCT, central corneal thickness; ECD, endothelial cell density, 6A, regular hexagonal cells in endothelium; Ave, average size of endothelial cells; M, mean; SD, standard deviation; CI, confidence interval.

In this study, we identified whether CCT is correlated to ECD in the Lithuanian population and whether these parameters depend on the presence of eye diseases such as cataract and glaucoma,[9] as well as age and sex. Our aim was to describe endothelial cell parameters (total number, size, percentage of regular hexagonal cells) and CCT and to compare this data among four different groups (patients with cataract, patients with glaucoma, healthy elderly subjects, and young healthy subjects) and between sexes and to identify correlations between ECD, percentage of regular hexagonal cells, CCT, and age.

Methods

A total of 104 subjects were involved in the study. This study was approved by the Regional Ethical Committee. Patients were divided into four groups: patients with cataract, patients with glaucoma, elderly healthy subjects, and young healthy subjects. General criteria for inclusion in the study were patient consent, no symptoms of cornea or conjunctiva irritation, no previous cornea surgeries, and no history of contact lens wearing.

Group 1 included patients who had visited the Vilnius University Hospital Santariskiu Clinic Center of Eye Diseases for cataract surgery. These 29 patients had senile cataract in at least one eye. Conditions in the other eye were diverse and included incipient and severe cataract and pseudophakia. No signs of glaucoma were observed.

Group 2 included 26 chronic primary open-angle glaucoma patients. Eye drops were not effective in lowering intraocular pressure to a normal value for moderate and advanced stages of glaucoma; thus, surgery was indicated.

Group 3 included patients with extraocular pathology (19 subjects). Thirty healthy medical students formed Group 4.

Specular microscopy (Noncon Robo Pachy Konan Specular Microscope; Konan Medical, Irvine, CA) was performed to measure ECD, percentage of regular hexagonal cells, and CCT. This study was conducted by one examiner between 11 am and 4 pm. In the first two groups, data from the morbid eye was used for final analysis. We analyzed parameters for this eye, which was healthier in the Group 3. Data were collected from the right eye in the group of young healthy subjects because no statistically significant difference was observed between left and right eyes. The Statistical Package for the Social Sciences (version 19; SPSS, Inc, Chicago, IL) and Excel 2007 (Microsoft, Redmond, WA) software were used for statistical analysis. *t*-test, Pearson and Fisher correlation coefficients, and chi-square values were calculated. Data were considered statistically significant when $P < 0.05$.

Results

A total of 104 patients were examined; 47 (45%) were men and 57 (55%) were women. The average age of the elderly subjects (Groups 1–3) was 73.5 (±8) years (Table 1). The average age of the younger subjects (Group 4) was 23.5 (±1) years. The number of men and women in the groups was approximately equal. CCT and other corneal endothelium parameters were compared between the four groups.

Table 2 Corneal characteristics distribution by sex

Feature	Sex		*P*-value
	Male (n = 47)	Female (n = 57)	
CCT (μm)	546.11 (±56.9)	550.79 (±37)	0.614
Endothelial cell parameters:			
ECD (cells/mm^2)	2640.62 (±460.9)	2640.95 (±467.4)	0.997
6A (%)	65.11 (±10.2)	60.63 (±10.4)	0.03
Ave (μm)	379.17 (±52.8)	392.56 (±84.3)	0.346

Abbreviations: n, number of subjects; *P*, probability level; CCT, central corneal thickness; ECD, endothelial cell density; 6A, regular hexagonal cells in endothelium; Ave, average size of endothelial cells.

Table 3 Relationship between endothelial cell density and other parameters

Feature	Group 1 (n = 29)		Group 2 (n = 26)		Group 3 (n = 19)		Group 4 (n = 30)	
	Pearson	*P*-value	Pearson	*P*-value	Pearson	*P*-value	Pearson	*P*-value
CCT (μm)	0.363	0.053	0.324	0.106	0.309	0.198	–0.083	0.664
Ave (μm)	–0.981	0	–0.514	0.007	–0.952	0	–0.991	0
6A (%)	–0.114	0.555	0.087	0.672	–0.055	0.822	–0.015	0.938
Age (years)	–0.074	0.702	–0.322	0.109	–0.294	0.221	–0.181	0.338

Notes: Group 1, cataract; Group 2, glaucoma; Group 3, older healthy eyes; Group 4, young healthy eyes.
Abbreviations: n, number of subjects; *P*, probability level; CCT, central corneal thickness; 6A, regular hexagonal cells in endothelium; Ave, average size of endothelial cells.

Table 1 shows statistically significant data; a greater number of corneal endothelial cells that were smaller in size were observed in healthy young subjects (Group 4) relative to the number and size in older subjects (Groups 1–3). Furthermore, CCT and percentage of hexagonal cells in the corneal endothelium was not significantly different between groups. Cells in the corneal endothelium of males were significantly more hexagonal than in females in all groups. Other characteristics did not differ between sexes (Table 2).

Pearson's correlation coefficient and *P*-values were used to identify significant correlations (Tables 3 and 4). When ECD is larger, endothelial cells are smaller. The percentage of regular hexagonal endothelial cells did not correlate with ECD. A weak inverse correlation was observed between ECD and subject age, ECD, and CCT; thus, ECD and CCT decrease with age (Figures 1 and 2). Moreover, a weak direct correlation was observed between ECD and CCT, but determining generalized conditions was difficult due to the small group size (Figure 3).

Discussion

CCT was first measured in 1880. Since then, methods for investigating the cornea have significantly improved. New techniques for measuring corneal thickness and corneal endothelial cells were developed. A number of studies have examined CCT and endothelial cells to determine their clinical significance and the correlation of these values with eye diseases, age, and sex.

Our study confirmed previous data,[2,3,6] demonstrating that ECD is correlated with age. The number of corneal endothelial cells in healthy eyes decreases at the rate of approximately 0.5% per year.[10] We confirmed that dead cells are replaced by expanded healthy cells; this is not a consequence of the disease, but a process that occurs during natural aging. We examined four groups of subjects and found that older individuals have fewer corneal endothelial cells than do young individuals, regardless of the presence of eye disease. Various studies have focused on the effect of age on endothelial cells,[2,5,10–12] although the influence of eye diseases on corneal endothelial cells has not determined. A study by Hashemian et al unexpectedly found that the ECD and age are correlated up to 60 years of age; after this age, no correlation was observed between these parameters.[5]

The relationship between sex and ECD remains controversial. According to Snellingen et al, ECD in South Asian females is 2.9% higher than in males.[4] Higa et al revealed a correlation between male sex, increased intraocular pressure, and lower ECD.[6] We observed endothelium cells in males were more hexagonal than in females. No correlation was observed between sex and corneal thickness.[1]

Although most studies examined healthy human eyes,[2,3,5–8,10–12] other studies have focused on eyes with cataract[1,4] and on myopic adults.[13] By evaluating four groups, we included a wider range of subjects as well as patients with cataract and glaucoma.

Table 4 Relationship between central corneal thickness and other parameters

Feature	Group 1 (n = 29)		Group 2 (n = 26)		Group 3 (n = 19)		Group 4 (n = 30)	
	Pearson	*P*-value	Pearson	*P*-value	Pearson	*P*-value	Pearson	*P*-value
ECD (cells/mm^2)	0.363	0.053	0.324	0.106	0.309	0.198	–0.083	0.664
Ave (μm)	–0.355	0.059	–0.448	0.022	–0.361	0.129	0.085	0.654
6A (%)	–0.206	0.285	–0.092	0.0654	0.066	0.788	–0.235	0.212
Age (years)	–0.141	0.464	–0.572	0.002	0.215	0.377	–0.183	0.334

Notes: Group 1, cataract; Group 2, glaucoma; Group 3, older healthy eyes; Group 4, young healthy eyes.
Abbreviations: n, number of subjects; *P*, probability level; ECD, endothelial cell density; 6A, regular hexagonal cells in endothelium; Ave, average size of endothelial cells.

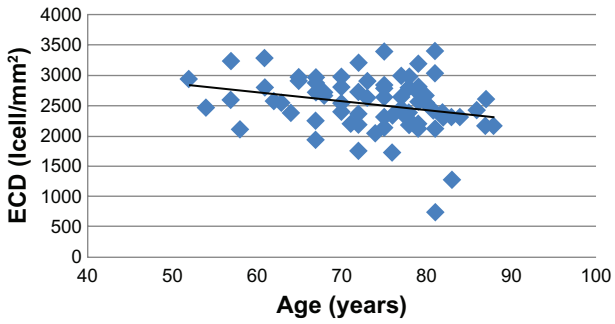

Figure 1 Relationship between endothelial cell density and age.
Abbreviation: ECD, endothelial cell density.

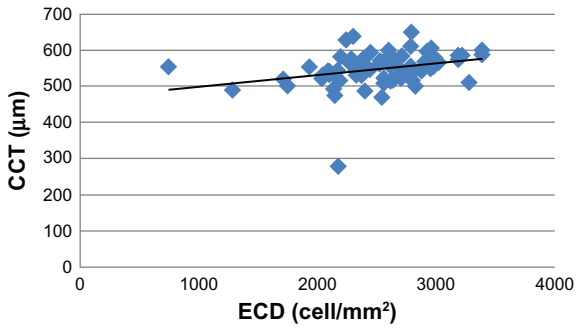

Figure 3 Central corneal thickness relation with endothelial cell density.
Abbreviations: CCT, central corneal thickness; ECD, endothelial cell density.

In our study, the average number of endothelial cells was 2641 (±462) (95% confidence interval [CI]: 2551–2731). This value was similar to previously published averages, including 2488 (±301),[1] 2720 (±1028),[4] and 2943 (±387).[6] According to Hollingsworth et al, the number of corneal endothelial cells was particularly high (3061 ± 382),[3] and Hashemian et al reported a lower ECD of 1961 (±457).[5] No statistically significant difference between results was identified.

In,[9–11] no correlation was observed between CCT and ECD in elderly subjects.

Conclusion

ECD is statistically significantly higher in younger subjects than in elderly subjects. Relative to elderly subjects, younger subjects have more endothelial cells and thinner corneas. Corneal endothelium cells in males are more regular hexagonal. There is no difference in CCT and ECD between sexes. CCT and average endothelial cell size do not differ among groups.

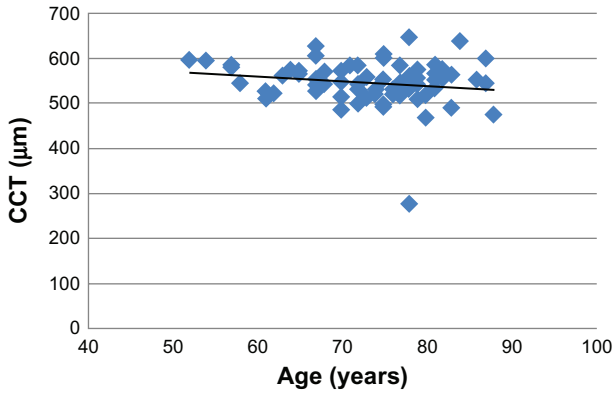

Figure 2 Relationship between central corneal thickness and age.
Abbreviation: CCT, central corneal thickness.

Disclosure

The authors report no conflicts of interest in this work.

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