Int Ophthalmol
DOI 10.1007/s10792-008-9249-8

ORIGINAL PAPER

The relationship between central corneal thickness and degree of myopia among Saudi adults

Hani S. Al-Mezaine · Saleh Al-Obeidan · Dustan Kangave · Abdulkareem Sadaawy · Taher A. Wehaib · Saleh A. Al-Amro

Received: 31 August 2007 / Accepted: 9 June 2008

Abstract *Purpose* To determine the relationship between central corneal thickness (CCT) and myopia among Saudi adults. *Methods* In a prospective study, the CCT of 982 myopic eyes and 158 emmetropic eyes as a control group was measured using ultrasound pachymetry at the Eye Consultants Center, Riyadh, Saudi Arabia. *Result* The mean myopic spherical equivalent (SE) was −3.7 ± 2.12 D, range −0.25 to −15.0 D.The mean CCT of the myopic group was 543.8 ± 35.40 μm, while for the emmetropic group it was 545.7 ± 27.6 μm. The difference in mean CCT between the two groups was statistically insignificant ($P = 0.5$). There was no correlation between CCT and the degree of myopic spherical equivalent ($r = -0.014$, $P = 0.939$). *Conclusion* This clinical study showed that there was no difference in CCT between emmetropic and myopic eyes. CCT did not correlate with the degree of myopia. It seems that the central cornea is not significantly involved in the process of myopic progression.

H. S. Al-Mezaine (✉) · S. Al-Obeidan · S. A. Al-Amro
Department of Ophthalmology, College of Medicine, King Saud University, PO BOX 230387, Riyadh 11321, Kingdom of Saudi Arabia
e-mail: almez2001@hotmail.com

D. Kangave
Diabetes Research Center, College of Medicine, King Saud University, Riyadh, Saudi Arabia

A. Sadaawy · T. A. Wehaib
The Eye Consultants Center, Riyadh, Saudi Arabia

Keywords Corneal thickness · Myopia · Pachymetry · Ultrasound

Introduction

Central corneal thickness (CCT) is an important indicator of corneal health status. As an estimate of the corneal barrier and endothelial function, CCT is an essential tool in the assessment and management of corneal disease [1]. Moreover, CCT is a measure of corneal rigidity and consequently has an impact on the accuracy of intraocular pressure measurement by applanation tonometry. Numerous studies have demonstrated that thicker corneas with greater rigidity may offer a greater resistance when subjected to applanation, resulting in artificially higher intraocular pressure readings [2–4]. In addition, with the development of corneal refractive surgery procedures, CCT values are of enormous importance during the pre-operative evaluation of the patients as they influence the decision whether or not to perform surgery, the type of recommended procedure, and rate of postoperative complications [5, 6].

Myopia is a common refractive error especially in Asian countries undergoing rapid development [7–9]. Myopia prevalence could be as high as 95% in medical school students [10].

Myopic changes of the eyes include elongated axial length [7], deeper anterior chamber [11], thinner retina with lattice changes and higher prevalence of retinal detachment [12], decreased choroid circulation [13], as well as decreased scleral thickness and elasticity [14, 15].

Studies that have attempted to investigate the effect of myopia on CCT have reported conflicting results. The aim of this study is to investigate the relationship between CCT and degree of myopia in Saudi adults who were being assessed for refractive surgery.

Patients and methods

Saudi patients included in this study were examined during the year 2006 in the Eye Consultants Center, Riyadh, Saudi Arabia. The study included a control emmetropic group of 158 eyes of 79 subjects with normal visual acuity and spherical equivalent (SE) of zero. This group consisted of volunteers from the Eye Consultants Center staff, and patients' relatives. The myopic group consisted of 982 eyes of 491 patients who were recruited from subjects referred to the refractive surgery clinic for Lasik assessment. The purpose of the study was explained to all participants and written informed consent was obtained from all patients.

The following data were collected from the preoperative examination: personal details, age, sex, manifest and cycloplegic refraction, intraocular pressure measurement, optical path difference scanning system (OPD scan), pentacam corneal topography (Oculus, Germany), and ultrasound pachymetry from both eyes.

CCT was measured with an A-scan ultrasound pachymeter (DGH technology, San Diego, CA, USA). The pachymeter was pre-calibrated for all measurements. The ultrasonic velocity was set at 1,640 m/s. Topical anesthesia with Novesin (0.4% benoxinate hydrochloride) was used. CCT was measured with patients seated upright. A hand-held probe was aligned as perpendicular as possible on the central cornea. Five readings were obtained and averaged. Pentacam was performed first to avoid any potential disturbance caused by the corneal contact involved in ultrasonic pachymetry. All measurements were taken between 1700 and 2100 hours and were done by a single observer.

The inclusion criteria included adults 18 years of age or older, spherical myopia between −0.25 and −15.0 D; cylinder of 3D or less; a stable refraction for at least 1 year, and no contact lens use for 2 weeks in case of soft lenses and 3 weeks for hard lenses before preoperative examination. Exclusion criteria included eyes with keratoconus or forme fruste keratoconus as demonstrated by OPD scan and/or pentacam. Eyes with suspected corneal dystrophy, known ocular pathology, or previous ocular surgery were also excluded.

Statistical analysis

Data were analyzed using SPSS version 11.0 for Windows. The distributions of CCT measurements for myopic and emmetropic eyes were inspected using histograms. For investigating the relationship between CCT and degree of myopia, the arbitrary groupings of myopic SE from −0.25 to −6.0 D for mild to moderate myopia and from −6.1 to −15.0 D for severe myopia, were used. Student's t test was used to compare means from two independent groups. A P value of less than 0.05 indicated statistical significance. The correlation between spherical equivalent and CCT was investigated using Pearson correlation coefficient and showed in the Scatter plot.

Results

A total of 982 eyes of 491 myopic patients and 158 eyes of 79 emmetropic controls were recruited. The majority of patients in the myopic group were females (60.7%), and the rest (39.3%) were males. The mean age of the patients was 27.7 ± 6.3 years (range 18–56 years), median 27 years (Table 1). For the control emmetropic group, there were 43 (54.4%) males and 36 (45.6%) females, and the mean age of the subjects was 30.3 ± 6.7 years (range 19–46 years), the median was 30 years.

The mean myopic spherical equivalent was –3.7 ± 2.12 D (range −0.25 to −15.0 D). The distribution of the myopic SE is shown in (Fig. 1). The spherical equivalent for males was −3.31 ± 1.79 D and for females was −4.03 ± 2.25 D (Table 1). The difference between the two means was statistically significant ($P < 0.001$, student's t-test).

The histogram for the distributions of CCT in the myopic and the control emmetropic group are shown

Table 1 Demographic features, degree of myopia, and CCT of the myopic patients ($n = 491$)

	Numbers	Mean CCT (μm)	Myopic SE
Sex			
Male	193 (39.3%)	544.3 ± 32.4	−3.31 ± 1.79
Female	298 (60.7%)	544.2 ± 33.5	−4.03 ± 2.25
Age (years)			
Mean (SD)	27.7 ± 6.3		
Range	18–56		
Median	27.0		
Spherical equivalent			
−0.25 to −6.00 D	846 eyes	543.2 ± 36.1	
−6.10 to −15.00 D	136 eyes	546.9 ± 30.6	

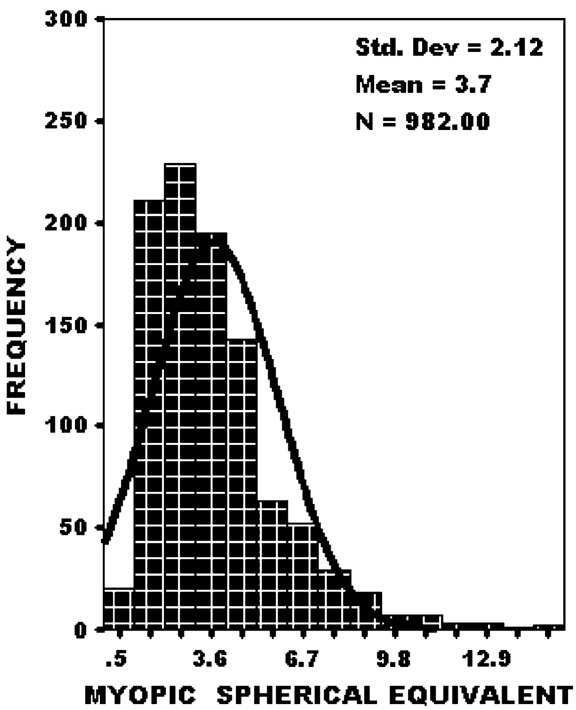

Fig. 1 Histogram showing the distribution of spherical equivalent in the myopic group

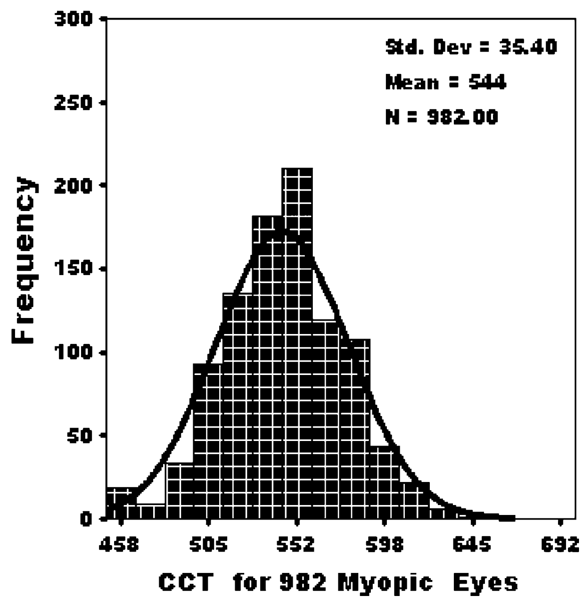

Fig. 2 Histogram showing the distribution of central corneal thickness in the myopic group

in Figs. 2 and 3. Both distributions appear similar and followed approximately the normal distribution curve with the mean CCT for the myopic group being 543.8 ± 35.40 μm and for the emmetropic group 545.7 ± 27.6 μm. The difference in mean CCT between the two groups were statistically insignificant ($P = 0.5$, Student's t test). In the myopic group, the mean CCT for males was 544.3 ± 32.4 μm and for females was 544.2 ± 33.5 μm. The difference between the two mean CCT was statistically insignificant ($P = 0.953$, Student's t test).There was no correlation between CCT and the degree of myopic spherical equivalent ($r = -0.014$, $P = 0.939$; Pearson's correlation coefficient) as shown in Fig. 4.

The mean CCT level for eyes with severe myopia were 546.9 ± 30.6 μm as compared to 543.2 ± 36.1 μm in the eyes with mild to moderate myopia, and the difference in mean CCT between the two groups was statistically insignificant ($P = 0.203$; Student's t test). In addition, there was no statistically significant difference between the mean CCT in the eyes with severe myopia compared to the eyes in the emmetropic group ($P = 0.7$; Student's t test).

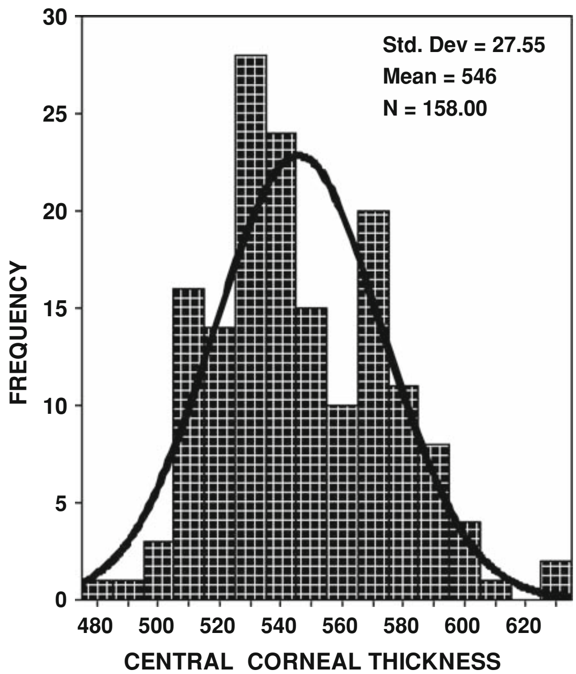

Fig. 3 Histogram showing the distribution of central corneal thickness in the emmetropic group

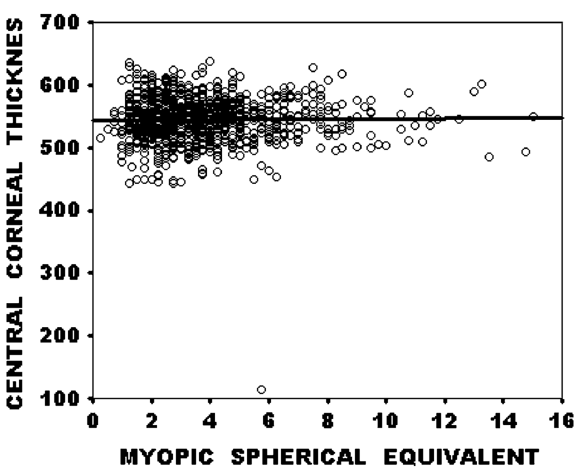

Fig. 4 Scatter plot showing the assocation between central corneal thickness and myopic spherical equivalent. Note that there is no signifiant association between CCT and the degree of myopia

Discussion

The effect of refractive status on CCT has been reported by many investigators. However, the results of these reports are conflicting. Some found that myopic subjects have a thicker [16], others a thinner CCT [17–20], while yet others found no correlation between CCT and myopia [21–31] (Table 2). This study showed no statistically significant difference between the mean CCT of the myopic and that of the emmetropic subjects. In addition, no significant differences were found in CCT mean levels between different levels of myopia. To the best of our knowledge, this study is the first to report CCT in myopic Saudi population.

The eyeball elongates during myopia progression. This progression not only makes the globe longer but also makes the sclera thinner [7, 14, 15], involving the posterior segment more significantly [12, 32]. In addition to the deepening of the anterior chamber found in higher myopia [11], there are dimensional changes in the anterior segment during myopia progression, but they are less well documented. Goss and his co workers [33] reported that eyes with greater vitreous depths tended to have flatter anterior corneal surfaces.

If the total corneal volume does not increase, we expect that the corneal stroma will become thinner in a similar way to the sclera during myopia progression. However, in our study, we did not find any statistically significant relationship between the CCT and presence of myopia. This observation agrees with Liu's series [27], where he concludes that the central corneal pachymetry correlated with the mean manual keratometric measurement, simulated keratometry, and intraocular pressure, but no correlation was noticed between CCT and the myopia in contact lens wearers. Neither did the CCT correlate with axial length, age, sex, horizontal corneal diameter, or refraction in Price's series [25]. In addition, Cho and Lam [26] found that CCT decreased with increasing age but not with refractive error or corneal curvatures. According to these observations, we think that if a stretching mechanism is really active, the thinning seems to be confined to the sclera only and does not involve the cornea.

In both Liu's and Price's series, the corneal thickness was measured in contact lens wearers. In addition, they did not specify the timing when corneal thickness was measured. Since great individual variation was noted after wearing contact lenses [34], this might confound the results. In our study, we took these factors into consideration. We thus deliberately measured the corneal thickness in the period between 1700 and 2100 hours to avoid the diurnal

Table 2 Overview of previously published papers with information on myopia and central corneal thickness

Author and year	Country	Method	No. of Subjects		Results CCT and Myopic
			Total	Myopic	
EGPS 2007 [31]	Europe	US	854	Unknown	No correlation
Fam et al. 2006 [30]	Singapore	Orbscan	714	714	No correlation
Oliveira et al. 2006 [29]	USA	US	140	140	No correlation
Aghaian et al. 2004 [28]	USA	US	801	Unknown	No correlation
Kunert et al. 2003 [16]	India	US/Orbscan	615	615	Thicker CCT in high myopic
Srivannaboon 2002 [20]	Thailand	Orbscan	280	280	Thinner CCT in high myopic
Chang et al. 2001 [19]	Taiwan	US	216	Unknown	Thinner in high myopic
Liu and Pflugfelder 2000 [27]	China	Orbscan	30	30	No correlation
Cho and Lam 1999 [26]	China	US	151	Unknown	No correlation in high myopic
Price et al. 1999 [25]	USA	US	450	Unknown	No correlation
Tanaka et al. 1996 [24]	Brazil	US	70	25	No correlation
Alsbirk 1978 [18]	Greenland	Optical	325	Unknown	Thinner CCT when myopic
Ehlers and Hansen 1976 [23]	Denmark	Optical	101	Unknown	No correlation
Hansen 1971 [22]	Denmark	Optical	113	Unknown	No correlation
Martola and Baum 1968 [21]	USA	Optical	121	Unknown	No correlation
von Bahr 1956 [17]	Sweden	Optical	125	12 eyes	Thinner CCT when > −4D

US Ultrasound pachymetry, *CCT* central corneal thickness, *EGPS* European Glaucoma Prevention Study

variation in corneal thickness and we excluded those subjects who wore contact lenses in the 2 weeks prior to the examination.

The inconclusive results of previous studies (Table 2) might be explained by any of the following: pachymeters with low reproducibility, inexperienced observers, no consideration of diurnal variation, the influence of contact lenses; genetic and racial difference in CCT, different criteria for exclusion, lack of highly myopic subjects, and too small sample size.

This study has a limitation that the axial lengths of the patients were not measured to differentiate those with axial myopia from those with index myopia. However, the study patients were recruited from a refractive surgery clinic and comprised patients with myopia who were assessed for LASIK, and such patients are not expected to have axial length measurement. Moreover, some investigators showed no relation between the CCT and axial length [29, 35].

In conclusion, in our study, the CCT of myopic and emmetropic eyes did not differ significantly. In addition, there was no correlation between CCT and the level of myopia. Therefore, it appears that the growth alterations in the ocular tunics of myopic subjects do not involve the corneal thickness.

Acknowledgments We would like to thank Bassam Abbara, Hanan Basoudan, Howaida Bakili for thire help with data processing.

References

1. Mishima S (1968) Corneal thickness. Surv Ophthalmol 13:57–96
2. Shah S, Chatterjee A, Mathai M (1999) Relationship between corneal thickness and measured intraocular pressure in a general ophthalmology clinic. Ophthalmology 106:2154–2160. doi:10.1016/S0161-6420(99)90498-0
3. Whiteacre MM, Stein RA, Hassanein K (1993) The effect of corneal thickness on applanation tonometry. Am J Ophthalmol 115:592–596
4. Herndon LW, Choudhri SA, Cox T, Damji K, Shield MB, Allingham R (1997) Central corneal thickness in normal, glaucomatous, and ocular hypertensive eyes. Arch Ophthalmol 115:1137–1141
5. Pallikaris IG, Kymionis GD, Astyrakakis NI (2001) Corneal ectasia induced by laser in situ keratomileusis. J Cataract Refract Surg 27:1796–1802. doi:10.1016/S0886-3350(01)01090-2
6. Binder PS (2003) Ectasia after laser in situ keratomileusis. J Cataract Refract Surg 29:2419–2429. doi:10.1016/j.jcrs.2003.10.012
7. Lin LL, Shih YF, Tsai CB, Chen CJ, Lee LA, Hung PT et al (1999) Epidemiologic study of ocular refraction among schoolchildren in Taiwan in 1995. Optom Vis Sci 76:275–281. doi:10.1097/00006324-199905000-00013

8. Hosaka A (1988) The growth of the eye and its components: Japanese studies. Acta Ophthalmol Suppl 185:65–68
9. Hosaka A (1988) Population studies: myopia experience in Japan. Acta Ophthalmol Suppl 185:37–40
10. Lin LL, Shih YF, Lee YC, Hung PT, Hou PK (1996) Changes in ocular refraction and its components among medical students-a 5-year longitudinal study. Optom Vis Sci 73:495–498. doi:10.1097/00006324-199607000-00007
11. Curtin BJ (1985) Ocular findings and complications. In: The myopias: basic science and clinical management. Harper and Row, Philadelphia, pp 277–385
12. Celorio JM, Pruett RC (1991) Prevalence of lattice degeneration and its relation to axial length in severe myopia. Am J Ophthalmol 111:20–23
13. Reiner A, Shih YF, Fitzgerald ME (1995) The relationship of choroidal blood flow and accommodation to the control of ocular growth. Vision Res 35:1227–1245. doi:10.1016/0042-6989(94)00242-E
14. Funata M, Tokoro T (1990) Scleral change in experimentally myopic monkeys. Graefes Arch Clin Exp Ophthalmol 228:174–179
15. Phillips JR, McBrien NA (1995) Form deprivation myopia: elastic properties of sclera. Ophthalmic Physiol Opt 15:357–362. doi:10.1016/0275-5408(95)00062-I
16. Kunert KS, Bhartiya P, Tandon R, Dada T, Christian H, Vajpayee RB (2003) Central corneal thickness in Indian patients undergoing LASIK for myopia. J Refract Surg 19:378–379
17. von Bahr G (1956) Corneal thickness: its measurement and changes. Am J Ophthalmol 42:251–266
18. Alsbirk PH (1978) Corneal thickness. 1. Age variation, sex difference and oculometric correlations. Acta Ophthalmol Scand 56:95–104
19. Chang SW, Tsai IL, Hu FR, Shih YF (2001) The cornea in young myopic adults. Br J Ophthalmol 85:916–920. doi:10.1136/bjo.85.8.916
20. Srivannaboon S (2002) Relationship between corneal thickness and level of myopia. J Med Assoc Thai 85:162–166
21. Martola EL, Baum JL (1968) Central and peripheral corneal thickness- a clinical study. Arch Ophthalmol 79:28–30
22. Hansen FK (1971) Clinical study of normal human central corneal thickness. Acta Ophthalmol Scand 49:82–89
23. Ehlers N, Hansen FK (1976) Further data on biometric correlations of central corneal thickness. Acta Ophthalmol Scand 54:774–778
24. Tanaka HM, Mori ES, Maia N, Freitas D, Campos M, Chamon W (1996) Corneal thickness in high myopes. Invest Ophthalmol Vis Sci 37:2566–2566
25. Price FW Jr, Koller DL, Price MO (1999) Central corneal pachymetry in patients undergoing laser in situ keratomileusis. Ophthalmology 106:2216–2220. doi:10.1016/S0161-6420(99)90508-0
26. Cho P, Lam C (1999) Factors affecting the central corneal thickness of Hong Kong Chinese. Curr Eye Res 18:368–374. doi:10.1076/ceyr.18.5.368.5347
27. Liu Z, Pflugfelder SC (2000) The effects of long-term contact lens wear on corneal thickness, curvature, and surface regularity. Ophthalmology 107:105–111. doi:10.1016/S0161-6420(99)00027-5
28. Aghaian E, Choe JE, Lin S, Stamper RL (2004) Central corneal thickness of Caucasians, Chinese, Hispanics, Filipinos, African Americans, and Japanese in a glaucoma clinic. Ophthalmology 111:2211–2219. doi:10.1016/j.ophtha.2004.06.013
29. Oliveira C, Tello C, Liebmann J, Ritch R (2006) Central corneal thickness is not related to anterior scleral thickness or axial length. J Glaucoma 15:190–194. doi:10.1097/01.ijg.0000212220.42675.c5
30. Fam HB, How AC, Baskaran M, Lim KL, Chan YH, Aung T (2006) Central corneal thickness and its relationship to myopia in Chinese adults. Br J Ophthalmol 90:1451–1453. doi:10.1136/bjo.2006.101170
31. European Glaucoma Prevention Study Group, Pfeiffer N, Torri V, Miglior S, Zeyen T, Adamsons I, Cunha-Vaz J (2007) Central corneal thickness in the European Glaucoma Prevention Study. Ophthalmology 114:454–459. doi:10.1016/j.ophtha.2006.07.039
32. Lam CS, Edward M, Millodot M, Goh WS (1999) A 2-year longitudinal study of myopia progression and optical component changes among Hong Kong schoolchildren. Optom Vis Sci 76:370–380. doi:10.1097/00006324-199906000-00016
33. Goss DA, Van veen HG, Rainey BB, Feng B (1997) Ocular component measured by keratometry, phakometry, and ultrasonography in emmetropic and myopic optometry student. Optom Vis Sci 74:489–495. doi:10.1097/00006324-199707000-00015
34. Schoessler JP, Baar JT (1980) Central thickness changes with extended contact lens wear. Am J Optom Physiol Opt 57:729–733
35. Shimmyo M, Orloff PN (2005) Corneal thickness and axial length. Am J Ophthalmol 139:553–554. doi:10.1016/j.ajo.2004.08.061