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Central and Peripheral Corneal Thicknesses in Cases with and without Keratoconus

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Abstract: Keratoconus is pathological condition of eye characterized by paraxial stromal thinning leads to corneal surface distortion. It is well documented that the corneal thickness is abnormally altered in keratoconus; but it seems that racial differences are exist in the amount of changes. This study compared the central and peripheral corneal thicknesses (CCT and PCT, respectively) in eyes with and without keratoconus in a large Iranian population. CCT and PCT were measured by ultrasonographic pachometry in ten thousands eyes undergoing refractive surgery during a six-year period (2003-2010) in Tabriz Nikookari Teaching Eye Hospital. These two variables were compared between the eyes with and without keratoconus. Two hundred and two eyes out of ten thousand eyes were diagnosed with keratoconus. The mean CCT and PCT were significantly lower in the eyes with keratoconus comparing with the others (CCT: 479.90±28.07 μm vs. 534.12±39.35 μm; $p<0.001$; PCT: 515.04±148.44 μm vs. 560.78±32.93 μm; $p<0.001$). This study confirmed that both CCT and PCT are lower in the eyes with keratoconus. Likewise, due to large sample size, the results can be used for epidemiological purposes.

Key words: Keratoconus, central corneal thickness, peripheral corneal thickness, ultrasonographic pachometry, refractive surgery

INTRODUCTION

Keratoconus is a progressive, noninflammatory, bilateral (but usually asymmetrical) disease of the cornea, characterized by paraxial stromal thinning that leads to corneal surface distortion. Visual loss occurs primarily from irregular astigmatism and myopia and secondarily from corneal scarring (Holopainen and Krootila, 2010). All layers of the cornea are believed to be affected by keratoconus, although the most notable features are the thinning of the corneal stroma, the ruptures in the Bowman layer and the deposition of iron in the basal epithelial cells, forming the Fleischer ring. Breaks in and folds close to the descemet membrane result in acute hydrops and striae, respectively (Sherwin and Brookes, 2004). The corneal thickness can be measured by different means, including the Ultrasonographic Pachometry (UP). Different studies have shown a high accuracy of UP in measuring the corneal thickness in the central and peripheral zones (Gherghel *et al*., 2004; Haque *et al*., 2006). Holladay (2009) concluded that standard corneal topography maps and simple clinical evaluation criteria are fundamental to detect keratoconus suspects and keratoconus (Holladay, 2009). Although there numerous studies about the topographic findings and the corneal thickness in the eyes with keratoconus, many of them are with limited results due to small sample sizes (Ucakhan *et al*., 2006; Kawana *et al*., 2005; Liu *et al*., 2002; Rufer *et al*., 2005; Nemeth *et al*., 2006). This study is performed on a large sample size of patients with and without keratoconus and to our knowledge, this is the first study in the Middle East region. This is important, because racial differences may have influence on the issue (Yo and Ariyasu, 2005). This study aimed at evaluating the central and peripheral corneal thicknesses in a huge number of eyes with and without keratoconus.

MATERIALS AND METHODS

Five thousand consecutive patients (10000 eyes) presenting to Tabriz Nikookari Teaching Hospital (a referral center in the northwest of Iran) for surgical correction of refractive errors were recruited during six years (2003-2009). The study was reviewed and passed by the Ethics Committee of Tabriz University of Medical Sciences and informed signed consent was obtained from all participants. The exclusion criteria were presence of keratoconus with extensive scar, presence of any other

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ophthalmic pathology and previous use of contact lens. Keratoconic eyes were diagnosed by combination of three procedures including slitlamp examination, retinoscopy and/or keratoscopy, and computerized topography (Humphrey® Atlas™ Corneal Topography Systems from Carl Zeiss Meditec, Inc., Germany) considering AK<47.5, AGC<1.5, SI<1.5 and Kpi = 0. Corneal curvature was measured by topography-based simulated keratometry (Sim K). Accordingly, the eyes divided into two groups; with and without keratoconus. Ultrasonographic pachometry (Sonomed® Micropach 200P, Japan) was employed for measuring the central and peripheral corneal thickness (shown as the CCP and PCT, respectively). Average of corneal thicknesses measured at the nasal, temporal, superior and inferior points three mm away from the central point considered as the PCT. All the measurements were performed by a skilled ophthalmologist. The mean CCT and PCT were compared between the two groups, as well as between the males and females. Correlations between the CCP, PCT, Sim K and age were assesses, too. Data were analyzed with the SPSS statistical software package (version 15.0; SPSS Inc., Chicago). One-ay ANOVA followed by tukey post hoc tests, independent samples t-test, cross-tabulation (Pearson Chi-square or Fisher's exact tests) and the correlation assessment (Pearson's r) were used. Stepwise logistic regression analysis was used to identify the independent factors among the parameters. Probability values <0.05 were considered statistically significant.

RESULTS AND DISCUSSION

Two hundred and two eyes (2.2) were diagnosed to be affected by keratoconus. Characteristics of the patients, as well as the results of the computerized topography and UP are summarized in Table 1. Accordingly, significantly more patients in the keratoconus group were male and affected with astigmatism as the main refractive error. In addition, the mean Sim K was significantly higher in the keratoconus group and the mean PCT and CCT were significantly higher in the group without keratoconus. The two groups were comparable for age of patients. After adjusting for gender and main refractive abnormality, the differences between the two groups in regard to the PCT and CCT remained significant ($p = 0.01$, ExpB = 1.1; $p<0.001$, ExpB = 1.2, respectively). Mean CCT and PCT were not significantly different between the males and females with keratoconus (CCT: 531.23±38.34 in males vs. 533.13±341.04 in females, $p = 0.06$; and PCT: 558.74±30.45 in males vs. 560.43±34.23 in females 0.07). Correlations between different parameters are shown in Table 2. Based on these results, there were weak reverse correlations between the Sim K and the PCT or CCT. There was a significant potent direct correlation between the PCT and CCT. No significant correlation was seen between the mentioned parameters and age of the patients.

In current study the CCT and PCT of then thousands eyes with different refractive abnormalities were measured by the UP method. The UP has been previously described as a noninvasive, simple and accurate method for measuring the corneal thickness with some limitations (Modis *et al*., 2001; Rainer *et al*., 2004; Fakhry *et al*., 2002). Inter and intra-observer variations are potential concerns in this regard (Higgins *et al*., 1993). In this study measurements of the UP were done by one trained and skilled observer in all eyes, so this possible error was minimized. Two hundred and twenty eyes (2.2) were affected with keratoconus. The mean central cornea was significantly thinner in the keratoconic eyes comparing with the controls (479.90±28.07 vs. 534.12±39.35 μm, respectively; $p<0.001$). By now, different studies have reported a mean value of CCT in eyes with and without keratoconus ranging from 462.5 to 686 and 509.13 to 581 μm, respectively (Herndon *et al*., 1997; Velten *et al*., 2000; Hahn *et al*., 2003; Wu *et al*., 2004; Sun, 1991).

Table 1: Characteristics and the main data of the studied group

Variables	All (5000 patients,10000 eyes)	With Keratoconus (110 patents, 220 eyes)	Without Keratoconus- (4890 patients, 9780 eyes)	p value
Gender				
male	2550 (51)	80 (72.7)	2470 (50.5)	0.04*
female	2450 (49)	30 (27.3)	2420 (49.5)	
Main refractive disease				
myopia	8414 (84.1)	14 (6.4)	8400 (85.9)	<0.001*
hyperopia	926 (9.3)	6 (2.7)	920 (9.4)	
astigmatism	660 (6.6)	200 (90.9)	460 (4.7)	
Age (year)	26.69±6.80	24.00±5.06	26.75±6.83	0.061
Sim K (diopter)	43.96±2.03	45.59±3.60	43.92±1.97	<0.001*
PCT (μm)	559.77±33.55	515.04±30.89	560.78±32.93	<0.001*
CCT (μm)	532.92±39.93	479.90±28.07	534.12±39.35	<0.001*

CCT: central corneal thickness, PCT: peripheral corneal thickness, Sim K: simulated keratometry. Data are shown as mean±standard deviation and frequency (percent). *Statistically significant

Table 2: Correlation between the numerical data in the studied population

Variables	Pearson's (r)	p value
Sim K vs. CCT	-0.132	<0.001*
Sim K vs. PCT	-0.097	0.02*
PCT vs. CCT	0.940	<0.001*
Sim K vs. age	0.044	0.17
CCT vs. age	-0.004	0.91
PCT vs. age	-0.002	0.94

CCT: Central Corneal Thickness, PCT: Peripheral Corneal Thickness, Sim K: Simulated keratometry. *Statistically significant

Gromacki and Barr (1994) reported a similar result in their study on 56 eyes with and without keratoconus (Gromacki and Barr, 1994). Reports of Avitabile *et al.* (1997) and Rabinowitz *et al.* (1998) are also indicate that the mean CCT is lower in the eyes with keratoconus . In another study by Fontes *et al.* (2009) in patients with unilateral keratoconus, central corneal thickness was 508 μm in the keratoconus group, 531 μm in the fellow eye group and 528.6 μm in the control group Amounts reported in this study are also similar to the results of current survey. Shah and Laiquzzaman (2009) also showed that the mean CCT was significantly lower in patients with keratoconus. It should be emphasized that the large sample size in the present study is unique. Furthermore, no previous reports are available about the mean CCT or PCT in patients with keratoconus or even a large number of normal eyes in this geographical region; considering that these two parameters might be greatly influenced by the racial differences (Pearson *et al.*, 2000). Similar findings were obtained for the mean PCT; i.e., it was also significantly lower in the keratoconic eyes comparing with nonaffected counterparts (515.04±30.89 vs. 560.78±32.93 μm; $p<0.001$). On the other hand, there was also a significant strong correlation between the CCT and PCT ($r = 0.940$, $p<0.001$). Accordingly, it may be concluded that the thinning or thickening of the cornea (with or without keratokonus) is a general entity and should not be confined to a particular region (for example the central portion). The peripheral measurements were not significantly different between the keratoconic and normal eyes in Avitabile's series (Avitabile *et al.*, 1997). Small sample size and employment of a nonstandard method of measurement may justify this finding. To the best of our knowledge, there is not any other report available in this regard. In current study, there was not any significant association between the CCT and age ($p = 0.94$) or gender ($p = 0.06$). Ertan and Muftuoglu (2008) demonstrated a clear inverse correlation between age and severity of keratoconus. It seems that this effect is not present for the topographic changes of cornea in patients with keratoconus. Prospero Ponce *et al.* (2009) concluded that the influence of age on PCT requires further study. The present study confirms that there is not a significant correlation between these two variables. Although there may be difference between the two genders regarding the clinical process and symptomatology of this condition Fink *et al.*, 2005, 2010), no similar studies have ever been performed in this regard.

CONCLUSION

This study confirmed that both CCT and PCT are lower in the eyes with keratoconus. Likewise, due to large sample size, the results can be used for epidemiological purposes.

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