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Corneal biomechanical properties distribution in myopic population

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近视人群中角膜生物力学特性的分布

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摘要

目的:分析伊朗近视眼及散光人群中角膜生物力学参数的分布特征。

方法:对接受激光矫正手术的近视眼及散光患者 180 眼进行前后节、显然验光等效球镜度、Orbscan II 和 Zywave 全面的术前检查。用眼反应分析仪测量角膜滞后量,角膜阻力因子,模拟 Goldmann 眼压值及角膜补偿后眼压值。分析所有角膜生物力学的分布特性及其与显然验光等效球镜度、性别和年龄的相关性。数据采用 SPSS 17 软件进行统计学分析,以 $P<0.05$ 为有显著性差异。

结果:平均年龄为 28.20±6.78 岁。平均显然验光等效球镜为-4.21±1.19D。平均角膜滞后量,角膜阻力因子,模拟 Goldmann 眼压值和角膜补偿后眼压值分别为 10.00±1.28mmHg, 10.17±1.45mmHg, 15.71±2.67mmHg 和 16.68±2.41mmHg。近视人群中,28.4%角膜滞后量约为 10mmHg,71%从 9mmHg 增长到 11mmHg。25.9%的近视人群的角膜阻力因子为 10mmHg,48.7%为 9mmHg 增长到 11mmHg。显然验光等效球镜与角膜滞后量(Rs=0.001,P=0.71)和显然验光等效球镜与角膜阻力因子(Rs=0.01,P=0.18)之间正相关性不明显。

结论:研究显示了伊朗近视眼人群中角膜生物力学的分布特征(角膜滞后量,角膜阻力因子,模拟 Goldmann 眼压值及角膜补偿后眼压值),并证实了角膜生物力学特性参数和显然验光等效球镜,年龄及性别之间没有统计学相关性。

关键词:角膜生物力学特性;角膜滞后量;角膜阻力因子;近视

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Abstract

• AIM: To evaluate distribution of corneal biomechanical measurements in normal myopia and myopic - astigmatism population.

• METHODS: One hundred and eighty eyes with myopia and myopic - astigmatism candidated for laser refractive surgery were included in this study. Complete examination of anterior and posterior segments, manifest refraction spherical equivalent (MRSE), Orbscan and Zywave were performed preoperatively. Ocular response analyzer (ORA) was used to measure corneal hysteresis (CH), corneal resistance factor (CRF), Goldmann - correlated intraocular pressure (IOPg) and corneal compensated IOP (IOPcc). Distribution of all corneal biomechanical properties and correlation between these parameters and MRSE, age and sex were determined. Statistical analysis was performed using SPSS 17 software and a P-Value less than 0.05 was considered significant.

• RESULTS: Mean age was 28.20±6.78 years. Mean MRSE was -4.21±1.19D. Mean CH, CRF, IOPg and IOPcc was 10.00±1.28mmHg, 10.17±1.45mmHg, 15.71±2.67mmHg and 16.68±2.41mmHg respectively. 28.4% of all myopic population had CH about 10mmHg, and 71% had CH, 9mmHg up to 11mmHg. CRF in 25.9% of myopic population was 10mmHg, and in 48.7% was 9mmHg up to 11mmHg. There was very poor positive correlation between MRSE&CH (Rs=0.001, P=0.71) and MRSE&CRF (Rs=0.01, P=0.18).

• CONCLUSION: Our study demonstrated the distribution of corneal biomechanical properties (CH, CRF, IOPg, IOPcc) in normal myopia and myopic-astigmatism population in Iran, and confirmed that, there was no statistically significant correlation between CH, CRF and MRSE, age and sex but there was significant correlation between IOPg, IOPcc and formerly mentioned parameters.

• KEYWORDS: corneal biomechanical properties; corneal hysteresis; corneal resistance factor; myopia
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INTRODUCTION

The corneal biomechanical properties measured by the Reichert ocular response analyzer (ORA) are corneal hysteresis (CH) and corneal resistance factor (CRF) which proposed by Luce and Taylor. According to the manufacturer of the ORA, CH is a measure of viscous damping in the corneal tissue, or the energy absorption capability of the cornea when an air pulse is directed against it causing a momentary deformation[1,2]. The CRF parameter is a measure of the cumulative effects of both the viscous damping and elastic resistance of the cornea and reflects the overall resistance of the cornea[2-4]. The CH and CRF parameters vary from person to person, providing distinct biomechanical information[1,2]. The introduction of ORA has made corneal biomechanical measurements convenience and easy[5]. On the other hand myopia is the most common ocular disorder. Myopia prevalence is about 30% (3% - 84%) of people worldwide. Several studies have reported the associations between the refractive error and corneal properties, but are still under debate[6].

Recently, studies of corneal biomechanics are increasing because of the influence of these properties on the measurement of intraocular pressure (IOP)[2,7-9] and outcomes of refractive surgery procedures[3,10]. For example, Chen *et al*[1] evaluated the corneal biomechanical measurements before and after laser *in situ* keratomileusis (LASIK). Ortiz *et al*[7] compared the corneal biomechanical properties in normal, post-LASIK and keratoconic eyes. Kirwan and O'keefe[11] compared the CH pre- and post-LASIK and LASEK procedure. The CH and CRF parameters vary from person to person, providing distinct biomechanical information. Refractive surgery as a specific example alters the biomechanical properties of the cornea, which are thought to play an important role in affecting treatment outcome. Thus, an *in vivo* method of measuring corneal biomechanics could be useful in identifying LASIK and photorefractive keratectomy (PRK) candidates and in predicting treatment response.

In this study we used the ORA to evaluate the distribution of corneal biomechanical properties in myopia and myopic-astigmatism population that candidate for laser refractive surgery. The signal of the biomechanical waveform analysis device provides a morphologically unique fingerprint for each eye and as mentioned earlier may contain valuable clinical information[4].

SUBJECTS AND METHODS

Subjects All patients had a complete preoperative assessment and were determined to be suitable candidates for myopic laser refractive surgery.

Study inclusion criteria were age greater than 20 years, myopia and myopic-astigmatism, normal cornea and normal eye and absence of background systemic diseases. There was not any forme fruste keratoconus in our series. After slit-lamp and fondus examination, the manifest refraction spherical equivalent (MRSE), and were performed. The ORA (reichert ophthalmic instruments, Depew, Ny) was used to measure, CH, CRF, IOPg and IOPcc.

Methods The device utilized a rapid air impulse to deform the cornea, and shape changes were monitored by an electro-optical system. The air puff induced inward and outward applanations of the cornea. The two pressures were averaged to provide the IOPg。CH was calculated as the difference between the two pressures caused by the inward and outward applanations. CRF and Corneal-compensated IOP (IOPcc) were also derived from specific combinations of the ORA-induced inward and outward applanation values[1-3,6,12].

Table 1 All parameters in myopic population

Parameter	Mean±SD (Range)
Age(a)	28.20±6.78 (20-51)
MRSE(D)	-4.21±1.91 (-10.75--0.80)
PPR(D)	-4.49±2.24 (-11.08-1.30)
CH(mmHg)	10.00±1.28 (7.30-13.50)
CRF(mmHg)	10.17±1.45 (7.30-14.40)
IOPg(mmHg)	15.71±2.67 (8.80-21.00)
IOPcc(mmHg)	16.68±2.41 (10.20-21.00)

MRSE: Manifest refraction spherical equivalent; PPR: Predicted phoropter refraction; CH: Corneal hysteresis; CRF: Corneal resistance factor; IOPg: Goldmann-correlated intraocular pressure; IOPcc: Corneal-compensated intraocular pressure.

Statistical Analysis Statistical analysis was performed using SPSS17 Software. Distribution of corneal biomechanical properties and correlation between these parameters and MRSE, age, and sex were evaluated using descriptive methods, linear regression Analysis and Eta correlation coefficient (r), and a P-value less than 0.05 was considered significant.

RESULTS

Totally 180 myopic eyes were included in this study that comprised 40% males and 60% females (Table 1). The mean age was 28.20±6.78 years (range 20 to 51 years). The mean MRSE and PPR (Predicted Phoropter Refraction) was -4.21±1.91D and -4.49±2.24D respectively. Our study demonstrated a wide range of individual variation in corneal hysteresis (7.30-13.50mmHg) and corneal resistance factor (7.30-14.40mmHg). In all myopic eyes, the mean CH and CRF was 10.00±1.28mmHg and 10.17±1.45mmHg respectively. The mean IOPg and IOPcc was 15.71±2.67mmHg and 16.68±2.41mmHg respectively (Table 1).

No linear correlation was observed between age and biomechanical properties for the CH ($P=0.41$, $r=0.002$), CRF ($P=0.61$, $r=0.004$), IOPg ($P=0.96$, $r=0.003$) and IOPcc ($P=0.51$, $r=0.002$). A linear regression model showed that, there was no significant correlation between MRSE and CH ($P=0.71$, $r=0.001$), or CRF ($P=0.18$, $r=0.01$).

The correlation between MRSE&IOPg and IOPcc was positive ($P=0.001$, $r=0.07$ and $P=0.001$, $r=0.07$ respectively). Relationship between gender and using Eta method analysis, CH&CRF was statistically significant ($P=0.03$ and $P=0.04$ respectively), but there was no statistically significant relationship between gender and IOPg&IOPcc ($P=0.11$ and $P=0.11$ respectively) (Figures 1,2).

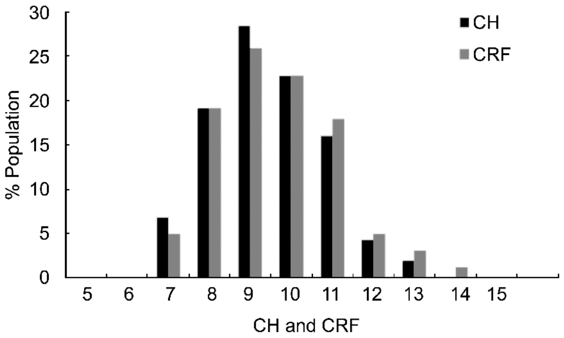

Figure 1　Corneal hysteresis and corneal resistance factor distribution in myopic population.

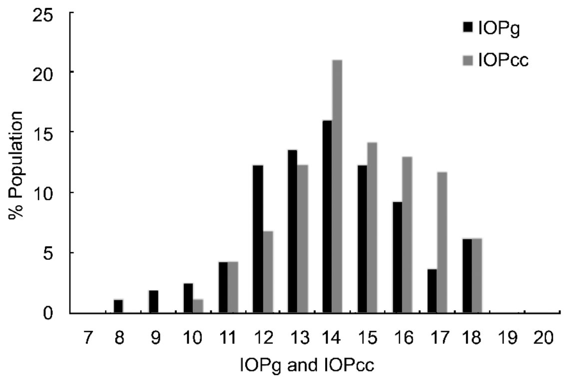

Figure 2　Goldmann correlated IOP and corneal compensated IOP distribution in myopic population.

DISCUSSION

The cornea is a complex composite of collagen, proteoglycans, water, and other elements. It is characterized by important local variation in the organization of central versus peripheral regions. The interlamellar adhesive strength of the central cornea depends on proteoglycan, whereas branching and interlacing of lamellae provide additional adhesive strength anteriorly and posteriorly. Thus the cornea has been modeled as a viscoelastie material with quantifiable biomechanical properties[1,5,13,14]. The corneal biomechanical properties measurement is now available, using the Reichert ORA, which is based on a dynamic bidirectional applanation process.

As shown by Luce[13], CH is altered in some clinical conditions such as Fuch's dystrophy, keratoconus, LASIK and glaucoma. These corneal pathologies and physiological variations may induce changes of corneal biomechanical properties and lead to decreases in CH. Other corneal pathological conditions such as stromal and epithelial edema as well as the early and late stages of keratoconus also affect CH. In glaucoma patients decreases in CH were associated with progressive worsening of visual field and some studies showed that CH decreased after LASIK surgery[3,7,8,15-18]. Our study demonstrated a wide range of individual variation in CH (7.30-13.50mmHg) and (7.30-14.40mmHg). Mean CH and CRF was 10.00±1.28mmHg and 10.17±1.45mmHg respectively. Mean CH and CRF in Chen *et al*[1] study in myopic patients was 11.52±1.28mmHg and 11.68±1.40mmHg respectively and range of CH&CRF was 9.25-14.30mmHg and 8.55-14.70mmHg respectively. Kirwan and O'keefe[11] reported the mean CH, in 84 myopic eyes 10.8±1.5mmHg with range of 6.9-13.7mmHg. Previous studies by Shah *et al*[17] demonstrated, mean of CH and CRF, in normal eyes, 10.7±2.00mmHg and 10.30±2.00mmHg respectively, and Luce[13] reported the CH in normal population about 9.60mmHg.

Shen *et al*[2] showed that CH was negatively correlated with SE (spherical equivalent) when the two groups were combined for analysis. This may indicate that the degree of myopia has an important role in the change of CH and they hypothesized that the higher myopia the more alterations occur in biomechanical properties of the cornea. They showed that CH was significantly lower in high myopia patients compared with normal subjects; CRF was similar in both groups. The results indicate that some compromised aspects of the biomechanical properties of cornea may exist in people with high myopia. Jiang *et al*[6] showed that CH is similar for non-myopic, low myopic and moderate myopic eyes, but significantly lower in high myopic eyes compared with the other three groups. These results indicate that CH is a useful additional assessment for the progression of myopia.

According to Luce[13], CRF is an optimized corneal biomechanical parameter that is independent of IOP and is strongly correlated with CCT in normal subjects. CRF decreased in patients with keratoconus and LASIK, and in each of these disease, CCT also decreased due to corneal damage or surgery[3,7]. The variations of CCT are associated with changes in corneal integrity that in turn may cause changes in CRF. Thus the CRF may be related to corneal hydration and possibly some other as yet unknown aspects of corneal biomechanics and CRF is a corneal factor that reflects the integrity of cornea[2]. The lack of association of CRF with the degree of myopia indicates that some aspects of the CRF are still not understood.

In this study we found the most (28.4%) myopic population had CH about 10mmHg and 87% had CH, 8mmHg up to 12mmHg, and CRF in 25.9% of myopic eyes was 10mmHg, and in 80% was 8mmHg up to 12mmHg.

In general, it seems that in our study CH and CRF between normal and myopic population have not significant difference and this is in contrast with some of the previous studies as mentioned earlier. However other previous studies did not show a correlation between myopia and biomechanical properties of the cornea neither did our study. This is probably attributed to differences between the studies in the range of age and/or refractive status, and ethnics for the subjects are selected[19,20]. For instance, in our study the subjects were much younger and the mean refraction was much lower. These results support that only high myopic eyes have a compromised corneal mechanical strength. In addition, other factors such as corneal curvature, race, axial length, and retinal vascular caliber may also influence the correlation between myopia and biomechanical properties of the cornea[6].

Consistent with Qazi *et al*[18] and Altan *et al*[21] study in myopic group (mean MRSE: −5.32D), in our study mean IOPg and IOPcc was 15. 71 ± 2. 67mmHg and 16. 68 ± 2. 41mmHg respectively.

Ortiz *et al*[7] study demonstrated that, mean of IOPg and IOPcc in normal control group was 16. 3±3. 5mmHg and 16. 2± 3. 5mmHg respectively. IOPg and IOPcc in Chen *et al*[1] study was 16. 31±4. 00mmHg and 16. 00±3. 32mmHg in myopic yes (MRSE = −4. 04D). Edward and Brown[22] found that myopic patients had higher IOP than the controls or subjects who not develop myopia. Similar to previous studies, IOPcc measurements provided by the ORA are less influenced by corneal properties than those provided by Goldmann applanation tonometery, and appears to be a better clinical measurement[6]. In this study IOPg and IOPcc measured by ORA were negatively correlated to the refraction. These findings are consistent with several previous reports suggesting a positive correlation between IOP and increasing degree of myopia[2,3,7]. There is an increased prevalence of glaucoma among myopic eyes compared with non−myopic eyes. These results demonstrate that myopia increases IOP by an elevated stress of the global wall and a declined ocular rigidity and especially, coneal biomechanical properties potentially affect the accuracy of IOP measurements.

In conclusion, our study demonstrated the distribution of corneal biomechanical properties in normal myopic and myopic−astigmatism population in Iran, and confirmed that, there was no statistically significant linear correlation between corneal biomechanical properties (CH, CRF) and MRSE, patients' age and gender.

Additionally, this study showed that, the quantitative values of corneal biomechanical properties in myopic population, is similar to normal population but further studies with large sample sizes with age and gender match need to be considered to confirm this relationship.

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