ARTICLE

Ocular anterior segment changes in pregnancy

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PURPOSE: To evaluate the changes occurring in the cornea, anterior segment anatomy, and intraocular pressure (IOP) in pregnant women.

SETTING: Department of Ophthalmology, Assaf Harofeh Medical Center, Zerifin, Israel.

DESIGN: Prospective single-center comparative study.

METHODS: The Ocular Response Analyzer dynamic bidirectional applanation device and the Pentacam HR Scheimpflug imaging system were used to obtain data on the anterior eye segments of healthy pregnant and nonpregnant women.

RESULTS: Sixty pregnant and 60 nonpregnant women were enrolled. The Goldmann-correlated IOP and corneal-compensated IOP were significantly lower in the pregnant group (mean 10.96 mm Hg versus 12.97 mm Hg, $P<.001$; and 10.97 mm Hg versus 13.16 mm Hg, $P<.001$, respectively). The corneal front steep keratometry value was statistically significantly higher in the pregnant group (44.81 diopters [D] versus 44.1 D, $P=.039$). No significant difference was found in corneal hysteresis, the corneal resistance factor, corneal posterior curvature, central corneal thickness and volume, anterior chamber depth and volume, or iridocorneal angle.

CONCLUSIONS: Pregnancy was associated with greater corneal curvature and lower IOP. Further studies should be performed to learn whether these alterations result from changes in corneal biomechanical properties during pregnancy.

Financial Disclosure: No author has a financial or proprietary interest in any material or method mentioned.

J Cataract Refract Surg 2014; 40:1868–1871 © 2014 ASCRS and ESCRS

Hormonal changes associated with pregnancy may influence a woman's cornea. Corneal thickness, corneal curvature, and corneal biomechanical parameters have been found to be affected by variations in sex hormones.[1–5] Corneal thickness has been found to increase during pregnancy, resolving postpartum.[2] A possible cause of increased corneal thickness is fluid retention related to pregnancy. The corneal curvature is also found to increase by an average of 1.00 diopter (D) in the second half of pregnancy, resolving postpartum or after cessation of breastfeeding.[1] Hormonal changes during pregnancy may affect corneal biomechanics because pregnancy has been described as a potential risk factor for the progression of keratoconus.[6] Women taking contraceptives report problems with hard contact lenses, and pregnant women frequently report contact lens intolerance.[7,8] These changes are probably driven by direct interaction of sex hormones with sex hormone receptors located in the human cornea.[9,10]

The ability to assess and predict these corneal changes during pregnancy might have clinical implications, such as need to change spectacles, intolerance to contact lenses, and decisions regarding performing

Submitted: December 13, 2013.
Final revision submitted: February 19, 2014.
Accepted: February 20, 2014.

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Published by Elsevier Inc.

0886-3350/$ - see front matter
http://dx.doi.org/10.1016/j.jcrs.2014.02.042

(delay in performing) refractive eye surgery. For that reason, the aim of our study was to evaluate the changes in the biomechanical properties of the cornea, anterior segment anatomy, and intraocular pressure (IOP) in pregnant women.

SUBJECTS AND METHODS

This prospective case-control study enrolled healthy pregnant women and a control group of healthy nonpregnant women visiting the Assaf Harofeh Medical Center Obstetrics and Gynecology department for regular checkups. Nonpregnancy was confirmed by a urine pregnancy test. The study protocol received institutional review board approval and followed the tenets of the Declaration of Helsinki. All participants signed an informed consent form approved by the local ethics committee.

The exclusion criteria were preexisting ocular surface pathology, history of eye trauma, contact lens wear, previous eye surgery, use of eyedrops, and known eye pathology. Only the right eye, fulfilling all the inclusion criteria and none of the exclusion criteria, was designated as the study eye.

A standardized examination was performed in all subjects by the same observer (Y.G.). The examination included a medical and ocular history, measurement of corrected Snellen visual acuity, subjective refraction, slitlamp biomicroscopy, fundus examination, corneal biomechanical assessment with a dynamic bidirectional applanation device (Ocular Response Analyzer, Reichert Ophthalmic Instruments), and anterior segment tomography by a Scheimpflug imaging system (Pentacam HR, Oculus Optikgeräte GmbH).

An experienced clinician (Y.G.) performed 3 dynamic bidirectional applanation device measurements in all subjects. Three good-quality (symmetric, well-defined inward and outward applanation spike height) measurements were obtained in each eye. The mean of these 3 readings was used in the analysis according to the manufacturer's instructions. The automatic release mode of the Scheimpflug imaging system was used to determine when correct focus and alignment with the corneal apex had been achieved. This reduced operator-dependent variables associated with manual scanning. Imaging was performed using the 50-scan setting obtained in 2 seconds. Only scans that had an examination quality specification graded as “OK” were saved.

Statistical Analysis

The data are presented as the mean ± standard deviation (SD). The unpaired 2-tailed Student *t* test was used to assess differences in respective parameters in the pregnant group and the control group. The distributions of values in each dataset were evaluated using graphs. A *P* value of 0.05 was selected for the threshold of statistical significance. Analyses were performed using Excel software (Microsoft Corp.).

RESULTS

The study included 120 eyes of 120 subjects, 60 pregnant women (study group) and 60 nonpregnant women (control group). The mean age of the study group and the control group was 29.7 years ± 4.6 (SD) and 28.0 ± 7.4 years, respectively ($P = .1$). The mean gestational age was 31.2 ± 8.9 weeks.

Table 1. Parameters measured using the dynamic bidirectional applanation device.

Parameter	Mean (mm Hg) ± SD Pregnant	Mean (mm Hg) ± SD Control	*P* Value
CH	11.39 ± 1.5	11.00 ± 1.3	.14
CRF	9.89 ± 1.7	10.17 ± 1.6	.37
IOPg	10.96 ± 3.1	12.97 ± 2.7	<.001
IOPcc	10.97 ± 2.8	13.16 ± 2.2	<.001

CH = corneal hysteresis; CRF = corneal resistance factor; IOPcc = corneal-compensated intraocular pressure; IOPg = Goldmann-correlated intraocular pressure

Table 1 and Figure 1 compare the ocular parameters obtained with the dynamic bidirectional applanation device in the study group and the control group. No statistically significant difference in corneal hysteresis (CH) and corneal resistance factor (CRF) measurements was found between the 2 groups. The IOP, presented as Goldmann-correlated IOP and corneal-compensated IOP, was statistically significantly lower in the pregnant group ($P < .001$).

Table 2 compares the ocular parameters obtained with the Scheimpflug imaging system in the study group and the control group. The study group had statistically significantly higher keratometry (K) values on the front steeper axis than the control group ($P = .039$). No significant difference was observed in back curvature, pachymetry, corneal volume, anterior chamber depth and volume, or iridocorneal angle.

DISCUSSION

In the present study, pregnant women had lower IOP values and steeper corneas than nonpregnant women.

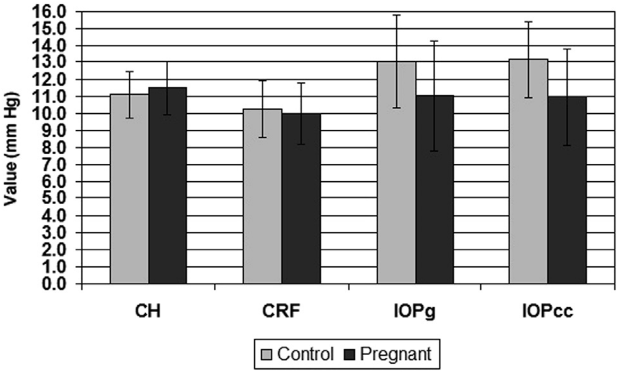

Figure 1. Intraocular pressure and corneal biomechanical parameters in the pregnant and control groups (CH = corneal hysteresis; CRF = corneal resistance factor; IOPcc = corneal-compensated intraocular pressure; IOPg = Goldmann-correlated IOP).

Table 2. Scheimpflug measured parameters and their mean values and statistical significance.

Parameter	Mean ± SD		*P* Value
	Pregnant	Nonpregnant	
Cornea front flat K (D)	43.76 ± 1.33	43.37 ± 1.58	.19
Cornea front steep K (D)	44.81 ± 1.48	44.15 ± 1.61	.039
Cornea back flat K (D)	−6.13 ± 0.20	−6.07 ± 0.22	.16
Cornea back steep K (D)	−6.47 ± 0.26	−6.39 ± 0.24	.11
Pachymetry at pupil center (μm)	540.40 ± 32.89	539.35 ± 28.94	.87
Pachymetry at corneal apex (μm)	539.25 ± 33.78	540.16 ± 29.10	.89
Pachymetry, thinnest local (μm)	536.46 ± 33.93	537.47 ± 28.58	.87
Cornea volume (μL)	59.85 ± 4.15	59.37 ± 3.22	.54
Chamber volume (μL)	167.40 ± 28.97	172.66 ± 39.09	.45
Iridocorneal angle (°)	38.85 ± 6.71	37.82 ± 5.75	.43
Anterior chamber depth (mm)	3.02 ± 0.31	3.01 ± 0.33	.85

Reduction of IOP during pregnancy was previously described.[2,11,12] Weinreb et al.[2] reported a 10% decrease in IOP and a 3% increase in central corneal thickness associated with pregnancy. They suggest that the decreased IOP may be explained by an increase in corneal thickness due to retention of water in the corneal stroma; however, no correlation between these 2 parameters was found. In normal corneas, small amounts of swelling should result in tonometric overestimation.[13] In our study, no difference in corneal thickness between pregnant women and nonpregnant women was observed. Similarly, Park et al.[3] and Manges et al.[14] studied the ocular effects of pregnancy and found that corneal thickness did not change significantly during pregnancy. Considering that we did not observe significant differences in the anterior chamber volume and depth, corneal thickness and volume, or iridocorneal angle between pregnant women and nonpregnant women, the IOP differences cannot be explained by static anatomic changes on a macro level. Theoretically, some dynamic changes in aqueous physiology may be implicated. Indeed, Green et al.[11] showed that pregnancy is associated with a decreased IOP and increased aqueous outflow capacity. They suggest that sustained elevated sex hormone levels during pregnancy are responsible for blocking the ocular hypertensive effects of endogenous corticosteroids.

In the present study, pregnant women had statistically significantly higher steep K values than the nonpregnant women. Previous studies of the relationship between K values and pregnancy are rather contradictory. Manges et al.[14] did not find any change in corneal curvature during pregnancy. Park et al.[3] report an increase in corneal curvature during the second and third trimesters that resolved postpartum or after the cessation of breastfeeding. Hypothetically, physiologic hormonal changes that happen during pregnancy may influence corneal curvature by changing the surrounding soft tissue pressure on the cornea or by changing the biomechanical stability of the cornea.

The CH and CRF are new parameters that assess corneal biomechanical response to an air puff.[15] These parameters are reported to decrease in biomechanically weak corneas, such as eyes with keratoconus or after laser in situ keratomileusis surgery.[15] A decrease in the CH and CRF values was observed during the menstrual cycle and associated with ovulation and elevation in the level of estrogen.[5] In our study, we used the Ocular Response Analyzer dynamic bidirectional applanation device to assess whether hormonal changes during pregnancy may also lead to a decrease in these biomechanical parameters. Bilgihan et al.[6] describe 4 patients with progression of keratoconus and a change in corneal topography during pregnancy. None of the patients had associated diseases or predisposing factors for keratoconus progression, and the authors implied that pregnancy by itself, with its associated hormonal alternations, might be a risk factor for progression of keratoconus. However, in the present study, we found no significant difference in the CH and CRF values between pregnant women and nonpregnant women. Similar findings were recently reported by Sen et al.[16] Experimental studies by Spoerl et al.[17] showed the role of estrogen as a modulating factor in the biomechanical properties of the cornea. Increased levels of estrogen lead to a reduction in corneal stiffness, which is not explainable by an increased corneal swelling.

Understanding that CH and the CRF are viscoelastic parameters and not directly associated with corneal stiffness, further studies should be performed to assess corneal stiffness during pregnancy. In a normal pregnancy, the estrogen level increases but the biomechanical effect of estrogen is widely compensated for by the hormone progesterone. Progesterone inhibits prostaglandin production, whereas estrogen increases prostaglandin synthesis. Prostaglandins lead to an increase in collagenases. Other hormones may also play an important role in corneal biomechanics. Relaxin, which is known for its collagenolytic properties mediated by collagen-degrading enzymes and matrix metalloproteinases, is elevated during pregnancy and may weaken the corneal collagen matrix.[18]

In conclusion, hormonal changes during pregnancy may lead to decreased IOP and increased corneal curvature. Further studies should be performed to determine whether these alterations result from changes in corneal stiffness that are not evaluated by CH and the CRF.

WHAT WAS KNOWN

- Several studies showed that pregnancy might influence IOP and corneal curvature.

WHAT THIS PAPER ADDS

- Pregnant women had lower IOP and steeper corneal curvature.
- Current available technology cannot determine whether there are changes in corneal biomechanics induced by pregnancy.

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