BMC Ophthalmology

RESEARCH

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Pregnancy-induced ocular changes: impacts on intraocular pressure, the cornea, and the anterior chamber

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Abstract

Background This study aims to comprehensively evaluate the trimester-specific effects of pregnancy on intraocular pressure, corneal biomechanics, anterior segment anatomy, and endothelial cell morphology.

Methods This prospective cross-sectional study included 90 healthy pregnant women (30 per trimester) and 30 age-matched non-pregnant controls. Comprehensive ophthalmological assessments were performed, including IOP measurement using a non-contact tonometer, corneal structure evaluation with Pentacam Scheimpflug imaging, and endothelial cell analysis using a specular microscope.

Results A significant decrease in IOP was observed in the third trimester compared to the control group ($p=0.016$), although no significant difference was noted in the first and second trimesters ($p>0.05$). Corneal endothelial analysis revealed a significant decrease in hexagonal cell percentage (HEX) values during the first trimester ($p=0.007$). Correlation analysis demonstrated a strong positive relationship between central corneal thickness (CCT) and corneal volume ($r=0.817$, $p<0.001$) and a moderate positive correlation between CCT and IOP ($r=0.263$, $p=0.004$). Axial length was strongly negatively correlated with both flat keratometry (r=-0.562, $p<0.001$) and steep keratometry (r=-0.538, $p<0.001$), and strongly positively correlated with anterior chamber volume and anterior chamber depth ($r=0.380$, $p<0.001$ and $r=0.384$, $p<0.001$, respectively). A moderate positive correlation was also identified between gestational trimester and HEX ($r=0.257$, $p=0.005$).

Conclusions Pregnancy induces temporary but significant ophthalmological changes, particularly a decrease in IOP in the third trimester and a decrease in HEX in the first. These findings highlight the importance of monitoring ocular health during pregnancy to detect potential risks early and ensure timely intervention.

Keywords Pregnancy, Intraocular pressure, Endothelial cell morphology, Corneal biomechanics, Anterior segment parameters

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Introduction

Pregnancy is a complex process in which hormonal, metabolic and anatomical changes occur in the female body [1]. These changes not only affect the general body systems, but also lead to various changes in the anterior and posterior segments of the eye [2–6]. Changes in the anterior segment of the eye, including parameters such as corneal thickness (CCT), corneal curvature (keratometry), anterior chamber depth (ACD) and intraocular pressure (IOP), yield clinically important findings as a result of physiological adaptations and in terms of the management of ocular diseases [2, 3, 7, 8]. A better understanding of these changes during pregnancy is critical for ophthalmological evaluations and disease management.

Various findings have been reported regarding the effects of pregnancy on IOP. Most studies show that IOP decreases significantly in the second and third trimesters of pregnancy in particular [7, 9, 10]. This decrease has been potentially attributed to factors such as hormonal changes, increased aqueous outflow, and decreased systemic vascular resistance [11]. However, other studies have reported no significant change in IOP during pregnancy [12]. These changes in IOP are thought to be important for the management of ocular diseases such as glaucoma during pregnancy.

The cornea is sensitive to hormonal changes during pregnancy, but studies show conflicting results about corneal thickness and curvature. Some research reports an increase in CCT during pregnancy [7, 13], while others find no significant change [4, 14]. Similar inconsistencies exist for corneal curvature, with some studies noting a decrease in keratometry values postpartum [8], and others reporting an increase during pregnancy [2, 10, 15]. These variations are important when considering ophthalmic procedures like refractive surgery during pregnancy. Corneal endothelial cells are essential for maintaining corneal transparency and function. The density, morphology, and functionality of these cells can be affected by systemic changes such as pregnancy. Specular microscopy is an important method for evaluating changes in these cells, but currently, only one study has examined changes in parameters like cell density (CD), hexagonal cell percentage (HEX), and coefficient of variation (CV) during pregnancy [14].

This study compared IOP, CCT, corneal curvature, anterior chamber, and corneal endothelial values of pregnant women in different trimesters with those of a non-pregnant control group to reveal the effects of pregnancy on the anterior ocular segment in detail. We think that the findings will make an important contribution to the diagnosis and treatment of glaucoma and other ocular diseases during pregnancy. The results may provide valuable data for the planning of applications such as refractive surgery during pregnancy.

We hypothesize that pregnancy induces significant and measurable changes in IOP, corneal thickness, corneal curvature, anterior chamber parameters, and corneal endothelial morphology compared to non-pregnant women, and that these changes vary across different trimesters.

Materials and methods

Participants and study design

This prospective cross-sectional study was conducted in accordance with the ethical standards of the Declaration of Helsinki and with the approval of Harran University Faculty of Medicine ethics committee, Türkiye (2024.21.10-406728). Written informed consent was obtained from all participants. Pregnant and non-pregnant healthy women who presented to the Harran University Faculty of Medicine ophthalmology and gynecology outpatient clinics between December 2024 and February 2025 were included. One hundred twenty women were enrolled and divided into four groups according to their gestational weeks:

- First Trimester Group: 30 pregnant women between weeks 1 and 13 of gestation.
- Second Trimester Group: 30 pregnant women between weeks 14 and 27 of gestation.
- Third Trimester Group: 30 pregnant women between weeks 28 and 40 of gestation.
- Control Group: 30 non-pregnant healthy controls age-matched with the pregnant women.

All participants were enrolled following evaluation of age, refractive status, and ocular history.

Inclusion criteria

- Age 20–40.
- Singleton pregnancy only.
- Refractive error within ± 3.0 diopters.

Exclusion criteria

- Previous history of eye surgery.
- Use of contact lenses.
- History of systemic disease (e.g. diabetes mellitus, pre-eclampsia, or hypertension).
- History of ocular disease (e.g. glaucoma, uveitis, or corneal dystrophy).
- Smoking or high-risk factors identified during pregnancy.

All measurements were based on data from the right eyes only.

Ophthalmological examinations

All participants underwent a detailed ophthalmological examination performed by the same specialist ophthalmologist and including the following measurements:

1. Refractive Error: These measurements were performed using a Nidek ARK-700 A auto refractometer (Nidek Co., Ltd., Japan). The measurements were repeated at least three times, and mean values were recorded.
2. Best Corrected Visual Acuity (BCVA): Measured using Snellen's threshold. It has been converted to logMAR.
3. IOP: Measurements were performed with a NIDEK NT-2000 non-contact tonometer (Nidek Co. Ltd., Japan) by taking three consecutive values and calculating the mean thereof. Measurements were carried out between 09:30 and 11:00 a.m.
4. Biometry: Axial length (AL) and intraocular lens power (IOLP) were measured using IOLMaster 500 (Carl Zeiss Meditec AG, Germany).
5. Corneal Topography: Corneal curvature and anterior segment parameters were evaluated using a Pentacam Scheimpflug topography device (Oculus Optikgeräte GmbH, Germany).
   Parameters: K1 (straight meridian curvature), K2 (steep meridian curvature), maximum keratometry (Kmax), CCT, thinnest corneal thickness (TCT), corneal volume (CV), anterior chamber volume (ACV), ACD, and anterior chamber angle (ACA) were measured.
6. Specular Microscopy and Corneal Endothelial Evaluation: Endothelial cell morphology was examined using a NIDEK CEM-530 specular microscope (Nidek Co., Ltd., Japan). Measurements were performed between 09:30 and 11:00 a.m. A minimum of 110 cells was manually analyzed in each measurement.

Parameters: -CD: Numerical density of endothelial cells (cells/mm^2).

- Average cell area (AVG): Area of cells of average size (μm^2).
- Standard deviation (SD): Standard deviation of the mean cell area (μm^2).
- HEX: The regularity of endothelial cells (%).
- CV: Variability in cell size.
- Area of the largest cell (Max): Area (μm^2) of the largest of the cells within the evaluation frame.
- Area of the smallest cell (Min): The area (μm^2) of the smallest of the cells within the evaluation frame.

Statistical analysis

Statistical analysis was performed on Statistical Package for the Social Sciences version 25 software. The Kolmogorov-Smirnov test was applied to assess the assumption of normality of numerical variables. Continuous variables were expressed as the mean ± standard deviation or the median (interquartile range, IQR). Student's t-test was used to compare variables with normal distribution between two groups, and the Mann-Whitney U test for non-normally distributed variables. Normally distributed variables were compared between more than two groups using One-Way ANOVA (Welch's test), and non-normally distributed variables with the Kruskal-Wallis test. Spearman's correlations were applied to assess relationships between continuous or ordinal variables. A p-value less than 0.05 was regarded as statistically significant.

Results

The study involved 90 pregnant women (30 for each trimester) and 30 age-matched healthy controls. No statistically significant differences were observed between the groups in terms of age (first trimester: 27.1 ± 5.32 years; second trimester: 27.2 ± 5.77 years; third trimester: 29.9 ± 4.40 years; control: 29.6 ± 4.69 years; $p = 0.190$). Mean IOP values decreased significantly in the third trimester compared to the control group ($p = 0.016$). The mean IOP values in the first and second trimesters exhibited no significant difference compared to the control group ($p > 0.05$) (Fig. 1).

No significant differences were determined between the groups in terms of other ophthalmological parameters such as BCVA, spherical equivalent, AL, or IOLP ($p > 0.05$). The groups' demographic and clinical parameters are summarized in Table 1.

Anterior segment analysis revealed no significant difference between the groups in terms of parameters such as K1, K2, Kmax, CCT, TCT, CV, ACV, ACD, or ACA ($p > 0.05$). A comparison of the mean anterior segment parameter values between the control, first, second, and third trimester groups is presented in Table 2.

Corneal endothelial cell analysis revealed no significant difference between the groups in parameters such as CD, AVG, SD, CV, MAX, and MIN. However, there was a significant decrease in HEX in the first trimester ($p = 0.007$), suggesting the possibility of transient changes in corneal endothelial cell structure in the early period of pregnancy (Fig. 2). A comparison of mean corneal endothelial parameter values in the control and first, second and third trimester groups is presented in Table 3.

Analysis of the relationships between ocular parameters revealed significant correlations. A moderate positive correlation was observed between trimester and HEX ($r = 0.257$, $p = 0.005$). CCT exhibited a strong positive

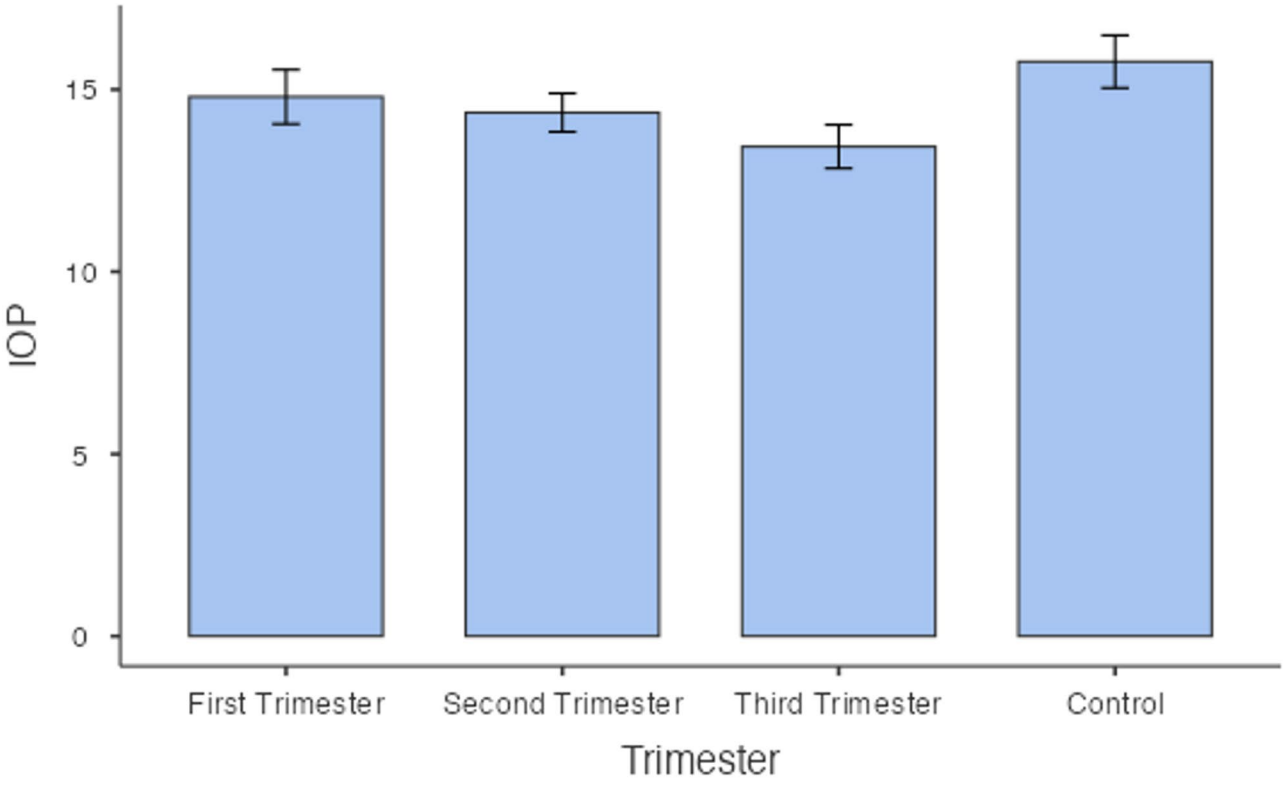

Fig. 1 Bar graph showing mean IOP between groups. IOP, Intraocular pressure

Table 1 The study groups' demographic and clinical parameters

	1st Trimester ($n=30$) p^b	2nd Trimester ($n=30$) p^b	3rd Trimester ($n=30$) p^b	Control ($n=30$)	p^a
Age (years)	27.1 ± 5.32 0.058	27.2 ± 5.77 0.087	29.9 ± 4.40 0.778	29.6 ± 4.69	0.190
IOP (mmHg)	14.8 ± 4.08 0.356	14.4 ± 2.89 0.124	13.4 ± 3.28 **0.016**	15.8 ± 3.96	0.086
BCVA (logMAR)	0.02 ± 0.04 0.853	0.01 ± 0.04 0.575	0.01 ± 0.03 0.380	0.03 ± 0.05	0.419
Spherical Equivalent (D)	-0.34 ± 1.75 0.116	-0.25 ± 1.54 0.070	-0.20 ± 0.87 0.053	-1.29 ± 2.13	0.092
AL (mm)	23.2 ± 1.05 0.192	23.1 ± 0.680 0.093	23.2 ± 0.773 0.115	23.4 ± 0.794	0.185
IOLP (D)	21.4 ± 2.76 0.244	21.9 ± 1.79 0.086	22.1 ± 1.76 0.055	21.1 ± 2.59	0.206

Mean ± standard deviation. A p value less than 0.05 was considered statistically significant. Values exhibiting statistical significance are shown in bold. [a]Comparison within the groups (One-Way ANOVA, Welch's test). [b]Comparison with the controls (Student's t test). IOP, Intraocular pressure; BCVA, Best Corrected Visual Acuity; AL, Axial length; IOLP, intraocular lens power

correlation with CV ($r=0.817$, $p<0.001$) and a moderate positive correlation with IOP ($r=0.263$, $p=0.004$). AL measurements exhibited strong negative correlations with K1 and K2 (r=-0.562, $p<0.001$; r=-0.538, $p<0.001$, respectively) and strong positive correlations with ACV and ACD ($r=0.380$, $p<0.001$; $r=0.384$, $p<0.001$, respectively). IOLP was negatively correlated with both ACV and ACD (r=-0.318, $p<0.001$; r=-0.565, $p<0.001$, respectively). Correlations between corneal parameters, anterior chamber parameters, intraocular pressure, axial length, lens power and trimester are presented in Table 4.

Discussion

This study represents an extensive and detailed examination of ocular changes during pregnancy by evaluating IOP, anterior segment parameters, and corneal

Table 2 A comparison of mean anterior segment parameter values in the control, and first, second, and third trimester groups

	1st Trimester (*n* = 30) *p*[b]	2nd Trimester (*n* = 30) *p*[b]	3rd Trimester (*n* = 30) *p*[b]	Control (*n* = 30)	*p*[a]
K1 (D)	43.1 ± 2.46 0.469	43.2 ± 1.74 0.988	43.1 ± 1.44 0.998	43.2 ± 1.54	0.877
K2 (D)	44.3 ± 1.34 0.496	43.9 ± 1.79 0.554	43.8 ± 1.54 0.559	44.2 ± 1.70	0.498
Kmax (D)	44.9 ± 1.27 0.717	44.5 ± 1.94 0.348	44.4 ± 1.65 0.395	45.1 ± 2.25	0.523
CCT (µm)	537 ± 34.5 0.609	525 ± 29.7 0.068	526 ± 33.8 0.113	541 ± 39.7	0.202
TCT (µm)	533 ± 34.9 0.945	521 ± 30.7 0.165	521 ± 34.2 0.182	534 ± 40	0.289
CV (mm^3)	60.3 ± 3.38 0.973	58.8 ± 3.25 0.116	58.7 ± 3.61 0.261	60.3 ± 4.06	0.162
ACV (mm^3)	173 ± 25.6 0.532	167 ± 30.6 0.180	174 ± 30.0 0.127	177 ± 27.4	0.612
ACD (mm)	2.98 ± 0.215 0.934	2.91 ± 0.311 0.313	2.97 ± 0.289 0.638	2.99 ± 0.328	0.672
ACA (º)	39.4 ± 5.56 0.133	38.3 ± 5.64 0.431	36.9 ± 5.45 0.944	37.1 ± 6.47	0.276

Mean ± standard deviation. A *p* value less than 0.05 was considered statistically significant. K1, flat keratometry; K2, steep keratometry; Kmax, maximum keratometry; CCT, central corneal thickness; TCT, thinnest corneal thickness; CV, corneal volume; ACV, anterior chamber volume; ACD, anterior chamber depth; ACA, anterior chamber angle. [a]Comparison within the groups (One-Way ANOVA, Welch's test). [b]Comparison with the controls (Student's t test)

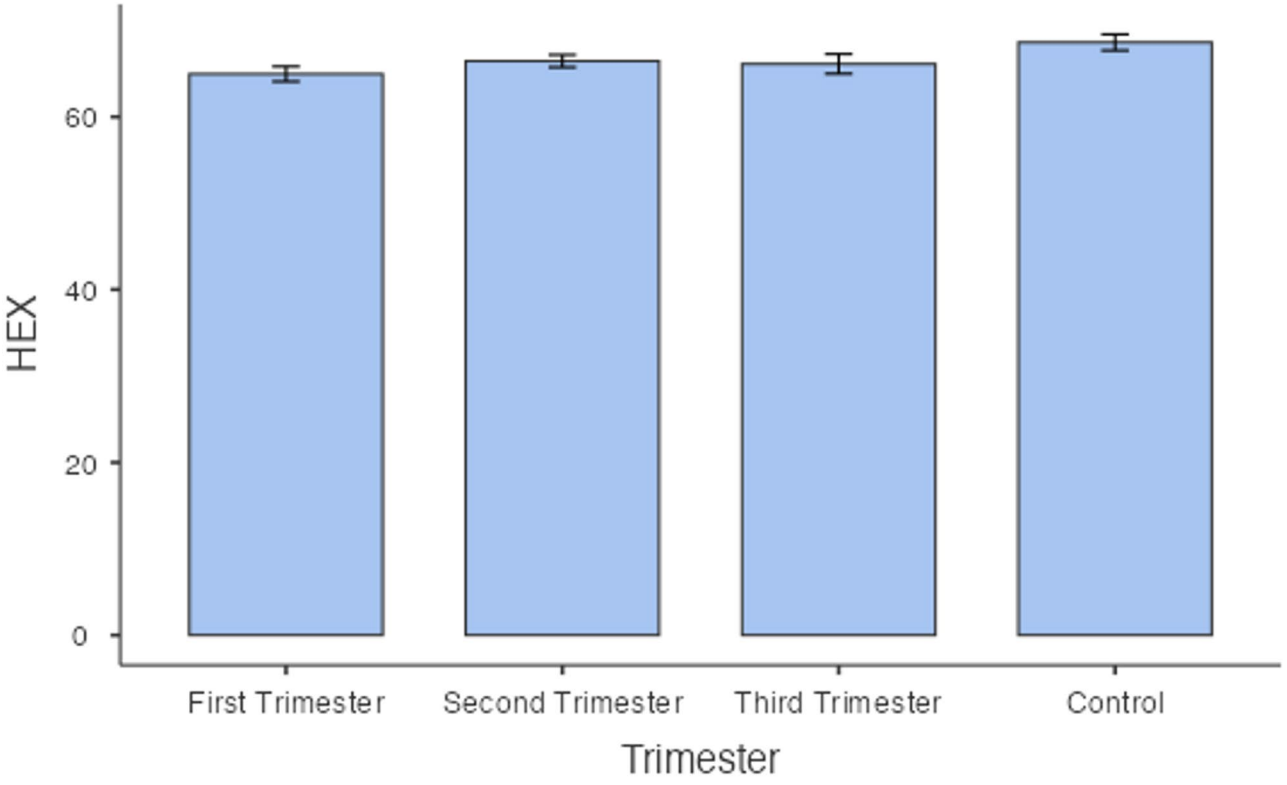

Fig. 2 Bar graph showing mean HEX between groups. HEX, hexagonal cell ratio

endothelial cell morphology in different trimesters and comparing these with those of a control group of non-pregnant women. These findings add to the growing body of literature on pregnancy-induced ocular modifications, their potential clinical implications, and the need for refined monitoring protocols.

One of the most significant findings of this study was the decrease in IOP observed in the third trimester compared to the control group ($p = 0.016$). This aligns with previous studies reporting a diminution in IOP during pregnancy, likely due to hormonal fluctuations, increased aqueous humor outflow, or decreased episcleral venous pressure associated with gestational physiological changes [7, 9–11]. However, no significant differences were observed in the first and second trimesters, suggesting that the decline in IOP becomes more pronounced as pregnancy progresses. Erkan Pota and Çetinkaya Yaprak also observed a statistically significant decrease in IOP toward the third trimester and reported a return to first trimester values in the postpartum period

Table 3 A comparison of mean corneal endothelial parameter values in the control and first, second, and third trimester groups

	1st Trimester (*n* = 30) Mean ± SD (Median, IQR 25–75) *P*[b]	**2nd Trimester (*n* = 30) Mean ± SD (Median, IQR 25–75) *P*[b]**	**3rd Trimester (*n* = 30) Mean ± SD (Median, IQR 25–75) *P*[b]**	**Control Group (*n* = 30) Mean ± SD (Median, IQR 25–75)**	***P*[a]**
CD (cells/mm2)	2871 ± 236 (2860, 2726–3073) 0.178	2793 ± 210 (2819, 2701–2912) 0.982	2822 ± 266 (2830, 2628–3035) 0.520	2791 ± 248 (2819, 2599–2997)	0.481
AVG (μm^2)	351 ± 30.1 (350, 325–367) 0.294	360 ± 28.6 (355, 343–370) 0.728	358 ± 35.7 (354, 330–384) 0.767	359 ± 33.6 (355, 333–383)	0.569
SD (μm^2)	97.1 ± 13.3 (95, 85.8–107) 0.807	105 ± 14.7 (96, 81.3–109) 0.491	96.6 ± 12.9 (93.5, 87–105) 0.684	101 ± 12.7 (96.5, 88–110)	0.897
CV	29.2 ± 3.18 (29.5, 26.3–32) 0.435	27.9 ± 4.25 (28, 25–31) 0.476	28.5 ± 3.26 (28, 26.3–31) 0.517	29.2 ± 5.22 (28.5, 26–31)	0.573
HEX (%)	65.0 ± 4.74 (65.5, 62-67.8) **0.007**	66.5 ± 3.90 (67, 64.3–68) 0.055	66.1 ± 6.24 (67.5, 62.3–71) 0.157	68.6 ± 5.13 (68, 66-72.8)	**0.040**
MAX (μm^2)	982 ± 246 (921, 843–1052) 0.734	974 ± 237 (923, 766–1145) 0.830	954 ± 240 (928, 750–1105) 0.912	957 ± 230 (923, 793–1056)	0.973
MIN (μm^2)	134 ± 9.39 (131, 126–138) 0.213	134 ± 8.43 (131, 127–136) 0.197	133 ± 6.27 (132, 129–135) 0.178	137 ± 10.5 (136, 128–145)	0.451

Mean ± standard deviation. Median values with interquartile ranges (25th–75th percentiles). A *p* value less than 0.05 was considered statistically significant. Values with statistical significance are shown in bold. [a]Comparison within the groups (non-parametric One-Way ANOVA, Kruskal-Wallis test). [b]Comparison with the controls (Mann-Whitney U test). CD, endothelial cell density; AVG, average cell area; SD, standard deviation of cell area; CV, coefficient of variation; HEX, hexagonal cell ratio; MAX, maximum cell area; MIN, minimum cell area

Table 4 Correlations between corneal parameters, anterior chamber parameters, intraocular pressure, axial length, lens power and trimester

	IOP	**K1**	**K2**	**Kmax**	**CV**	**ACV**	**ACD**	**ACA**	**Trimester**
IOP	-	*r* = -0.058 *p* = 0.529	*r* = -0.111 *p* = 0.228	*r* = -0.131 *p* = 0.154	***r* = 0.239** ***p* = 0.009**	*r* = -0.036 *p* = 0.693	*r* = -0.085 *p* = 0.354	*r* = 0.098 *p* = 0.288	*r* = 0.074 *p* = 0.422
CCT	***r* = 0.263** ***p* = 0.004**	***r* = -0.198** ***p* = 0.030**	*r* = -0.164 *p* = 0.073	***r* = -0.188** ***p* = 0.040**	***r* = 0.817** *p* < 0.001	*r* = -0.043 *p* = 0.642	*r* = -0.025 *p* = 0.788	*r* = -0.088 *p* = 0.337	*r* = 0.042 *p* = 0.646
AL	*r* = 0.059 *p* = 0.519	***r* = -0.562** *p* < 0.001	***r* = -0.538** *p* < 0.001	***r* = -0.509** *p* < 0.001	*r* = -0.005 *p* = 0.957	***r* = 0.380** *p* < 0.001	***r* = 0.384** *p* < 0.001	***r* = 0.227** ***p* = 0.013**	*r* = 0.176 *p* = 0.054
IOLP	*r* = -0.018 *p* = 0.842	*r* = 0.010 *p* = 0.915	*r* = -0.022 *p* = 0.813	*r* = -0.009 *p* = 0.923	*r* = -0.060 *p* = 0.513	***r* = -0.318** *p* < 0.001	***r* = -0.565** *p* < 0.001	***r* = -0.303** *p* < 0.001	*r* = -0.097 *p* = 0.293
HEX	*r* = -0.030 *p* = 0.743	*r* = 0.110 *p* = 0.233	*r* = 0.144 *p* = 0.116	*r* = 0.143 *p* = 0.120	*r* = -0.007 *p* = 0.938	*r* = -0.041 *p* = 0.660	*r* = 0.045 *p* = 0.623	*r* = 0.097 *p* = 0.290	***r* = 0.257** ***p* = 0.005**
Trimester	*r* = 0.074 *p* = 0.422	*r* = -0.063 *p* = 0.495	*r* = -0.060 *p* = 0.517	*r* = -0.015 *p* = 0.871	*r* = 0.007 *p* = 0.937	*r* = 0.111 *p* = 0.227	*r* = 0.100 *p* = 0.275	*r* = -0.156 *p* = 0.088	-

A *p* value less than 0.05 was considered to be statistically significant. Values with statistical significance are shown in bold. IOP, Intraocular pressure; AL, Axial length; IOLP, intraocular lens power; K1, flat keratometry; K2, steep keratometry; Kmax, maximum keratometry; CCT, central corneal thickness; CV, corneal volume; ACV, anterior chamber volume; ACD, anterior chamber depth; ACA, anterior chamber angle; HEX, hexagonal cell ratio

[8]. Kelly et al. noted that the decrease observed in IOP during pregnancy corresponds to high concentrations of the hormones progesterone, estrogen and relaxin, which peak in the third trimester. Those authors also reported a significant inverse correlation between these hormonal fluctuations and IOP [16]. Akar et al. showed that IOP decreased significantly in the third trimester of pregnancy, and that pregnancy affected intraobserver and interobserver agreement in IOP measurements. Those authors obtained excellent intraobserver agreement with non-contact tonometry compared to Goldmann and Schiotz tonometry in IOP measurements from pregnant patients. They recommended non-contact tonometry for IOP measurements in the follow-up of pregnant women at risk of glaucoma [9]. In addition, Goldich et al. emphasized the importance of taking the phases of the menstrual cycle into account when evaluating IOP in non-pregnant women, since these may cause pressure variations. Those authors determined a significant change in CCT and biomechanical parameters during the

menstrual cycle. They also showed transient decreases in corneal hysteresis (CH) and corneal resistance factor (CRF) during ovulation, and that the cornea was thinnest at the beginning and thicker at the end of the cycle [17]. In their review study, Bujor et al. reported a decrease in IOP in the third trimester, but no statistically significant change in CH or CRF [18]. Taradaj et al. emphasized the need for standardized measurement methodologies to improve research consistency [3]. In the light of these observed decreases in IOP, close monitoring is required, particularly in pregnant women with glaucoma or other ocular hypertension conditions, to avoid misinterpretation of pressure readings and to prevent under-treatment of ocular pathologies.

No significant differences were determined in anterior segment parameters such as K1, K2, Kmax, CCT, TCT, CV, ACV, ACD, and ACA across the trimesters and compared to the control group ($p > 0.05$). This suggests that pregnancy does not significantly alter corneal curvature, thickness, or anterior chamber dimensions. These results are consistent with previous studies indicating that structural changes in the anterior segment during pregnancy are minimal and unlikely to affect visual function [4, 14, 16, 19]. Erkan Pota and Çetinkaya Yaprak also observed no significant change in K1, ACA, BCVA, IOLP, or spherical equivalent values. However, they reported a statistically significant decrease in IOP in the 3rd trimester and a significant increase in ACV, CCT, and TCT as pregnancy progressed [8]. Kelly et al. also noted that while variations in CCT occur during pregnancy, these do not significantly impact anterior segment parameters [16]. Örnek et al. observed no significant change in CCT during pregnancy [14]. Additionally, Özkaya et al. determined no significant difference in anterior segment parameters, and keratometry and CCT measurements, except for a significant increase in ACV in the first trimester [4]. However, corneal edema and curvature changes have been reported in pregnant women with pre-existing corneal anomalies. Cross-linking therapy has been recommended for such women before conception to reduce the risk of keratoconus progression [2, 20]. Similarly, Morya et al. noted that hormonal changes may cause small corneal biomechanical changes, which may potentially affect refractive stability, and that procedures such as refractive surgery should be postponed until after delivery [21]. Goldich et al. observed an increase in K2 in their study of healthy pregnant women, while CH, CRF, CCT, CV, ACV, ACD, and ACA exhibited no significant differences [10]. Taradaj et al. attributed these inconsistencies between studies to differences in methodology and the small numbers of patients investigated. Those authors therefore concluded that no definite conclusions could be drawn regarding the anterior segment parameters of the eye other than IOP in pregnant women [3]. These findings indicate that while anterior segment parameters remain largely stable during pregnancy, individualized assessments are crucial for women with pre-existing corneal conditions or those considering refractive procedures. However, further longitudinal studies with larger sample sizes may be needed to confirm these findings and explore potential subtle changes.

Analysis of corneal endothelial cell parameters revealed no significant intergroup differences in CD, AVG, SD, CV, MAX, or MIN. However, one notable finding was a significant decrease in HEX in the first trimester ($p = 0.007$). HEX reflects the regularity and stability of the corneal endothelium, and a decrease in early pregnancy may indicate transient morphological changes in the endothelial cell layer. This may be attributable to hormonal changes, and particularly elevated levels of progesterone and estrogen, which may temporarily affect endothelial cell integrity [14]. Studies of corneal endothelial parameters are limited. Örnek et al. reported a significant decrease in HEX in the first trimester, similarly to the present study. Those authors reported that CV increased significantly in the first trimester, but observed no significant difference in ECD [14]. Taneja et al. linked pregnancy-induced keratectasia to hormonal alterations, reinforcing the importance of investigating corneal stability during pregnancy [22]. Karakucuk et al. observed no substantial changes in corneal densitometry across the trimesters, supporting the idea that endothelial function remains relatively stable [23]. Researchers have reported that changes in estrogen and progesterone levels may lead directly to changes in corneal parameters through estrogen, progesterone and androgen receptors in corneal endothelial and epithelial cells [3, 16, 24, 25]. Estrogen contributes to vasodilation during pregnancy by upregulating nitric oxide production and downregulating endothelin-1 levels through receptor-mediated mechanisms and mRNA expression [25]. These findings from the few available studies on this subject emphasize the need for further research into pregnancy-related changes in endothelial function, especially in women who undergo refractive surgery or other corneal interventions during pregnancy.

While this study yields a number of valuable insights, it also has a few limitations. First, while adequate, the sample size may not fully have captured subtle changes in ocular parameters. Second, the study design was cross-sectional, which limits the assessibility of individual, time-dependent changes. Future longitudinal studies with larger cohorts and repeated measurements throughout pregnancy would yield a more comprehensive understanding of ocular changes during that time. Additionally, investigating the impact of specific hormonal profiles on ocular parameters may further elucidate the mechanisms underlying these changes.

Conclusions

In conclusion, this study shows that pregnancy induces specific, but limited, changes in ocular parameters, including a significant decrease in IOP during the third trimester and transient alterations in corneal endothelial cell regularity in the first trimester. These findings contribute to the growing body of evidence regarding the effects of pregnancy on ocular health and emphasize the importance of tailored ophthalmological care for pregnant women. Close ophthalmological monitoring is recommended for pregnant women at risk of developing ocular complications. Future research should prioritize standardizing measurement methodologies and employing longitudinal follow-up studies to refine clinical management strategies for pregnant patients.

Author contributions

İrfan Uzun: Conceptualization, methodology, investigation, resources, writing—original draft preparation, writing—review and editing, project administration. Çağrı Mutaf: Software, validation, formal analysis, data curation, writing—review and editing, visualization, supervision. Ali Hakim Reyhan: Validation, data curation, writing—review and editing, visualization. Funda Yüksekyayla: Validation, formal analysis, data curation, writing—review and editing. Enes Colak: Software, data curation. Mehmet Yolaçan: Software, formal analysis, data curation.All the authors have read and agreed to the published version of the manuscript.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Data availability

The data presented in this study are available from the corresponding author upon request. The data are not publicly available, due to ethical restrictions.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Harran University (protocol code 2024.21.10-406728; date of approval 30 December 2024). Informed consent was obtained from all individuals involved in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 24 March 2025 / Accepted: 12 May 2025
Published online: 19 May 2025

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