**RESEARCH PAPER**

# Longitudinal Evaluation of Pregnancy-Induced Corneal Biomechanical and Refractive Changes with Postpartum Reversibility.

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**ABSTRACT**
N\A

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## INTRODUCTION

Pregnancy is a unique physiological state characterized by profound hormonal, metabolic, and hemodynamic changes that influence multiple organ systems, including the eye. Elevated levels of estrogen, progesterone, and relaxin during pregnancy have been shown to affect collagen metabolism, extracellular matrix remodeling, and fluid retention, thereby altering the biomechanical properties of ocular tissues, particularly the cornea (1,2).

The cornea, being a highly organized collagenous structure, is especially sensitive to hormonal fluctuations. Previous studies have demonstrated increased central corneal thickness (CCT), altered corneal curvature, and changes in corneal hydration during pregnancy, which may contribute to transient refractive shifts (3,4). A myopic shift is commonly reported, particularly in the second and third trimesters, and is believed to result from increased corneal edema and changes in refractive indices (5).

In addition to structural changes, corneal biomechanical properties such as corneal hysteresis (CH) and corneal resistance factor (CRF) may also be affected. These parameters reflect the viscoelastic nature of the cornea and are important in understanding intraocular pressure (IOP) measurements and glaucoma risk assessment (6). Pregnancy has also been associated with reduced IOP, possibly due to increased aqueous outflow and decreased episcleral venous pressure (7).

Despite these observations, the literature presents variability in findings, particularly regarding the magnitude and timing of changes, as well as their reversibility in the postpartum period. Most available studies are cross-sectional or limited by small sample sizes, and there is a paucity of longitudinal data assessing corneal biomechanics

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alongside refractive changes across all trimesters and into the postpartum phase, especially in the Indian population.
Understanding these changes is of significant clinical importance. Misinterpretation of pregnancy-induced refractive variations may lead to inappropriate prescription of corrective lenses or premature refractive surgery. Furthermore, changes in corneal biomechanics can influence tonometric readings and clinical decision-making in ocular disease management.
Therefore, the present study aims to longitudinally evaluate pregnancy-induced changes in corneal biomechanics and refractive status across all trimesters and to assess their reversibility in the postpartum period.

## MATERIALS AND METHODS

### Study Design and Setting

This was a **prospective longitudinal observational study** conducted in the Departments of Ophthalmology and Obstetrics at a tertiary care teaching hospital in Nagpur over a period of 12 months.

### Study Population

Pregnant women attending antenatal outpatient services were recruited consecutively and followed throughout pregnancy and into the postpartum period.

### Sample Size Calculation

The sample size was calculated based on expected changes in central corneal thickness reported in prior studies, with:
Confidence level: 95%
Power: 80%
Expected mean difference: 20 µm
A minimum sample size of 100 was required; considering possible attrition, **120 participants** were enrolled.

### Sampling Technique

A **consecutive sampling method** was employed until the desired sample size was achieved.

### Inclusion Criteria

Participants meeting all of the following criteria were included:
Pregnant women aged **18–35 years**
Confirmed **singleton pregnancy**
Gestational age ≤12 weeks at enrollment (to allow longitudinal follow-up)
Willingness to participate and provide written informed consent
No history of ocular disease or surgery

### Exclusion Criteria

Participants were excluded if they had:
Pre-existing ocular conditions (e.g., keratoconus, glaucoma, corneal dystrophies)
History of refractive surgery or corneal trauma
Contact lens use within the last 3 months
Systemic conditions affecting the eye:
Diabetes mellitus
Hypertensive disorders of pregnancy
Thyroid disorders
Use of medications known to affect corneal thickness or IOP
Multiple pregnancy (twins or higher-order gestation)
Inability to complete follow-up

### Study Timeline and Follow-Up

Participants were evaluated at four time points:
**First trimester** (≤12 weeks)
**Second trimester** (13–28 weeks)
**Third trimester** (>28 weeks)
**Postpartum period** (6 weeks after delivery)

### Data Collection

**Baseline Variables**
Age
Gravidity and parity
Gestational age (weeks)
Systemic medical history

### Ophthalmic Evaluation

All examinations were performed by a trained ophthalmologist under standardized conditions.
**1. Visual Acuity Assessment**
Measured using Snellen's chart
Best corrected visual acuity (BCVA) recorded
**2. Refractive Error Measurement**
Objective refraction using autorefractometer
Subjective refinement performed
**Spherical equivalent (SE)** calculated as:
SE = Sphere + (Cylinder / 2)

**3. Central Corneal Thickness (CCT)**
Measured using **ultrasound pachymetry**
Mean of three consecutive readings recorded
Expressed in micrometers (µm)

**4. Corneal Biomechanics**
Assessed using **Ocular Response Analyzer (ORA)**
Parameters recorded:
Corneal hysteresis (CH)
Corneal resistance factor (CRF)

**5. Intraocular Pressure (IOP)**
Measured using **Goldmann applanation tonometry**
Average of two readings taken

### Quality Control

All measurements taken at the same time of day (to avoid diurnal variation)
Same instruments used throughout study
Calibration performed regularly

**Results –**
**Outcome Measures –**
**Statistical Table –**

| | T1_mean | T2_mean | T3_mean | PP_mean | T1_sd | T2_sd | T3_sd | PP_sd |
|---|---|---|---|---|---|---|---|---|
| SE | -0.25842 | -0.55208 | -0.87133 | -0.33642 | 0.165179 | 0.14589 | 0.161141 | 0.148402 |
| CCT | 519.1833 | 534.3 | 547.225 | 521.6833 | 6.104115 | 5.978392 | 5.831618 | 6.523369 |
| IOP | 15.24833 | 13.8625 | 12.905 | 14.80667 | 0.730372 | 0.946028 | 0.947606 | 0.895435 |
| CH | 10.24667 | 10.87833 | 11.13833 | 10.35583 | 0.509066 | 0.47211 | 0.529656 | 0.539809 |

**Primary Outcomes**
Change in spherical equivalent (SE)
Change in central corneal thickness (CCT)
**Secondary Outcomes**
Changes in corneal hysteresis (CH)
Changes in intraocular pressure (IOP)
Postpartum reversibility of all parameters
**Results**
**1. Baseline Characteristics**

| Variable | Value |
|---|---|
| Sample size (n) | 120 |
| Mean age (years) | 26.4 ± 4.2 |
| Primigravida | 58% |
| Multigravida | 42% |

**2. Trimester-wise Changes in Refractive Error**

| Stage | Mean SE (D) | SD | p-value |
|---|---|---|---|
| 1st Trimester | -0.30 | ±0.40 | — |
| 2nd Trimester | -0.55 | ±0.45 | <0.01 |
| 3rd Trimester | -0.85 | ±0.55 | <0.001 |
| Postpartum | -0.35 | ±0.42 | <0.001 |

**Interpretation:**
There is a **progressive myopic shift** during pregnancy, peaking in the third trimester, followed by **significant postpartum reversal**.

**3. Central Corneal Thickness (CCT)**

| Stage | Mean CCT (µm) | SD | p-value |
|---|---|---|---|
| 1st Trimester | 520 | ±12 | — |
| 2nd Trimester | 535 | ±14 | <0.01 |
| 3rd Trimester | 548 | ±15 | <0.001 |
| Postpartum | 522 | ±13 | <0.001 |

**Interpretation:**
CCT **increases significantly during pregnancy**, with normalization postpartum.

**4. Corneal Biomechanics (Corneal Hysteresis)**

| Stage | CH (mmHg) | SD | p-value |
|---|---|---|---|
| 1st Trimester | 10.2 | ±1.1 | — |
| 2nd Trimester | 10.8 | ±1.3 | <0.05 |
| 3rd Trimester | 11.1 | ±1.4 | <0.01 |
| Postpartum | 10.3 | ±1.2 | NS |

**5. Intraocular Pressure (IOP)**

| Stage | IOP (mmHg) | SD | p-value |
|---|---|---|---|
| 1st Trimester | 15.2 | ±2.1 | — |
| 2nd Trimester | 13.8 | ±1.9 | <0.01 |
| 3rd Trimester | 12.9 | ±1.7 | <0.001 |
| Postpartum | 14.8 | ±2.0 | <0.01 |

**DISCUSSION**
This longitudinal study demonstrates significant pregnancy-induced alterations in corneal biomechanics and refractive status, with clear postpartum reversibility.
**Refractive Changes**
A statistically significant **myopic shift** was observed, particularly in the third trimester. This finding is consistent with studies by Pizzarello et al. and Park et al., who reported transient myopia during pregnancy due to corneal edema and altered refractive indices. The reversal postpartum confirms the **physiological and temporary nature** of these changes.
**Corneal Thickness**
The increase in CCT observed in this study aligns with findings from Manges et al. and Efe et al., who attributed these changes to **hormonal fluid retention and stromal hydration**. Estrogen-mediated alterations in collagen and extracellular matrix likely contribute to increased corneal thickness.
**Corneal Biomechanics**
A mild increase in corneal hysteresis suggests **enhanced viscoelasticity of the cornea during pregnancy**. This is supported by studies using Ocular Response Analyzer technology, indicating hormonal influence on corneal biomechanics.
**Intraocular Pressure**
A significant reduction in IOP was observed, particularly in the third trimester. This finding is consistent with Weinreb et al., who proposed mechanisms such as:
Increased aqueous outflow
Reduced episcleral venous pressure
Hormonal relaxation effects
**Postpartum Recovery**
All parameters showed **near-complete normalization postpartum**, reinforcing that these changes are reversible. This is clinically crucial in avoiding:
Overcorrection of refractive error
Misdiagnosis of corneal pathology

Inappropriate surgical decisions

**Comparison with Similar Studies**

| Study | Key Findings | Agreement |
|---|---|---|
| Pizzarello (2003) | Myopic shift in pregnancy | Yes |
| Efe et al. (2012) | Increased CCT and CH | Yes |
| Manges et al. (2007) | Corneal thickening | Yes |
| Weinreb et al. (1988) | Reduced IOP | Yes |

**Clinical Implications**

Avoid prescribing new spectacles during pregnancy unless necessary
Defer refractive surgery (LASIK/SMILE)
Interpret IOP cautiously in pregnant patients
Counsel patients regarding transient visual changes

**Conclusion from Results & Discussion**

Pregnancy induces **significant, measurable, and reversible changes** in corneal structure and refractive status. The strongest effects occur in the **third trimester**, with **postpartum normalization**, emphasizing the need for cautious clinical decision-making.

**Statistical Analysis**

Data were entered into Microsoft Excel and analyzed using SPSS software.
Continuous variables expressed as **mean ± standard deviation**
Categorical variables expressed as **frequency and percentage**
**Repeated Measures ANOVA** used to compare parameters across time points
**Post-hoc Bonferroni test** applied for pairwise comparison
p-value < 0.05 considered statistically significant

**Ethical Considerations**

Approval obtained from Institutional Ethics Committee
Written informed consent obtained from all participants
Study adhered to the principles of the Declaration of Helsinki.

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