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CASE SERIES

Menopausal Status and Central Corneal Thickness: Differences and Implications

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Abstract

Purpose: To compare the Central Corneal Thickness (CCT) measured using ultrasonic pachymetry in pre-menopausal and post-menopausal women and discuss the need for incorporating menopausal status into glaucoma risk stratification and interpretation of IOP recordings. **Materials and Methods:** This was an observational cross-sectional study for a period of 2 years from May 2023 to May 2025 conducted at the Regional Institute of Ophthalmology and Government Ophthalmic Hospital, Chennai. 300 eyes of 150 females were part of the study- 75 pre and post-menopausal women. Central Corneal Thickness (CCT) was measured using ultrasonic pachymetry and data analysed statistically as in Table 2. **Results:** In our study, the mean age of the pre-menopausal females was 42.253 ± 8.311 while the mean age of the post-menopausal females was found to be 60.053 ± 7.274. As expected, the mean age of Post-Menopausal Females was significantly higher than that of the pre-menopausal females (p-value <0.001). The mean central corneal thickness, as measured by ultrasonic pachymetry was found to be 546.63 ± 42.36 microns in the pre-menopausal category and 521.59 ± 32.02 microns in the post-menopausal category. An independent samples t-test revealed the CCT to be significantly lesser in post-menopausal females compared to pre-menopausal females. ($t = 6.46$, $p < 0.0001$). **Conclusion:** Menopause is thus associated with thinner CCT values and thus plays a pivotal role in the approach and evaluation of post-menopausal glaucoma patients.

Keywords: Menopause, Central Corneal Thickness, Glaucoma, Intraocular Pressure, Menopause, Postmenopause, Ultrasonic Pachymetry

1. Introduction

Menopause induces profound hormonal shifts, particularly a marked decline in estrogen levels that is known to affect ocular tissues. One measurable outcome of this change is a statistically significant reduction in Central Corneal Thickness (CCT) in postmenopausal women compared to their premenopausal counterparts. This thinning has been found to correlate positively with serum estradiol levels, reinforcing the biological basis of menopause-linked corneal alterations[1].

The clinical importance of CCT extends well beyond anatomical variation. Thinner corneas have been repeatedly emphasised to be an important risk factor for the development and progression of Primary OpenAngle Glaucoma (POAG), even when the measured intraocular pressures appear normal. In the landmark Ocular Hypertension Treatment Study (OHTS)[2], patients with CCT ≤ 555 µm had approximately three-fold higher risk of converting to glaucoma compared to those with thicker corneas (≥ 588 µm). Menopause-associated CCT reduction could lead to underestimation of true Intraocular Pressure (IOP)[3] and misclassification of glaucoma risk among older women. Beyond applanation tonometry misestimation, thinner CCT may reflect underlying biomechanical tissue vulnerability and increased optic nerve strain, factors that independently contribute to glaucomatous damage.

In this study, we aim to compare CCT between pre and postmenopausal women using ultrasonic

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pachymetric measurement, and to discuss the implications of these findings for glaucoma screening and IOP interpretation in postmenopausal populations.

2. Aim and Objectives

- To investigate and compare the Central Corneal Thickness (CCT) measured using ultrasonic pachymetry in premenopausal and postmenopausal women and evaluate its relevance in glaucoma risk assessment.
- To discuss clinical relevance, particularly how menopause-associated CCT reduction could influence intraocular pressure measurement accuracy and glaucoma screening in aging women.
- To provide recommendations for incorporating menopausal status into glaucoma risk stratification and interpretation of IOP readings.

3. Review of Literature

Keskin *et al.,* (Turkey)[1] conducted a prospective case–control study with 40 premenopausal and 40 postmenopausal women, finding mean CCT significantly lower in postmenopausal women (521.2 ± 37.97 µm vs. 561 ± 42.8 µm; $p < 0.005$). Serum estradiol levels correlated positively with CCT ($p < 0.01$)

Verma *et al.*, (India, 2022–23)[4] compared 27 pre- and 27 postmenopausal women (54 eyes per group) using specular biomicroscopy; they reported mean CCT values of ~558 ± 20.8 µm (premenopausal) vs. ~524 ± 18.7 µm (postmenopausal), confirming menopause-associated thinning ($p < 0.05$)

Sampoorna H Rao *et al.,* (2021, India)[5] compared postmenopausal women with (n = 40) and without (n = 40) Meibomian Gland Dysfunction (MGD). They found significantly lower CCT in the MGD group, correlating with estradiol levels and tearfilm instability

Turgut *et al.*, (Istanbul, 54 + 54 women)[3] investigated CCT, corneal curvature, ovarian hormones, and dry eye. CCT was significantly thinner post-menopause ($p = 0.017$). Estradiol positively correlated with CCT ($p = 0.003$–0.006) and Schirmer test scores, while progesterone correlated only with tear production ($p = 0.036$–0.044). Corneal curvature differences were not significant overall.

4. Materials and Methods

Study Type: A cross- sectional observational study
Study Period: May 2023 to May 2025
Sample Size: 300 eyes of 150 patients (75 Pre-Menopausal and 75 Post-Menopausal Females)

4.1 Inclusion Criteria

- Female participants, aged more than 18 years of age.
- Premenopausal group: regular menstrual cycles, not amenorrhoeic for >12 months.
- Postmenopausal group: absence of menses for at least 12 consecutive months, with no menstruation; naturally or surgically induced menopause permitted (≥3 months postop).
- Healthy ocular status: no history of ocular disease (e.g., keratoconus, glaucoma, uveitis), surgery, or trauma.
- Able and willing to provide informed consent and comply with study protocol.
- No current use of systemic or topical hormones, including Hormone Replacement Therapy (HRT), oral contraceptives, or eye drops with hormonal components.

4.2 Exclusion Criteria

- History of ocular surgery, trauma, or refractive procedures (e.g. LASIK), which may alter corneal thickness.
- Pregnant and Lactating Women
- Presence of ocular surface disorders, including dry eye, Meibomian Gland Dysfunction (MGD), or corneal scars—especially as these can independently affect CCT
- Systemic disease or medications known to affect ocular parameters: e.g. diabetes, autoimmune disease, collagen vascular disorders, long-term topical or systemic corticosteroids.
- Current Hormone Therapy (HRT or contraceptive steroids) or recent use within the past six months—mitigates confounding hormonal effects.
- Smoking, alcohol abuse, or BMI > 25 or > 30 kg/m²
- Unable to provide informed consent or any condition compromising study participation.

5. Methodology

- Detailed history taking including medical and reproductive history-menopausal status and duration.

- Keen slitlamp biomicroscopy to rule out corneal pathology
- Ultrasound pachymetry used to measure the Central Corneal Thickness
- Measurements conducted between 10:00–12:00 PM (stable corneal thickness period) and at least 2–3 hours after waking
- Topical anaesthesia (0.5% Proparacaine) instilled. Ten readings were taken per eye with the probe perpendicular to central cornea, and the mean of central five (after discarding highest/lowest) used for analysis.
- Values obtained were then analysed statistically

6. Results and Observations

In our study, the mean age of the pre-menopausal females was found to be 42.253 years with standard deviation of 8.311 (42.253 ± 8.311) while the mean age of the post-menopausal females was found to be 60.053 years with standard deviation of 7.274 (60.053 ± 7.274). As expected, the mean age of post-menopausal females was significantly higher than that of the pre- menopausal females (p-value <0.001) (Table 1 and distributions in Figure 1, 2 and Table 2 and 3). The mean central corneal thickness, as measured by ultrasonic pachymetry was found to be 546.63 ± 42.36 microns in the pre-menopausal category and 521.59 ± 32.02 microns in the post-menopausal category (Table 4). An independent samples t-test revealed a statistically significant difference in mean CCT between the two groups (t = 6.46, p < 0.0001). The effect size, calculated using Cohen's d, was 0.75, indicating a moderate to large clinical significance. In the pre-menopausal group, 4.67% of eyes had CCT between 450-479µ, 6.00% between 480-509µ, 17.33%

Table 1. Analysis with respect to age (Years)

	Pre-Menopausal	Post-Menopausal
Mean	42.253	60.053
Standard Deviation (S.D)	8.311	7.274
Minimum AG	19	48
Maximum Age	54	85
Mean ± S.D	42.253 ± 8.311	60.053 ± 7.274

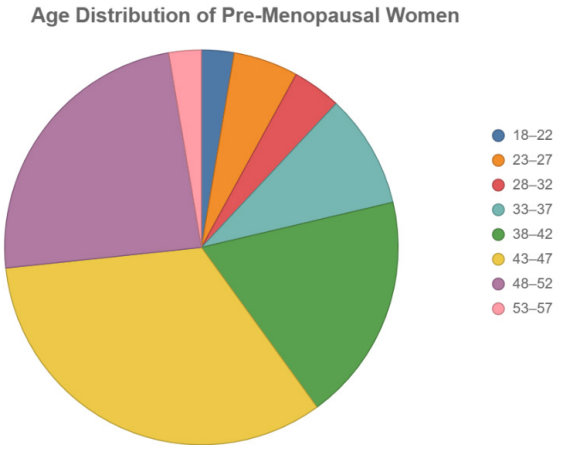

Figure 1. Age distribution of pre-menopausal women.

Table 2. Age Distribution of Pre-menopausal Women

Class Interval	Frequency	Percentage Frequency (%)
18 – 22	2	2.67%
23 – 27	4	5.33%
28 – 32	3	4.00%
33 – 37	7	9.33%
38 – 42	14	18.67%
43 – 47	25	33.33%
48 – 52	18	24.00%
53 – 57	2	2.67%
Total	**75**	**100.00%**

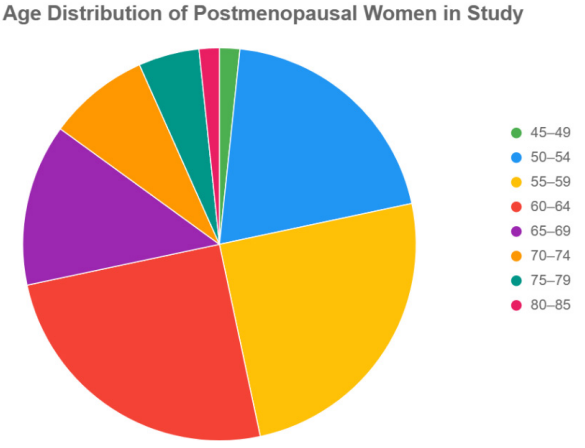

Figure 2. Age distribution of post-menopausal women.

between 510-539µ, 18.67% between 540-569µ, 16.00% between 570-599µ, 3.33% between 600-629µ, 2.67% between 630-659µ, 1.33% between 660-689µ and 0.67% between 690-719µ. In the post-menopausal

Table 3. Age Distribution of Post-menopausal Women

Age Group	Frequency	Relative Frequency	Percentage
45–49	1	0.013	1.3%
50–54	14	0.187	18.7%
55–59	19	0.253	25.3%
60–64	16	0.213	21.3%
65–69	9	0.120	12.0%
70–74	6	0.080	8.0%
75–79	3	0.040	4.0%
80–85	1	0.013	1.3%
Total	**75**	**1.000**	**100.0%**

group, 1.33% of eyes had CCT between 420-449µ, 6.67% between 450-479µ, 14.67% between 480-509µ 30.00% between 510-539µ, 16.00% between 540-569µ, 4.67% between 570-599µ and 0.67% between 600-629µ (Table 5 and Figure 3).

7. Discussion

Recent comparative studies consistently show that postmenopausal women exhibit significantly thinner central corneas than their premenopausal counterparts. In a Turkish case–control study of 40 premenopausal and 40 postmenopausal women, mean CCT was reported at 561 ± 42.8 µm versus 521 ± 38.0 µm, respectively ($p < 0.005$), with a strong positive correlation between serum estradiol levels and CCT ($p < 0.01$)[1]. In an Indian cohort study (54 eyes in each group), specular biomicroscopy revealed mean CCT values of 558 ± 20.8 µm in premenopausal women and 524 ± 18.7 µm postmenopause ($p < 0.05$)[4]. Interestingly, certain other studies like the one by Sachis Gimeno et al[6] have also shown how post- menopausal women with dry eye are increasingly associated with decreasing central corneal thickness.

Table 4. CCT in pre- and post-menopausal women in the study

	Pre Menopausal	Post Menopausal
Mean CCT	549.63	521.59
Standard Deviation (S.D)	42.36	32.02

Mechanistic studies support the hormonal basis of these findings[7]: systemic estrogen decline during menopause reduces corneal hydration and stromal matrix deposition. Estrogen and progesterone receptors are expressed in corneal tissues, and estrogen promotes glycosaminoglycan accumulation, collagen remodelling, and water retention within the stroma—physiologic influences that diminish after menopause.

Also, thin corneas carry an increased risk for development and progression of Primary Open-Angle Glaucoma (POAG). In major cohort studies like the Ocular Hypertension Treatment Study (OHTS) and the Early Manifest Glaucoma Trial[8], thinner CCT independently predicted glaucoma risk—even when

Table 5. Frequency distribution of central corneal thickness in pre- vs post-menopausal women in the study

Class Interval (µm)	Pre-Menopausal Frequency	Pre-Menopausal %	Post-Menopausal Frequency	Post-Menopausal %
420–449	0	0.00%	2	1.33%
450–479	7	4.67%	10	6.67%
480–509	9	6.00%	22	14.67%
510–539	26	17.33%	45	30.00%
540–569	28	18.67%	24	16.00%
570–599	24	16.00%	7	4.67%
600–629	5	3.33%	1	0.67%
630–659	4	2.67%	0	0.00%
660–689	2	1.33%	0	0.00%
690–719	1	0.67%	0	0.00%
Total	**150**	**100.00%**	**150**	**100.00%**

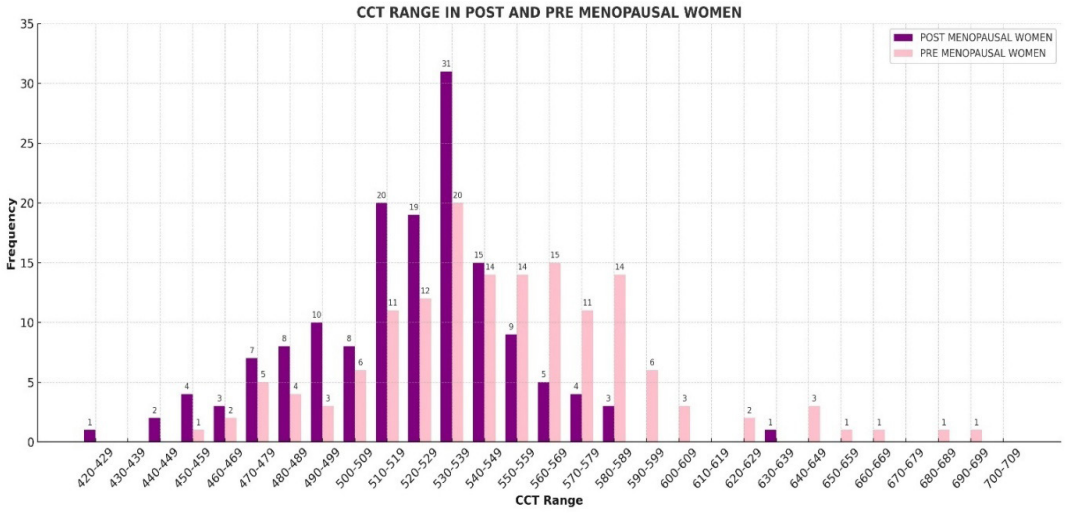

Figure 3. Distribution of central corneal thickness in pre- and post-menopausal women in the study.

the IOP was within normal range. These findings imply that postmenopausal women, due to estrogen-linked corneal thinning, may be at greater risk of underestimation of true IOP if the central pachymetry is not accounted for.

Epidemiological studies also report that early menopause—before age 45—is linked to about a 2.6-fold increased risk of POAG[9], implying that duration of estrogen exposure modulates optic nerve vulnerability. Some analyses report that women with early or surgical menopause have elevated IOP (by ~1.5–3.5 mmHg) compared to age-matched premenopausal controls, although Hormone Replacement Therapy (HRT) per se has not universally demonstrated IOP-lowering efficacy in trials.

Although Corneal Hysteresis (CH) has emerged as a more dynamic biomechanical metric[10], its use is not yet widespread. However, as measurements of CCT are simpler and more affordable, they remain a widely used tool in glaucoma risk stratification—particularly in patients over age 50 or in glaucoma suspects. Routine pachymetry is thus absolutely necessary in these groups to avoid misclassification based on tonometry alone.

8. Summary and Conclusion

This study thus provides compelling evidence that menopause is associated with a significant reduction in Central Corneal Thickness (CCT). Our findings align with previous research indicating that postmenopausal women exhibit thinner corneas compared to their premenopausal counterparts. The observed decrease in CCT could be attributed to hormonal changes, particularly the decline in estrogen levels.

The implications of reduced CCT are particularly pertinent in the context of glaucoma diagnosis and management. Thinner corneas can lead to an underestimation of Intraocular Pressure (IOP) measurements, potentially delaying the detection of glaucoma. Therefore, incorporating CCT measurements into routine ophthalmic evaluations for postmenopausal women is essential to ensure accurate IOP assessment and timely intervention.

In conclusion, our study underlines the importance of considering menopausal status when evaluating corneal health and IOP measurements. Further research however is necessary to explore further mechanisms of corneal thinning during menopause and to develop strategies to mitigate its impact on ocular health.

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