

Effect of 360 Degree Endo-Laser during Pars Plana Vitrectomy on the Cornea

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Short title: 360 Degree Endo-Laser during Pars Plana Vitrectomy on the Cornea.

Abstract

Purpose: This study aimed to evaluate the impact of intraoperative 360-degree prophylactic laser retinopexy during pars plana vitrectomy (PPV) on corneal sensitivity and thickness in patients undergoing surgery for rhegmatogenous retinal detachment (RRD) versus macular hole (MH).

Methods: In this prospective observational study, 30 eyes of 30 patients were divided into two groups: 15 eyes with RRD underwent PPV with 360° laser retinopexy and C2F6 gas tamponade, while 15 eyes with MH received PPV and SF6 gas tamponade (no laser). Corneal sensitivity was measured pre- and postoperatively using a Cochet-Bonnet esthesiometer, and corneal thickness was assessed via Oculus Pentacam. Data were analyzed at 6 weeks postoperatively.

Results: The RRD group exhibited a 46.3% reduction in corneal sensitivity postoperatively (5.4 ± 0.3 cm preoperatively vs. 2.5 ± 2.1 cm at 6 weeks; $p < 0.001$), while the MH group showed no significant change (5.11 ± 0.28 cm vs. 5.05 ± 0.43 cm; $p = 0.672$). Corneal thickness remained stable in both groups (RRD: 545.8 ± 30.38 μm vs. 540.1 ± 32.21 μm ; MH: 544.12 ± 31.08 μm vs. 541.32 ± 30.76 μm ; $p > 0.05$).

Conclusion: Prophylactic 360° laser retinopexy during PPV significantly reduces corneal sensitivity, likely due to thermal injury to long ciliary nerves, while vitrectomy alone (without laser) preserves corneal innervation. Structural corneal thickness remains unaffected short-term. Surgeons should weigh the benefits of laser retinopexy against neurotrophic risks, particularly in patients with preexisting conditions like diabetes or glaucoma. Optimizing laser parameters to minimize nerve damage is recommended to preserve corneal health.

Keyword: Corneal Sensitivity, Laser Retinopexy, Pars Plana Vitrectomy, Neurotrophic Keratopathy, Retinal Detachment.

INTRODUCTION:

Corneal sensory innervation originates from the ophthalmic branch of the trigeminal nerve, traveling through the nasociliary nerve and its long ciliary branches, ultimately forming nerve fibers that penetrate the cornea¹. These sensory nerves release trophic substances, including neuropeptides, neurotrophins, and growth factors, which are vital for maintaining the proliferation of corneal epithelial cells, ensuring

epithelial integrity, and promoting wound healing within the cornea^{2,3}. The loss of corneal sensory innervation can lead to neurotrophic keratopathy, a vision-threatening condition characterized by diminished corneal sensation, abnormal tear film, and, in severe cases, persistent epithelial defects, corneal ulceration, and stromal perforation. Several other conditions, including herpetic keratitis, keratoconjunctivitis sicca, and

keratoconus, are also associated with reduced corneal sensitivity^{4,5}.

Argon laser photocoagulation relies on a photothermal process, where melanin in the retinal pigment epithelium and choroid absorbs the laser energy and produces heat to target and either fuse or destroy blood vessels⁶. The absorption of laser light may occur in the target tissue or in surrounding tissues, from where heat is transferred to the target by thermal conduction. This thermal damage results from chemical changes when ocular tissues are heated to temperatures sufficient to denature proteins or other vital macromolecules⁷. Argon laser retinal photocoagulation (ALRP) is frequently used to treat ischemic retinal disorders and to seal retinal tears. Prophylactic 360° laser retinopexy performed anterior to the equator has been shown to reduce the incidence of retinal re-detachment by 50%, strengthening the chorioretinal adhesion and decreasing the likelihood of retinal breaks and detachment^{8,9}. This study aims to assess the impact of intraoperative 360° laser retinopexy on corneal health during vitrectomy on corneal health.

PATIENTS AND METHODS

PATIENTS

This was a prospective, observational, non-randomized comparative study conducted between November 2023 and February 2025. All participants underwent 23-gauge PPV performed by two surgeons (A.E. and A.A.) based on specific inclusion and exclusion criteria. The study included 30 eyes from 30 patients (14 men and 16 women). Informed consent was obtained from all patients prior to surgery, in accordance with the Declaration of Helsinki. The study was approved by the Scientific Research Ethics Committee of Kafrelsheikh University (Study number: KFSIRB200-366). Of the 30 eyes, 15 underwent PPV combined with 360-degree laser retinopexy and SF6 gas tamponade for retinal detachment (RD), while the remaining 15 eyes underwent PPV with SF6 gas tamponade for macular hole, serving as the control group for laser treatment.

The inclusion criteria for the study were as follows: first-time PPV for retinal detachment (RD) or macular hole repair. Exclusion criteria included a history of ocular trauma or prior eye surgery, giant retinal tears, proliferative vitreoretinopathy

(grade C or higher), glaucoma, and combined cataract surgery performed during vitrectomy. Additionally, individuals with a history of cataract surgery, refractive corneal surgery, or retinal photocoagulation were also excluded from the study.

Data Collection

The following patient data were collected: age, gender, systemic health conditions, history of ocular surgery, and any associated eye diseases. Postoperative assessments were performed at 1 and 7 days, and at 2, 4, and 6 weeks. During each visit, a comprehensive ocular examination was conducted, including slit-lamp findings, best spectacle-corrected visual acuity measured with a standard Snellen chart, intraocular pressure, and fundoscopic examination. Corneal sensation was evaluated using a Cochet-Bonnet esthesiometer (Luneau Ophthalmologie, Paris, France), and corneal thickness was measured with the Oculus Pentacam (Oculus Inc., Germany). These measurements were recorded preoperatively and at the 6-week postoperative follow-up.

For corneal sensation assessment, the filament of the esthesiometer was extended to a full length of 6 cm and then retracted incrementally in 0.5 cm steps until the patient reported feeling the contact. The length at which the patient felt the filament was recorded (note: a shorter length indicates reduced sensation). This process was repeated for each quadrant: superior, temporal, inferior, and nasal, and the average sensitivity value across all five areas was used for statistical analysis. The filament was sterilized after each use, and retracted back into the device to prevent damage.

Corneal thickness was measured using the Oculus Pentacam, with data output including total corneal and epithelial thickness maps within a 6.0-mm diameter area. The imaging was always performed by the same investigator before clinical examination to minimize potential artifacts caused by eye drop instillation. The average corneal thickness across the 6-mm sample area was used for statistical analysis.

Surgical Technique

The 23-gauge pars plana vitrectomy (PPV) was performed using the Stellaris Vitreoretinal Surgical System (Bausch & Lomb Incorporated, Bridgewater, NJ, USA) with a wide-angle

viewing system. Posterior visualization was achieved with either a Resight 700 (Carl Zeiss Meditec AG, Jena, Germany) or a BIOM viewing system (Oculus, Wetzlar, Germany). None of the surgeries involved simultaneous scleral buckle surgery, cataract surgery, or limbal peritomy.

Prior to surgery, the pupil was dilated with 10% phenylephrine and 1% cyclopentolate. All procedures were conducted under peribulbar anesthesia by two surgeons (A.E. and A.A.). A 23-gauge blade was introduced at a 15 to 30-degree angle through the conjunctiva, sclera, and pars plana, approximately 4.00 mm from the corneoscleral limbus, at the superotemporal, superonasal, and inferotemporal quadrants. Following this, a microcannula was inserted through the conjunctival incision into the scleral tunnel using a specially designed blunt inserter.

Triamcinolone acetonide was used intraoperatively to highlight the vitreous body, allowing for the removal of the posterior cortical vitreous up to the vortex vein. Brilliant Blue G (ILM Blue; Dore International, Zuidland, The Netherlands) was used to stain the macula in MH cases. The inner limiting membrane (ILM) was then peeled at least 2 disc diameters from the macular hole's edge, along with the hole flap. Core and peripheral vitrectomy were performed under indentation, except for in macular hole surgeries. Liquid perfluorocarbon (perfluoro-n-octane, Al.chi.mi.a. S.r.l., Ponte S. Nicolò, Padova, Italy) was injected for further assistance.

After fluid-air exchange, the original retinal break was treated with laser photocoagulation, followed by 360-degree laser retinopexy (Laser 532 nm integrated into the Stellaris Vitreoretinal system, 532 nm wavelength, continuous mode).

Two rows of laser spots were applied encircling the ruptures or degenerative areas, and three additional rows of laser spots were applied circumferentially, creating a new ora serrata posterior to the natural one. After air-gas exchange (SF6 for macular hole or RD patients), the cannulas were withdrawn, and the conjunctiva was gently pushed laterally with a cotton wool applicator to seal the sclerotomy site. If leakage persisted, the sclerotomy site was closed using a 7-0 polyglactin 910 suture.

Statistical analysis

Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 26). The normality of data was first tested with one-sample Kolmogorov-Smirnov test. Qualitative data were described using number and percent. Association between categorical variables was tested using Chi-square test while Continuous variables were presented as mean \pm SD (standard deviation) and compared by independent t test for different groups and paired t test for paired groups. The results were considered significant when the $p \leq 0.05$.

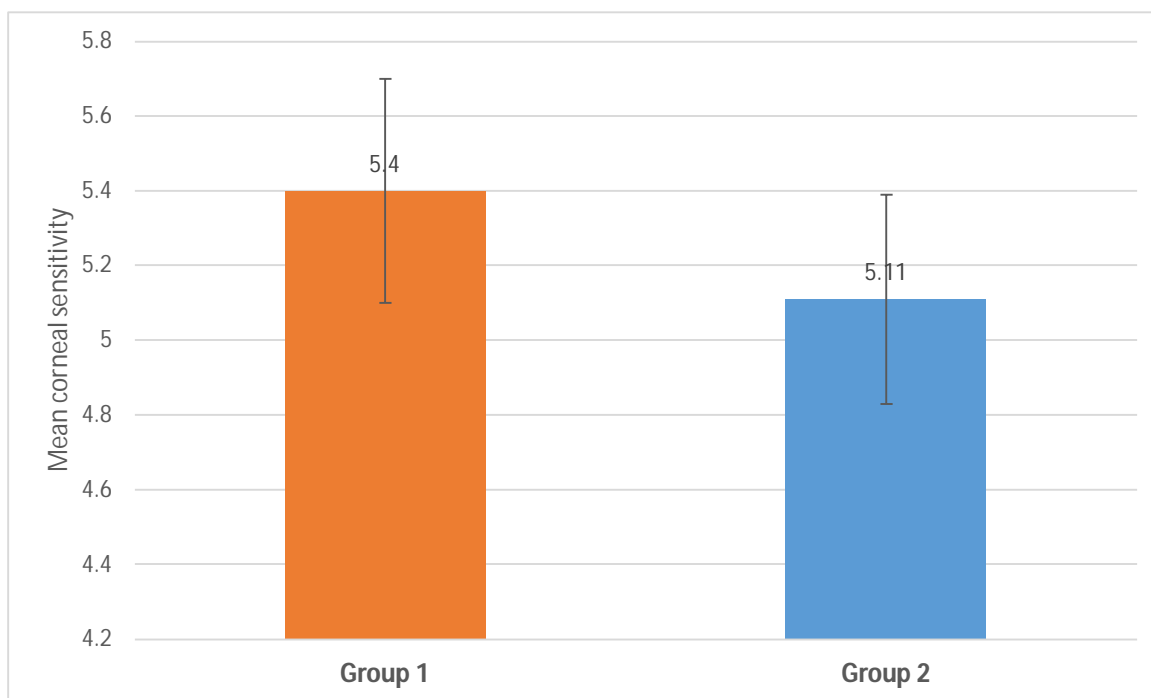
RESULTS:

This prospective comparative study included 30 eyes of 30 patients (15 retinal detachment [RRD] and 15 macular hole [MH] cases) undergoing 23-gauge pars plana vitrectomy (PPV). Baseline demographic and clinical characteristics were comparable between groups, with no significant differences in age (RRD: 59.41 ± 12.34 years vs. MH: 60.13 ± 11.77 years; $p=0.895$), sex distribution (60% male in both groups; $p=1.0$), laterality (RRD: 80% right eyes vs. MH: 70%; $p=0.606$), preoperative corneal sensitivity (RRD: 5.4 ± 0.3 cm vs. MH: 5.21 ± 0.28 cm; $p=0.138$), or corneal thickness (RRD: $545.8 \pm 30.38 \mu\text{m}$ vs. MH: $544.12 \pm 31.08 \mu\text{m}$; $p=0.904$) (Table 1).

Table 1. Baseline Characteristics of Patients before Surgery in Retinal Detachment Group (Group 1) and Macular Hole Group (Group 2)

	Group 1 (n = 10)	Group 2 (n = 10)	All Patients (n = 20)	Test of sig. P Value
Age (yrs)				
mean \pm SD (Range)	59.41 \pm 12.34 (37-73)	60.13 \pm 11.77 (41-74)	60.50 \pm 11.91 (37-74)	t= 0.134 p=0.895
Sex, n (%)				
Male	6 (60%)	6 (60%)	12 (60%)	$\chi^2=0$
Female	4 (40%)	4 (40%)	8 (40%)	P=1.0
Side, n (%)				
Right eye	8 (80%)	7 (70%)	15 (75%)	$\chi^2=0.267$
Left eye	2 (20%)	3 (30%)	5 (25%)	P=0.606
Mean corneal sensitivity, cm \pmSD	5.4 \pm 0.3	5.21 \pm 0.28	5.26 \pm 0.25	t=2.23 p=0.138
Mean corneal thickness, μm \pmSD	545.8 \pm 30.38	544.12 \pm 31.08	544.08 \pm 32.93	t=0.122 p=0.904

t: Independent t-test, χ^2 : Chi square test, *significant $p \leq 0.05$

**Figure (1):** Mean corneal sensitivity among the studied groups

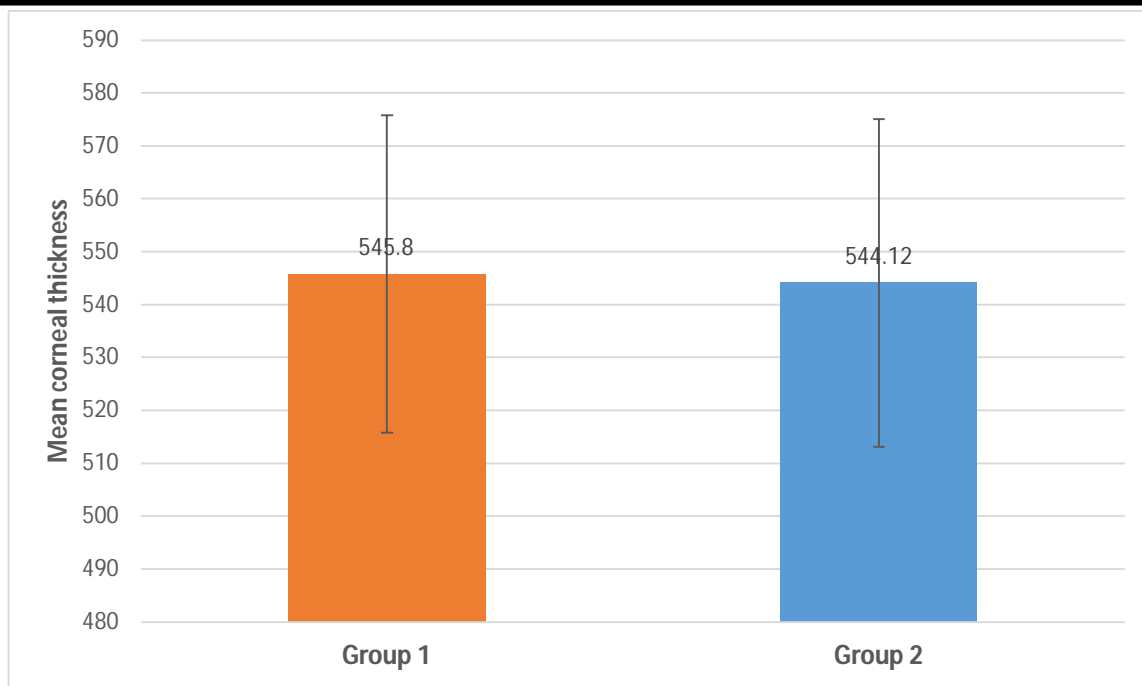


Figure (2): Mean corneal thickness, mm among the studied groups

At 6 weeks postoperatively, corneal sensitivity decreased significantly in the RRD group (5.4 ± 0.3 cm to 2.5 ± 2.1 cm, $p < 0.001$), reflecting a 46.3% reduction, whereas no significant change occurred in the MH group (5.11 ± 0.28 cm to 5.05 ± 0.43 cm, $p = 0.672$) (Table 2, Figure 3). Corneal thickness

remained stable in both groups (RRD: $545.8 \pm 30.38 \mu\text{m}$ to $540.1 \pm 32.21 \mu\text{m}$, $p = 0.682$; MH: $544.12 \pm 31.08 \mu\text{m}$ to $541.32 \pm 30.76 \mu\text{m}$, $p = 0.842$) (Table 2, Figure 4).

Table 2. Mean Corneal Sensitivity \pm Standard Deviation, Mean Corneal Epithelium Thickness \pm Standard Deviation in Retinal Detachment Group (Group 1) and Macular Hole Group (Group 2) Preoperatively and at 6 weeks Postoperatively

Group 1	Preoperatively	6 weeks Postoperatively	Paired t test
RRD			P value
Corneal sensitivity, cm Mean \pm SD	5.4 ± 0.3	2.5 ± 2.1	$t = 4.32$ $P \leq 0.001^*$
Corneal thickness, mm Mean \pm SD	545.8 ± 30.38	540.1 ± 32.21	$t = 0.411$ $P = 0.682$
Group 2			Paired t test
Macular hole			P value
Corneal sensitivity, cm Mean \pm SD	5.11 ± 0.28	5.05 ± 0.43	$t = 0.431$ $P = 0.672$
Corneal thickness, μm Mean \pm SD	544.12 ± 31.08	541.32 ± 30.76	$t = 0.202$ $P = 0.842$

t: Paired t-test, *significant $p \leq 0.05$

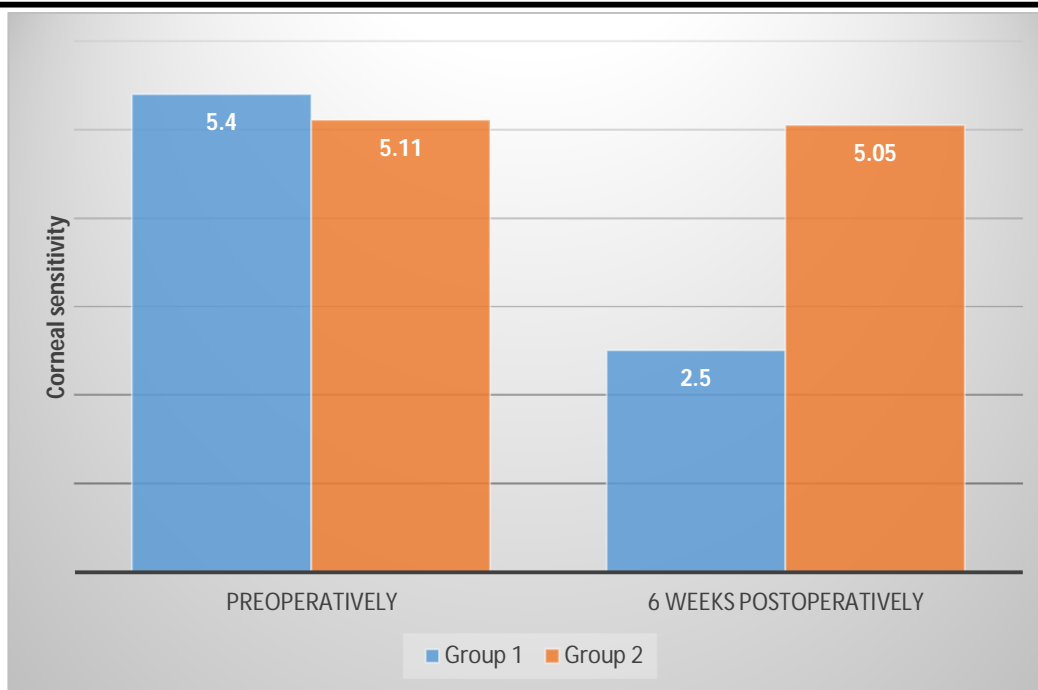


Figure (3): Mean corneal sensitivity preoperatively and at 6 weeks postoperatively

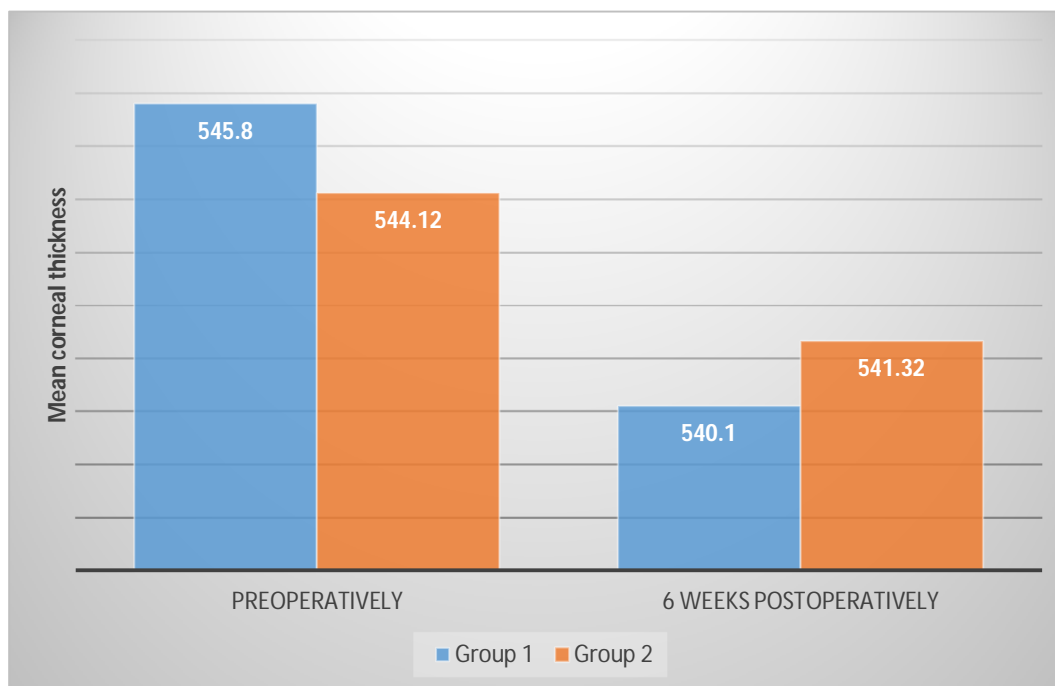


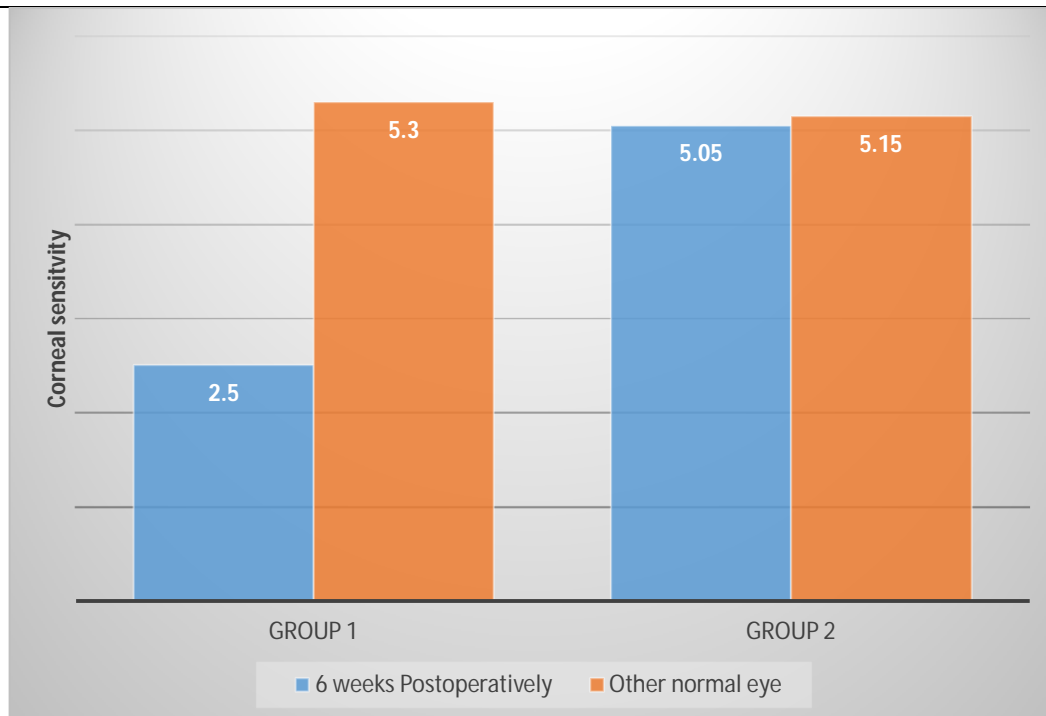
Figure (4): Mean corneal thickness preoperatively and at 6 weeks postoperatively

When compared to the contralateral normal eye, postoperative corneal sensitivity in the RRD group remained significantly reduced (2.5 ± 2.1 cm vs. 5.3 ± 2.2 cm, $p=0.009$), while no differences were observed in the MH group (5.05 ± 0.43 cm vs. 5.15 ± 0.62 cm, $p=0.68$) (Table 3, Figure 5).

Similarly, **corneal thickness** showed no significant differences between operated and contralateral eyes in either group (RRD: $540.1 \pm 32.21 \mu\text{m}$ vs. $542.3 \pm 33.49 \mu\text{m}$, $p=0.882$; MH: $541.32 \pm 30.76 \mu\text{m}$ vs. $542.47 \pm 32.45 \mu\text{m}$, $p=0.936$) (Table 3, Figure 6).

Table 3. Mean Corneal Sensitivity \pm Standard Deviation, Mean Corneal Epithelium Thickness \pm Standard Deviation in Retinal Detachment Group (Group 1) and Macular Hole Group (Group 2) at 6 weeks Postoperatively compared to other normal eye

Group 1	6 weeks Postoperatively	Other normal eye	Paired t test
RRD			P value
Corneal sensitivity, cm Mean \pm SD	2.5 \pm 2.1	5.3 \pm 2.2	t=2.91 P= 0.009*
Corneal thickness, μ m Mean \pm SD	540.1 \pm 32.21	542.3 \pm 33.49	t= 0.149 P=0.882
Group 2			Paired t test
Macular hole	6 weeks Postoperatively	Other normal eye	P value
Corneal sensitivity, cm Mean \pm SD	5.05 \pm 0.43	5.15 \pm 0.62	t=0.419 P=0.68
Corneal thickness, μ m Mean \pm SD	541.32 \pm 30.76	542.47 \pm 32.45	t= 0.081 P=0.936

**Figure (5):** Mean corneal Sensitivity at 6 weeks postoperatively and in other normal eye

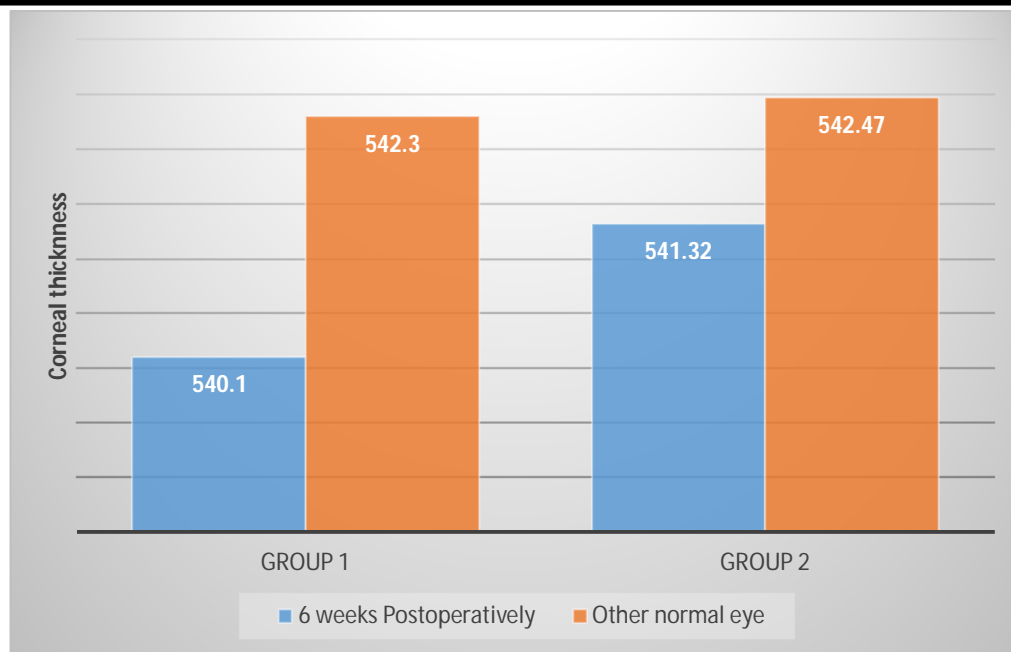


Figure (6): Mean corneal thickness at 6 weeks postoperatively and in other normal eye

DISCUSSION

The cornea, being the tissue with the highest density of nerve fibers in the body, depends on neurotrophic factors from the trigeminal nerve endings to preserve its epithelial structure and metabolic balance⁴. Impairment of this nerve function, as observed in neurotrophic keratopathy, can cause defects in the epithelium, lead to ulceration, and result in loss of vision^{2,3}. This study shows that performing 360-degree laser retinopexy during pars plana vitrectomy (PPV) for rhegmatogenous retinal detachment (RRD) leads to a notable 46.3% reduction in corneal sensitivity, which is consistent with previous studies indicating laser-induced damage to corneal nerves^{10,11}. Interestingly, corneal sensitivity was maintained in macular hole (MH) surgery without laser retinopexy, suggesting that the laser, rather than the vitrectomy alone, is the main contributor to sensory deficits.

Mechanisms of Corneal Nerve Injury

The 532 nm argon laser produces thermal energy that causes protein denaturation and disrupts nerve fibers^{6,7}. In patients with rhegmatogenous retinal detachment (RRD), circumferential retinopexy near the ora serrata likely transmits heat anteriorly, affecting the long ciliary nerves that pass through the suprachoroidal space to innervate the cornea^{4,11}. This

mechanism is similar to findings in diabetic retinopathy patients undergoing panretinal photocoagulation (PRP), where laser-induced thermal damage has been linked to decreased corneal sensitivity and a reduction in subbasal nerve plexus (SBNP) density^{15,16}. For example, De Cillà et al.¹³ observed a 33% decrease in SBNP density following PRP, while Misra et al.¹⁴ did not report such changes, possibly due to the presence of preexisting diabetic neuropathy masking the laser's effects^{15,16}. Our study, which excluded diabetic patients, demonstrates that laser retinopexy itself directly impacts corneal innervation, independent of systemic conditions.

Contrast with Glaucoma and Diabetic Neuropathy

Corneal nerve damage is well-established in glaucoma patients using topical beta-blockers (such as timolol) that are preserved with benzalkonium chloride (BAC)¹⁷⁻²¹. Similarly, diabetes is associated with decreased subbasal nerve plexus (SBNP) density and corneal sensitivity, which correlates with the severity of peripheral neuropathy²²⁻²⁴. However, our study cohort for RRD excluded patients with diabetes and glaucoma, thereby isolating laser retinopexy as the primary cause of sensory loss. This distinction highlights the importance of separating laser-specific effects from comorbid conditions during clinical evaluations.

Confounding Factors

Various factors can influence corneal sensitivity. Choroidal detachment, a potential surgical complication, can decrease corneal sensitivity by compressing the suprachoroidal nerves²⁵. However, choroidal detachment was not observed in our study. Myopic RRD patients, with thinner retinas and choroids, might be more susceptible to laser energy¹¹. Subgroup analyses based on axial length were not conducted, indicating the need for further research in this area. Additionally, long-term use of preservative-containing antiglaucoma medications (e.g., for ocular hypertension) may contribute to increased corneal toxicity²⁰, though in this study, medication use was limited to just two weeks postoperatively.

Clinical Implications

To minimize corneal nerve injury, several strategies can be considered. Optimizing laser parameters, such as reducing total laser energy and exposure time, may help mitigate nerve damage^{26,27}. For instance, using lower energy settings that avoid the horizontal meridians, where the long ciliary nerves converge, could preserve corneal sensitivity²⁸. Additionally, postoperative use of preservative-free medications, particularly those without benzalkonium chloride (BAC), may help reduce ocular surface toxicity^{20, 21}. Regular monitoring of corneal health through esthesiometry or in vivo confocal microscopy (IVCM) is also recommended to detect early neurotrophic changes, especially in high-risk patients^{16,22,29}.

Study Limitations

- Short Follow-Up: A 6-week period may miss delayed epithelial thinning or ulceration.
- Small Sample Size: Limited power to assess subgroups (e.g., myopia and diabetics).
- Lack of IVCM: Direct quantification of SBNP density changes would strengthen correlations with functional deficits.

Future Directions

1. Long-Term Studies: Evaluate corneal sensitivity recovery or progression to neurotrophic keratopathy.
2. Laser Sparing Protocols: Test whether avoiding laser in ciliary nerve pathways preserves innervation.

3. IVCM Integration: Correlate SBNP morphology with esthesiometry findings.

CONCLUSION

This study demonstrates that performing 360-degree laser retinopexy during PPV significantly affects corneal sensory function, likely due to thermal damage to the long ciliary nerves. Although corneal thickness remains unaffected in the short term, surgeons should carefully consider the prophylactic advantages of laser treatment against the potential neurotrophic risks. There is an urgent need for updated laser protocols that focus on reducing energy and preserving nerve integrity. Future randomized trials are necessary to validate these approaches, ensuring the optimization of retinal reattachment outcomes while safeguarding corneal health.

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Data Availability: The authors declare that all data supporting the findings of this study are available within the article.

Competing interests: The authors declare no competing interests.

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Conflict of interest

All authors have no conflicts of interest that are directly relevant to the content of this review.

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