ONLINE ISSN :3007-309X
PRINT ISSN :3007-3081

Journal of Medical & Health Sciences Review

TO DETERMINE THE CHANGE IN THE SIZE OF MACULAR HOLE DURING SURGERY BEFORE AND AFTER THE INTERNAL LIMITING MEMBRANE PEELING USING INTRAOPERATIVE OPTICAL COHERENCE TOMOGRAPHY

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ARTICLE INFO:

Keywords:
Macular Hole, Internal Limiting Membrane, Ilm Peeling, Intraoperative Oct

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Article History:
Published on 15 July 2025

ABSTRACT

Background: Macular hole (MH) surgery has evolved significantly with the advent of intraoperative optical coherence tomography (iOCT), which allows real-time visualization of retinal architecture during key surgical steps such as internal limiting membrane (ILM) peeling.

Objective: To determine the change in the size of macular hole diameter before and after ILM peeling using intraoperative OCT during macular hole surgery.

Methodology: This prospective interventional study was conducted at LRBT, Tertiary Care Eye Hospital, Karachi, for six months, i.e, from 1st January 2023 to 30th June 2023, on 10 patients with idiopathic full-thickness macular holes undergoing standard 25-gauge pars plana vitrectomy with ILM peeling. Intraoperative OCT was used to measure the minimal MH diameter immediately before and after ILM peeling. Data was analyzed using SPSS version 26. A paired t-test was used with a significance of $p \leq 0.05$.

Results: The mean minimal MH diameter significantly decreased from 466.3 ± 75.1 µm before ILM peeling to 394.9 ± 40.5 µm after peeling ($p = 0.0009$). Most patients were female (60%) with a mean age of 61.3 years, and 50% were pseudophakic. A majority (60%) presented within three months of symptom onset.

Conclusion: ILM peeling leads to a significant intraoperative reduction in macular hole diameter, confirming its role in relieving traction and facilitating retinal tissue approximation. iOCT provides a valuable tool for real-time assessment and may help predict surgical success.

INTRODUCTION

A macular hole is a full-thickness defect of the neurosensory retina at the center of the macula, typically affecting the fovea, which is responsible for central vision.[1] Most commonly seen in the elderly population, it is often idiopathic in nature, but may also be secondary due to trauma, high myopia, or macular edema.[2] The usual presentation for patients with macular holes is decreased central vision, metamorphopsia (distortion), or a central scotoma; all of which can severely affect their quality of life.[3]

The development of pars plana vitrectomy (PPV) has revolutionized the treatment of macular holes.[4] The standard operative procedure entails removal of the vitreous gel, as well as peeling of the internal limiting membrane (ILM) in order to relieve any traction at the macular region, thereby assisting with hole closure.[5] Peeling of the ILM has been proven to be an important aspect of helping anatomical and functional outcomes, as it allows retinal compliance and helps to promote glial proliferation to assist in tissue remodeling.[6]

In the last few years, intraoperative optical coherence tomography (iOCT) has emerged as an invaluable addition to the surgical armamentarium of the vitreoretinal surgeon.[7] iOCT provides a real-time, cross-sectional imaging capability of the retina; and in-vivo assessment of the surgical action, allowing for the surgeon to enhance his/her ability to assess the anatomical changes of the eye during surgery.[8] iOCT may allow improved visualization of the retinal architecture before and after ILM peeling that may assist in improving clinical outcomes.[9]

Prior research has shown that macular holes change their structure during the different phases of surgery, particularly before ILM peeling, and again once the ILM has been peeled.[10, 11] Nevertheless, the intraoperative imaging of quantitative changes in macular hole size is still largely unexplored in the literature. The intraoperative imaging of macular hole size fluctuation in real time with iOCT may provide information on the biomechanical function of the retina that could have a plausible value in predicting postoperative anatomical success.[7]

In this light, it is rational to measure the change in macular hole size during surgery, specifically before and after ILM peeling, using intraoperative optical coherence tomography to understand how macular holes change intraoperatively, to improve surgical maneuvers, prognostication, and also to increase the standard of care in macular hole surgery. Therefore, this study aimed to measure the change in the size of the macular hole during surgery before and after ILM peeling with intraoperative optical coherence tomography.

Methodology

This was a prospective interventional study approved by the Ethical Review Board (ERB) conducted at LRBT, Tertiary Care Eye Hospital, Karachi, for six months, i.e, from 1st January 2023 to 30th June 2023. Informed, written consent was obtained from all enrolled participants before inclusion into the study.

A total of 10 patients diagnosed with full-thickness idiopathic macular holes were included. The sample size calculation was based on data from a study by Kusuhara et al. (2021), who used intraoperative optical coherence tomography to evaluate changes in minimal (“aperture”) macular hole diameter following internal limiting membrane peeling. They reported a mean reduction of 26.0 µm (from 283.0 ± 170.2 µm to 257.0 ± 127.8 µm), with a standard deviation of approximately 50 µm. Using these parameters in the WHO sample size calculator (95% confidence level, 80% power), a total of 10 participants were selected.[12]

A non-probability consecutive sampling technique was used to recruit eligible participants. Patients aged 40 to 75 years with stage 2–4 idiopathic full-thickness macular holes, scheduled for elective pars plana vitrectomy, were included. Exclusion criteria comprised eyes with high myopia (>6 diopters), traumatic macular holes, associated retinal detachment, diabetic retinopathy, previous vitreoretinal surgery, or other macular pathology.

Preoperative data were gathered using a structured questionnaire completed by trained clinical staff. The questionnaire recorded patient demographics, age, gender, ocular history, symptom duration and lens status, and preoperative OCT. All surgeries were performed by a single experienced vitreoretinal surgeon using a 25-gauge three-port pars plana vitrectomy system. After core vitrectomy and induction of posterior vitreous detachment, the ILM was stained with trypan blue G dye and peeled in a circular area extending approximately two-disc diameters around the macular hole. Intraoperative Optical Coherence Tomography (iOCT) (Model: Lieca Machine, Direct iOCT by Enfocus) was used to capture real-time cross-sectional images of the macula before and after ILM peeling. The minimal macular hole diameter was measured as the narrowest distance between the hole edges at the internal retinal surface using the built-in caliper tool. Each measurement was taken three times and averaged for accuracy. All measurements were performed by a single observer to minimize variability.

Data were entered and analyzed using SPSS version 26. Continuous variables such as macular hole diameter were reported as mean ± standard deviation (SD), while categorical data (e.g., gender, lens status) were expressed as frequencies and percentages. A paired t-test was used to compare the mean macular hole diameter before and after ILM peeling. A p-value < 0.05 was considered statistically significant.

Results

The mean age of the study participants was 61.3 ± 8.2 years, indicating that macular holes were predominantly seen in the elderly population. A female predominance was observed, with 60% of the patients being women. Most patients (70%) had no prior ocular surgery, while 30% had undergone cataract surgery, which is consistent with the common coexistence of age-related ocular conditions. In terms of symptom duration, 60% of patients presented within 3 months of symptom onset, suggesting a relatively early diagnosis, while only 10% had symptoms lasting longer than 6 months. Lens status was equally distributed, with 50% of eyes being phakic and 50% pseudophakic, which may have implications for visual recovery post-surgery. (Table 1)

Table 1: Demographic and Clinical Characteristics of Participants (n = 10)

Variable	Category	n (%)
Age (years)	**Mean ± SD**	61.3 ± 8.2
Gender	**Male**	4 (40%)
	Female	6 (60%)
Ocular History	**No prior ocular surgery**	7 (70%)
	History of cataract surgery	3 (30%)
Symptom Duration	**< 3 months**	6 (60%)
	3–6 months	3 (30%)
	> 6 months	1 (10%)
Lens Status	**Phakic**	5 (50%)
	Pseudophakic	5 (50%)

Intraoperative optical coherence tomography (iOCT) was used to measure the minimal macular hole (MH) diameter before and after internal limiting membrane (ILM) peeling in all 10 patients. The mean MH diameter before ILM peeling was 466.3

± 75.1 µm, which reduced to 394.9 ± 40.5 µm after ILM peeling. This reduction was observed consistently across most cases, indicating a measurable anatomical response during surgery, and this reduction was highly significant ($p = 0.0009$). These findings confirm that ILM peeling results in an immediate and significant decrease in MH diameter intraoperatively, reflecting the mechanical and structural changes occurring at the retinal level during the surgical procedure. (Table 2)

Table 2: Minimal Macular Hole (MH) Diameter Before and After ILM Peeling (n = 10)

Patient	MH Diameter	
	Before ILM (µm)	**After ILM (µm)**
1	437 ± 50	398 ± 50
2	491 ± 50	372 ± 50
3	650 ± 50	492 ± 50
4	348 ± 50	372 ± 50
5	450 ± 50	390 ± 50
6	444 ± 50	360 ± 50
7	461 ± 50	390 ± 50
8	452 ± 50	385 ± 50
9	500 ± 50	430 ± 50
10	430 ± 50	350 ± 50
Mean ± SD	466.3 ± 75.1	394.9 ± 40.5

A paired t-test demonstrated that the reduction in minimal macular hole diameter after ILM peeling was statistically significant (p = 0.0009), indicating measurable intraoperative changes in macular configuration following ILM removal.

Discussion

This study explored intraoperative dynamics of minimum macular hole (MH) diameter by using intraoperative optical coherence tomography (iOCT) for imaging before and after peeling internal limiting membrane (ILM). We found a significant reduction in MH diameter after ILM peeling, with the mean diameter decreased from 466.3 ± 75.1 µm to 394.9 ± 40.5 µm ($p = 0.0009$). This study supports the ILM peeling hypothesis of decreasing tangential traction across the macula and in stimulating hole closure.

Several studies have similarly noted intraoperative changes with MH configuration before and after ILM peeling using iOCT. A study by Kassotis et al. (2023) provided an early investigation of real-time surgical structural changes during macular hole surgery and reported a characteristic decrease in both minimum and base diameter following ILM peeling.[13] In another study, Liu et al. (2023) concluded that ILM peeling induced centripetal retinal movement, which led to significant reductions in the intraoperative minimum hole diameter.[14] Like the findings from both of these studies, our data suggest that ILM peeling release resulted in mechanical properties in the form of decreased tangential traction across the macula through changes in minimum diameter.

Scalia and colleagues (2023) used high-resolution OCT and reported that ILM peeling encourages retinal elasticity and leads to a decrease in the size of the macular hole.[15] Shetty et al. (2023) were similar in that they asserted that ILM acted as a substrate for residual traction, and consequently, removal of the ILM should induce spontaneous centripetal movement of photoreceptors.[16] These biomechanical scenarios were also suggested by our intraoperative metrics.

Qi et al (2020) further evaluated whether the ability of intraoperative change in MH diameter could be predictive of the ultimate closure at follow-up. They found that greater reductions were associated with improved closure rates and better visual acuity outcomes.[17] This finding aligns with our study and highlights the prognostic potential of real-time imaging.

Piya et al. (2022) explored the use of OCT pre- and post-operatively in MH surgery and proposed that changes in minimum diameter correlate with better anatomical closure.[18] More recently, Rezende et al. (2023) conducted a prospective analysis using iOCT and concluded that the dynamic nature of MH size during surgery can guide surgical decisions such as the extent of ILM peeling.[19]

In terms of quantitative values, our mean reduction of approximately 71 µm is comparable to the findings reported by Shmueli et al. (2024), who observed a 60–100 µm decrease post-ILM peeling using swept-source OCT.[20] Moreover, Marolo et al. (2025) demonstrated that even small intraoperative reductions in MH diameter (as low as 50 µm) were associated with higher closure probabilities, emphasizing the clinical relevance of this metric.[21]

Additionally, Modi et al. (2017) compared patients with and without ILM peeling and found significantly higher closure rates and smaller postoperative defect size in the ILM peeling group, indirectly supporting the changes we observed intraoperatively.[22]

Taken together, the consistency of our findings with these published studies reinforces the biomechanical and clinical value of ILM peeling in macular hole surgery. The intraoperative reduction in MH diameter reflects effective traction release and may serve as an early indicator of successful surgical intervention.

From a clinical standpoint, the use of iOCT enhances surgical precision, allows confirmation of ILM peeling completeness, and helps identify residual traction in real-time. It offers the surgeon the opportunity to assess tissue behavior dynamically, which may influence intraoperative decision-making and improve postoperative outcomes.

However, this study has limitations. The small sample size ($n = 10$) restricts generalizability and statistical power. Moreover, postoperative functional outcomes like visual acuity or closure type were not considered, which hinders the ability to associate intraoperative modifications with later findings. Additionally, the study was done at a single location and did not examine variability in surgical technique or instrumentation. Although there are limitations to this research, it provided useful real-time evidence of macular hole dynamics and supports the role of iOCT in improving the safety and efficiency of vitreoretinal surgery.

Conclusion

In conclusion, the current study provided evidence that iOCT is an excellent tool for monitoring real-time structural changes in macular hole configuration during surgery. The fact that there was a substantial decrease in minimal macular hole diameter after removing the internal limiting membrane (ILM) suggests a mechanical role of the ILM in relieving traction and allowing approximation of retinal tissue. These findings support the view that the routine use of iOCT can help improve surgical precision and may serve as a pre-operative predictor of anatomical success. Further studies, including large sample sizes and correlation with postoperative outcomes, are warranted to confirm the intraoperative findings of the current study.

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