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Optical Coherence Tomography Study of Macular Hole

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Running Title: OCT of macular hole.

Abstract

Purpose: The study aimed to assess the ability of optical coherence tomography (OCT) to describe vitreomacular-interface and foveal structure in patient with idiopathic macular hole

Methods: This is a cross sectional, observational study that included 30 eyes of 30 patients attending outpatient clinic of Mansoura Ophthalmic center. They presented with idiopathic macular hole during the period between june, 2016 and April, 2019All. The study included patients with idiopathic macular hole. Cases were subjected to complete history taking, thorough ophthalmic examination, and OCT scanning. Anti-inflammatory eye drops were used to treat eye inflammation. At follow up, all cases were evaluated by slit lamp examination, OCT scanning, fundus examination with slit lamp biomicroscopy with the+ 90D lens, as well as intraocular tension measurement by applanation tonometry.

Results: The mean age of the cases was 67.07 ± 5.58 years with range between 58 and 77 years. There were 12 males (40%) and 18 females (60%) among the included cases. The mean BCVA was 0.904 ± 0.169 with range between 0.6 and 1.176. There is a statistically significant positive correlation between macular hole index with BCVA, hole rim diameter, hole maximum diameter, hole minimum diameter, hole height, right arm length, left arm length, hole form factor, tractional hole index, diameter hole index and lateral fluid pocket.

Conclusion: The fact that OCT is a technically simple, quick, accurate way in describation of vitreomacular-interface and foveal structure in patient with idiopathic macular hole

Key words: Idiopathic macular hole, Optical coherence tomography, various vitreomacular-interface

INTRODUCTION

Macular hole is a full-thickness defect in neurosensory retina at fovea which leads to marked visual impairment. It can be idiopathic or secondary to ocular trauma, retinal detachment, high myopia and laser injury. Idiopathic macular hole is the most common type of macular hole. On the contrary, traumatic macular hole is relatively rare[1].

Optical coherence tomography (OCT) technology allows observation of the retinal structures and thus provides important diagnostic information for accurate evaluation of the macular area[2-3].

Spectral-domain optical coherence tomography (SD-OCT), helps in the identification of various vitreomacular-interface (VMI)-associated disorders such as idiopathic epiretinal membrane (ERM) with or without macular pseudoholes (MPH), lamellar macular holes (LMH), Full-thickness macular hole (FTMH), post vitreous detachment (PVD) and vitreomacular traction (VMT)[4]**.** SD-OCT has become the gold standard for diagnosis and follow-up of VMT syndrome[5-6]**.** So, this study aimed to describe vitreomacular-interface and foveal structure in patient with idiopathic macular hole by spectral optical coherence tomography.

PATIENTS AND METHODS

This was a a cross sectional, observational study that included 30 eyes of 30 patients attending outpatient clinic of Mansoura Ophthalmic center. They presented with idiopathic macular hole during the period between June 2016 and April 2019.

Inclusion criteria

- The study included patients with idiopathic macular hole

Exclusion criteria

- Traumatic macular hole.
- Myopic macular holes.
- Patients with uveal diseases.
- Patients had undergone retinal photocoagulation or surgery for complications of retinochoroidal diseases.
- Severe cataract hindering satisfactory evaluation of the macula.
- Patients with glaucoma.

History taking:

- Age, gender.
- Systemic diseases: diabetes mellitus, hypertension.
- Onset, course, duration of diminution of vision.
- History of ocular trauma.
- History of ocular surgery.

Detailed ophthalmic Examination include:

- Measurement of V/A using Landolt C chart.
- Refraction using automated refractometer.
- Measurement of best corrected visual acuity (BCVA).
- Slit-lamp biomicroscopy to assess anterior segment (corneal clarity, depth of anterior chamber, state of pupillary dilatation, lens opacity and nuclear grading).
- Fundus examination by slit lamp biomicroscopy, using non-contact Volk 90 lens, and Indirect Ophthalmoscope.
- Measurement of ocular tension using Schiotz tonometry.
- OCT for detection macular pathologies.

The Steps of OCT scanning was done as follows:

OCT was performed through a dilated pupil the image involved multiple horizontal and vertical 5mm with fixation maintained. The OCT machine machine used was the 3D OCT -1 maestro2. The maestro2 automatically performs alignment, focus optimizing and capturing with a single touch. The scan which had the maximum diameter of macular hole was analysed. Only scans with good signal strength were used for analysis. the minimum diameter was measured at the nearest ends of the broken retinal tissue, while the maximum diameter was measured at the farthest ends of the broken retinal tissue, depth of the hole was also measured and at surface of the hole rim diameter, stages of MHs were determined according to both clinical features and factors

OCT Hole form factor (HFF)

It is the ratio of left arm length and right arm length to the base diameter of macular hole***(Dayani et al., 2009)***

Macular hole index (MHI)

It is the ratio of hole height to base diameter (ratio of perpendicular and horizontal dimensions of the hole). It can be calculated from OCT transverse images of the macular area[18].

Diameter hole index (DHI)

It is the ratio of minimum diameter of MH to base diameter and is an indicator of extent of tangential traction[17].

Tractional hole index (THI)

It is the ratio of maximal height of MH to minimum diameter and is an indicator of AP traction and retinal hydration ***(D. Steel et al., 2016)***

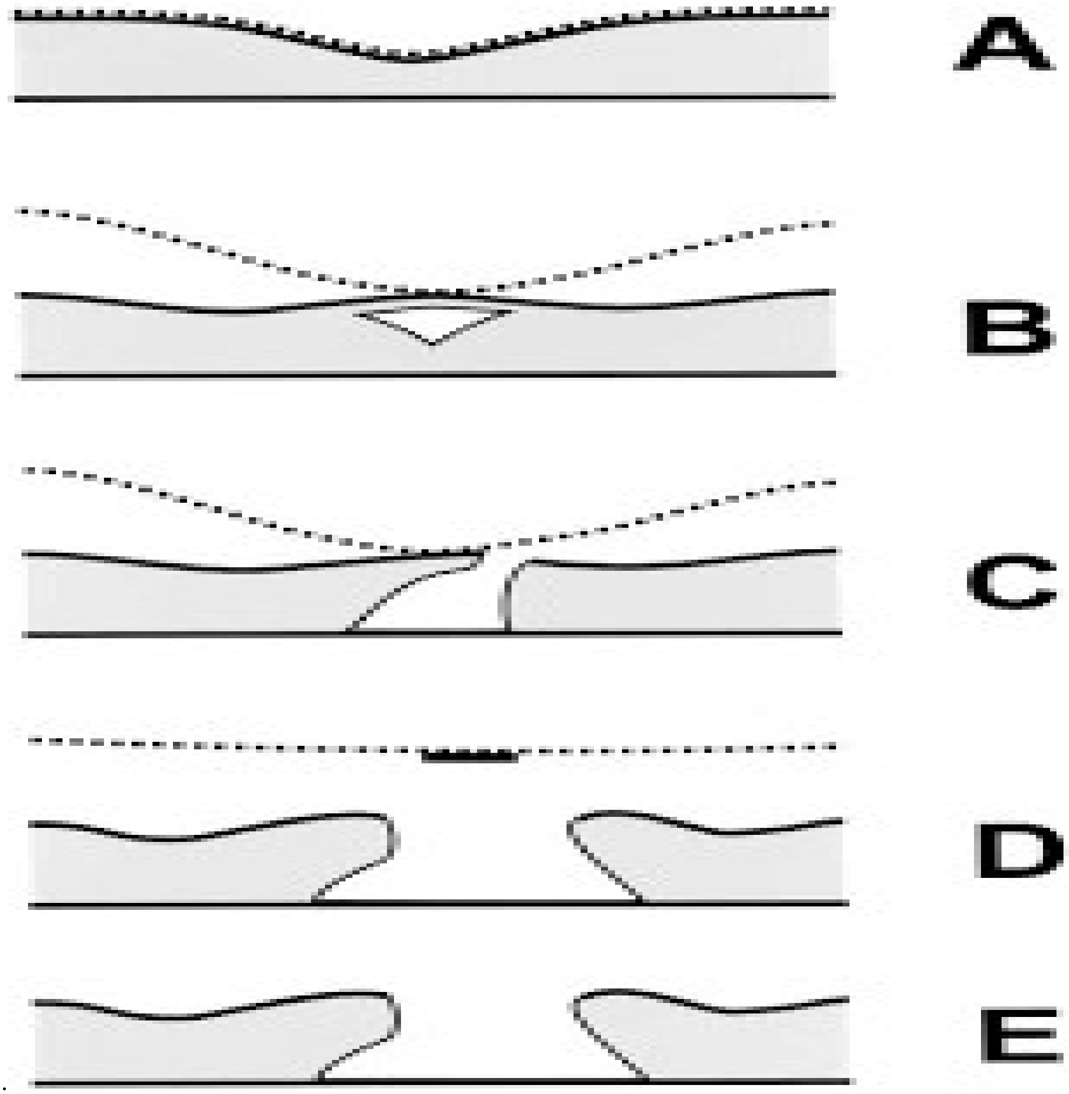

Figure (1): Diagram of a normal fovea. (B) An impending macular hole with a cystic space in the inner part of the foveal umbo. There is a perifoveal detachment of the posterior hyaloid, which exerts anterior–posterior traction on the foveal umbo. (C) Stage 2macular hole, with a dehiscence in the roof of the foveal cyst. This dehiscence has expanded outwards and a full thickness macular hole has developed. (D) Fully developed stage 3 macular hole. The hyaloid is detached from the fovea, but not from the optic disc. A small pseudo-operculum, consisting of the roof of the foveal cyst, is suspended in front of the macular hole. (E) Stage 4 macular hole, with complete posterior vitreous detachment, usually with a visible Weiss's ring ***(La Cour and Friis, 2002)***.

Gass anatomical classification of macular hole ***(Madi et al., 2016)***.

Stage 0 VMA in the fellow eye of a patient with a known/previous MH without any change in foveal architecture, stage 1 Impending macular hole with outer retinal elevation from RPE at foveal centre, Stage 2 ≤400 µm MH with VMA, stage 3 >400 µm MH without VMA, stage 4 MH with complete posterior vitreous detachment.

Additional OCT findins such as the presence of VMT, intraretinal cyst and subretinal fluid (SRF)were evaluated

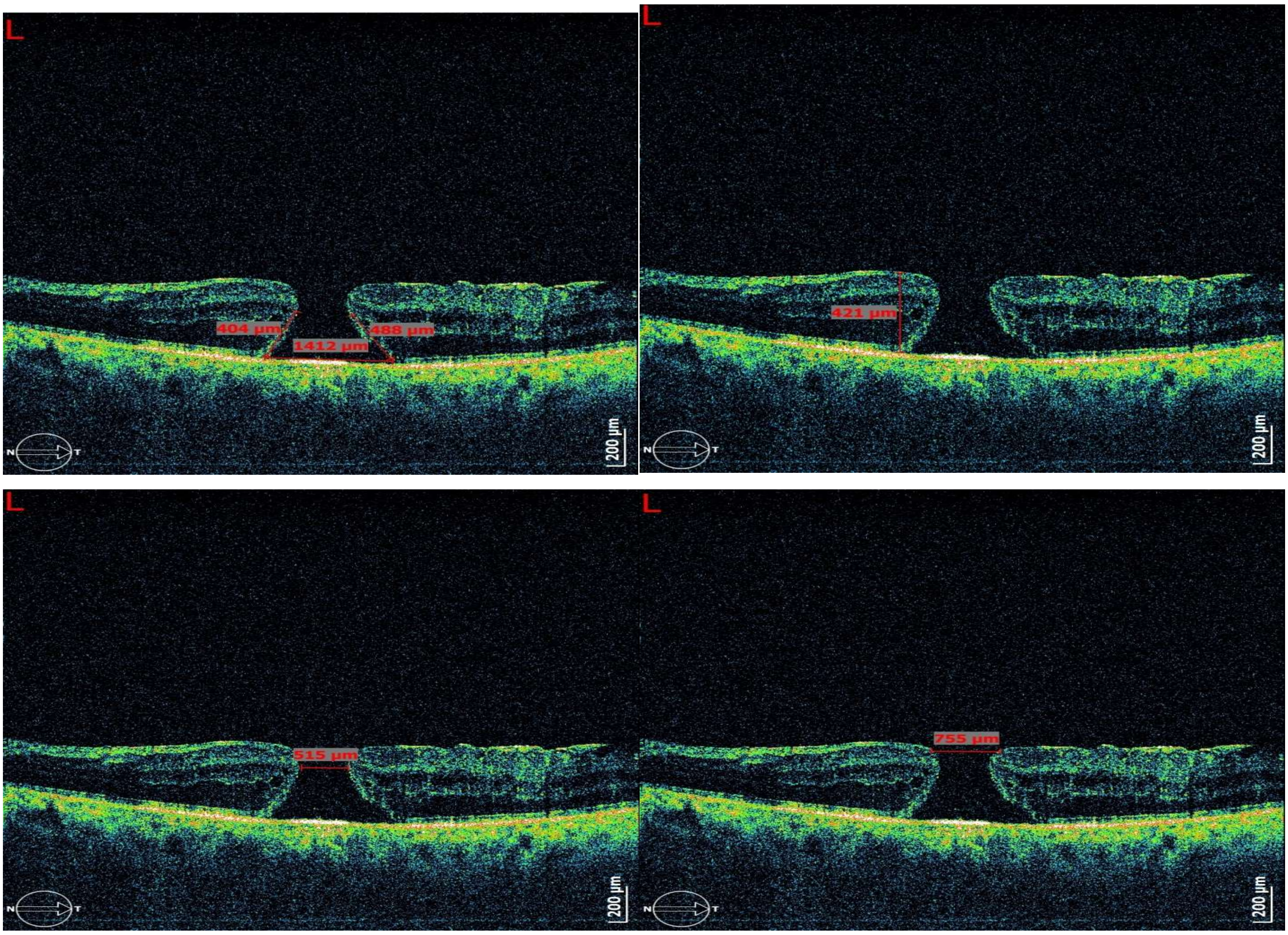

Figure (2):(a) Schematic representation of OCT factors; (b) HFF = (b + c)/a; (c) MHI = height/base (h/b); (d) Tractional hole index ***(Tinwala, 2018)***

Statistical analysis

The collected data were coded, processed, and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (SPSS Inc, Chicago, IL, USA). Qualitative data was presented as number (frequency) and Percent. Quantitative data was tested for normality by Kolmogorov-Smirnov test. Data was presented as mean ± SD.

Ethics approval and consent to participate:

This study was approved by Mansoura Medical Research Ethics Committee, Faculty of Medicine, Mansoura University (code number MS.19.10.858). All subjects provided written informed consent prior to study participation.

RESULTS

This study included 30 eyes of 30 patients with idiopathic macular hole recruited from Ophthalmology center, Mansoura University. The mean age of the cases was 67.07 ± 5.58 years with range between 58 and 77 years. There were 12 males (40%) and 18 females (60%) among the included cases (table 1).

Table (1): Demographic data in the cases included in the study

Items		**Study cases n=30**
Age (years)	Mean ± SD	67.07 ± 5.58
	Median (min-max)	68 (58-77)
Sex		
-Male		**12 (40%)**
-Female		**18 (60%)**

Continuous data expressed as mean±SD and median (range)
Categorical data expressed as Number (%)

The right eyes were affected in 13 cases (43.3%) and the left eyes were affected in 17 cases (56.7%). The mean BCVA was 0.904 ± 0.169 with range between 0.6 and 1.176. The mean IOP was 16.42 ± 0.92 with range between 15.1 and 18. Regarding the state of the length, it was phakic in 23 cases (76.7%) and pseudophakic in 7 eyes (23.3%) (table 2).

Table (2): State of eye affection in the cases included in the study

Items		Study cases n=30
Laterality		
RT		**13 (43.3%)**
Lt		**17 (56.7%)**
BCVA	Mean ± SD	0.904 ± 0.169
Log MAR	Median (min-max)	1 (0.6-1.176)
IOP	Mean ± SD	16.42 ± 0.92
	Median (min-max)	16.5 (15.1-18)
Lens status		
Phakic		**23 (76.7%)**
Nuclear sclerosis		**15 (65.2%)**
Senile immature cataract		**8 (34.8%)**
Pseudophakic		**7 (23.3%)**

VMA was found in 10 cases (33.3%), VMT in 6 cases (20%), ERM in 9 cases (30%) and operculum in 6 cases (20%). Incomplete PVD was detected in 8 cases (26.7%) and complete PVD in 22 cases (73.3%). Regarding the fellow eye, tigroid fundus was detected in 18 cases (60%) and NPDR in 12 cases (40%) (table 3).

Table (3): OCT findings of the cases in the study

Items	Study cases n=30
VMA	
Yes	10 (33.3%)
No	20 (66.7%)
VMT	
Yes	6 (20%)
No	24 (80%)
PVD	
Incomplete PVD	8 (26.7%)
Complete PVD	22 (73.3%)
ERM	
Yes	9 (30%)
No	21 (70%)
Fellow eye	
Tigroid fundus	18 (60%)
NPDR	12 (40%)
Operculum	
Yes	6 (20%)
No	24 (80%)

VMA (vitreomacular attachment), VMT (vitreomacular traction), PVD (posterior vitreous detachment), ERM (epiretinal membrane), NPDR (Non proliferative diabetic retinopathy)

Regarding the halo staging, Stage 2 was detected in 4 cases (13.3%), Stage 3 was present in 6 cases (20%) and Stage 4 in 20 cases (66.7%). The mean hole rim diameter was 684.03 ± 223.26 with range between 299 and 1122 µm. the hole maximum diameter was 763.03 ± 283.47 with range between 336 and 1412 µm. the hole minimum diameter was 451.03 ± 152.08 with range between 207 and 678 µm. the mean hole height 290.2 ± 128.62 with range between 98 and 476 µm (table 4).

Table (4): Analysis of the criteria for hole examination of the cases in the study

Items		Study cases n=30
Hole staging		
Stage 2		**4 (13.3%)**
Stage 3		**6 (20%)**
Stage 4		**20 (66.7%)**
Hole rim diameter	Mean ± SD	684.03 ± 223.26
	Median (min-max)	701.5 (299-1122)
Hole maximum diameter	Mean ± SD	763.03 ± 283.47
	Median (min-max)	778 (336-1412)
Hole minimum diameter	Mean ± SD	451.03 ± 152.08
	Median (min-max)	490 (207-678)
Hole height	Mean ± SD	290.2 ± 128.62
	Median (min-max)	327 (98-476)

Table (5) shows that according to the macular hole index (cutoff > 0.5), all the cases revealed poor prognosis while according to Hole form factor (cutoff > 0.9), there were 6 cases (20%) and 24 cases (80%) with poor prognosis.

Table (5): Classification of cases prognosis according to macular hole index and hole form factor

Items	Study cases n=30
Macular hole index (cutoff > 0.5)	
Good prognosis	**0 (0%)**
Poor prognosis	**30 (100%)**
Hole form factor (cutoff > 0.9)	
Good prognosis	**6 (20%)**
Poor prognosis	**24 (80%)**

There was a statistically significant positive correlation between macular hole index with BCVA, hole rim diameter, hole maximum diameter, hole minimum diameter, hole height, right arm length, left arm length, hole form factor, tractional hole index, diameter hole index and lateral fluid pocket (table 6). There was a statistically significant positive correlation between hole form factor with BCVA, hole rim diameter, hole maximum diameter, hole minimum diameter, hole height, right arm length, left arm length, hole form factor, tractional hole index, diameter hole index and lateral fluid pocket (table 7).

Table (6): Correlation between macular hole index and other parameters

Macular hole index Variable	r	p
Age	0.047	0.821
BCVA (logmar)	0.440	0.025*
Hole rim diameter	0.670	< 0.001*
Hole maximum diameter	0.511	0.008*
Hole minimum diameter	0.659	< 0.001*
Hole height	0.665	< 0.001*
Right arm length	0.648	< 0.001*
Left arm length	0.709	< 0.001*
Hole form factor	0.951	< 0.001*
Tractional hole index	0.501	0.009*
Diameter hole index	0.555	0.003*
Lateral fluid pocket	0.604	0.001*
Thickness	0.049	0.810

r: Pearson's correlation, *: statistically significant ($p< 0.05$)

Table (7): Correlation between hole form factor and other parameters

Hole form factor Variable	r	p
Age	-0.030	0.883
BCVA (logmar)	0.553	0.003*
IOP	0.212	0.299
Hole rim diameter	0.736	< 0.001*
Hole maximum diameter	0.621	0.001*
Hole minimum diameter	0.769	< 0.001*
Hole height	0.769	< 0.001*
Right arm length	0.781	< 0.001*
Left arm length	0.824	< 0.001*
Macular hole index	0.951	< 0.001*
Tractional hole index	0.560	0.003*
Diameter hole index	0.451	0.021*
Lateral fluid pocket	0.703	<0.001*
Thickness	0.115	0.557

r: Pearson's correlation, *: statistically significant ($p< 0.05$)

DISCUSSION

Idiopathic macular hole (IMH) is one of the most often causes of poor vision. The estimated incidence of IMH ranged from 0.3 to 0.8% in general population. It may cause a small dark spot in the central vision. MH may be related with high myopia or ocular trauma, but the reason of most MHs is unknown (idiopathic). Based on the optical coherence tomography (OCT) images of macular region, IMHs can be divided into 4 stages, stage III or IV MH was considered as refractory macular hole (MH) due to the low close rate after surgery[7-9].

Optical coherence tomography (OCT) provides confirmation of clinical findings, further anatomic characterization, means of educating patients, and improved staging of MH. In a study of 61 eyes with all stages of MH, OCT offered additional or different information in 92% of stage 1 MH. Clinical assessment of late-staged MH is enhanced with OCT by enabling measurement of the diameter of the MH and visualizing the posterior hyaloid[10-11].

Thus, the aim of the current study was to describe vitreomacular-interface and foveal structure in patient with idiopathic macular hole by spectral optical coherence tomography (OCT).

This was a prospective, interventional study that included 30 eyes of 30 patients attending outpatient clinic of Mansoura

Ophthalmic center. They presented with idiopathic macular hole during the period between June, 2016 and April, 2019.

With regard to demographic features, the average age of the studied cases was 67, with male to female ratio (M/F) was (40/60).

It was demonstrated that, diameter is an important factor that influences the outcomes of IMH surgery. It has been reported that IMH with a minimum diameter under 400um had a higher recovery rate [12]. Notably, stage III and IV IMHs are more difficult to heal[13].

According to the macular hole index (cutoff > 0.5), all the cases revealed poor prognosis while according to Hole form factor (cutoff > 0.9), there were 6 cases (20%) and 24 cases (80%) with poor prognosis.

colleagues believed that higher HFF correlated with better postoperative visual outcome and the correlation coefficient between HFF and postoperative visual acuity was 0.36.

Wakely and his colleagues[17] measured macular hole inner opening diameter, minimum linear diameter, base diameter, and macular hole height and calculated the MHI and the tractional hole index (FHI). They found base diameter, macular hole inner opening and minimum linear diameter could be used to predict anatomical and/or functional success rate of macular hole surgery. Preoperative base diameter is the most useful variable in this regard.

The current study demonstrated that, there was a statistically significant positive correlation between macular hole index with BCVA, hole rim diameter, hole maximum diameter, hole minimum diameter, hole height, right arm length, left arm length, hole form factor, tractional hole index, diameter hole index and lateral fluid pocket.

In agreement, Kusuhara and his colleagues and Wakely and his colleagues[17-18] proposed the concept of macular hole index (MHI, ratio of hole height to base diameter of hole) and found that MHI significantly correlated with the postoperative BCVA. However, most of the previous studies associated with MHI were limited to the IMHs under stage III.

Additionally, Chhablani and his colleagues[19] found a significant correlation of MHI (p=0.009), ratio of the macular hole height to the diameter of the base, with type of closure and that of THI with final BCVA (p=0.017).

The current study demonstrated that, there was a statistically significant positive correlation between hole form factor with BCVA, hole rim diameter, hole maximum diameter, hole minimum diameter, hole height, right arm length, left arm length, hole form factor, tractional hole index (THI), diameter hole index (DHI) and lateral fluid pocket.

It was demonstrated that, diameter is an important factor that influences the outcomes of IMH surgery. It has been reported that IMH with a minimum diameter under 400um had a higher recovery rate[12].

Yu and his colleagues[20] found the diameter more than 677um is a risk factors for postoperative unclosure of stage III and IV IMHs that underwent 23-gauge vitrectomy, ILM peeling, and air tamponade.

This came in accordance with a novel study conducted by Qi and his colleagues[7] who demonstrated that, preoperative hole diameter ratio (HDR) < 0.6 is predictive for a good postoperative anatomical outcome in stage III or IV idiopathic macular holes (IMHs).

On the contrary, Chhablani and his colleagues[19] showed no statistically significant correlation with BCVA. Additionally, the only index which demonstrated significant correlation with BCVA was THI. However, these indices have significant collinearity with various SD-OCT measurements.

CONCLUSION

Routine OCT imaging of the macular region feasible to detect macular pathologies in a considerable number of patients, which remained undiagnosed on biomicroscopic fundoscopy.

Technically simple, quick, accurate way in describation of vitreomacular-interface and foveal structure in patient with idiopathic macular hole Also, the higher accuracy OCT not only facilitates an accurate diagnosis, but preoperative surgical planning based on OCT factors also helps in improving anatomic and functional prognosis.

Disclosures

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DATA AVAILABILITY

All data are included in this article.

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Ethics declarations

Conflict of interest

Heba A. Khreba, Ahmed R. El-Lakkany, Sherief E. El-Khouly, Walid M. Gaafar. all authors have no conflicts of interest that are directly relevant to the content of this review.

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