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Evaluation of OCT Morphological Pattern in Prediction of Visual Outcome after Pars Plana Vitrectomy with ILM Peeling for Persistent Diffuse Nontractional Diabetic Macular Edema

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Abstract

Aim of Study: To assess the correlation between the OCT morphological pattern of macular edema and improvement of macular thickness and visual acuity following pars plana vitrectomy and ILM peeling for diffuse non-tractional diabetic macular edema.

Methods: 25 eyes with persistent diabetic macular edema were treated with 23 guage transconjunctival PPV with ILM peeling. Pre-operative evaluation performed including full medical and ophthalmological history and examination. Central Subfield Macular Thickness (CSMT) and Best Corrected Visual Acuity (BCVA) was evaluated at 6 weeks and 3 months and 6 months post-operatively.

Results: Mean pre-operative CSMT was 536.56μ (SD± 134.064) which was highest for Serous Retinal Detachment (SRD) group. Mean post-operative CSMT was 395.44μ (SD ±102.844), 359.16μ (SD±116.005), 321.8μ (SD±111.233) at 6 weeks, 3 months and 6 months respectively. The mean change in CSMT was –141.12μ (SD±122.588), –177.4μ (SD ±127.343) and –214.76μ (SD±124.331) at 6 weeks, 3 months and 6 months respectively. This was statistically significant (*p*-value <0.0001). This change was highest for Diffuse Retinal Thickening (DRT) group at 6 months and the change in CSMT is statistically significant in all groups at different follow-up visits (*p*-value <0.05).

Mean pre-operative BCVA (decimal notation) was 0.1 (SD±0.0674) and it was highest in CME group and lowest in DME group that was statistically significant (*p*-value=0.49). Mean post-operative change in BCVA from base line was limited which was only statistically significant at 6 months (*p*-value=0.008) and this change was highest in DRT group and lowest in Cystoid Macular Edema (CME) group and it was statistically significant in DRT group at month 3 and month 6 and in SRD group at month 6 follow-up visits (*p*-value <0.05).

Conclusion: The results showed that PPV with ILM peeling was successful in reducing the retinal thickness in all OCT morphological patterns and this effect was maintained during the follow-up and DRT and SRD patterns of macular edema have more favorable visual outcome after surgery.

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Key Words: *ILM peeling – Diabetic macular edema – OCT morphological pattern.*

Introduction

MACULAR edema is the leading cause of visual impairment in patients with diabetes mellitus **[1]**. It progressively decreases visual acuity, with more than half of the patients losing at least 2 lines within 2 years **[2]**. Two distinct types of macular edema have been described, focal and diffuse. Focal macular edema derives from individual micro aneurysms or small clusters of micro aneurysms that histopathologically leak in a more limited extent. Diffuse macular edema derives from extensively damaged capillaries, micro aneurysms and arterioles in a capillary bed that appears to be generally dilated. Diffuse Diabetic Macular Edema (DME) is defined as retinal thickening of two or more disc areas involving some portion of the Foveal Avascular Zone (FAZ) with or without cystoid macular edema **[3]**.

There are 5 OCT patterns of DME identified by Kim and colleague: A) Diffuse Retinal Thickening (DRT) as increased retinal thickness (defined as greater than 200 micron) with reduced intraretinal reflectivity and expanded areas of lower reflectivity, especially in the outer retinal layers greater than 200 micron in width. B) Cystoid Macular Edema (CME) was identified by the localization of intraretinal cystoid-like spaces that appeared as round or oval areas of low reflectivity with highly reflective septa separating the cystoid-like cavities. C) Posterior Hyaloidal Traction (PHT) was defined as a highly reflective signal arising from the inner retinal surface and extending towards

the optic nerve or peripherally. D) Serous Retinal Detachment (SRD) was defined as an accumulation of sub-retinal fluid (which appeared dark) beneath a highly reflective and elevation, resembling a dome, of the detached retina. E) Traction retinal detachment, defined as a peak-shaped detachment of the retina **[4]**. The qualitative information of morphology may aid in altering prognosis or therapeutic approach over and above the quantitative information of retinal thickness measurements **[5]**.

Material and Methods

This was a prospective, nonrandomized interventional study that was performed on 25 eyes of 23 patients with persistent clinically significant diabetic macular oedema. All the patients underwent pars plana vitrectomy with ILM peeling. The patients were selected from the outpatient ophthalmology clinic of Kasr Al-Aini Hospital, Cairo University between March 2013 and August 2014. The protocol was revised and approved by our Ophthalmology Departement Ethical Committee.

A- *Inclusion criteria:*

Persistent diffuse DME defined as more than 2 disc diameters in area with central macular thickness (CMT) ≥300μm with history of at least one session of Macular Photocoagulation (MPC) and intravitreal injection of either triamcinolone acetonide or anti-vascular endothelial growth factor (anti-VEGF).

B- *Exclusion criteria:*

1- Lens opacity precluding Optical Coherence Tomography (OCT).

2- Massive hard exudates in the fovea.

3- Only focal macular edema attributable to focal leaks from microaneurysm.

4- History of previous vitreoretinal surgery.

5- Evidence of vitreomacular traction on OCT including anteroposterior by posterior hyaloid and tangential traction by taut hyaloid or epiretinal membrane.

6- Angiographic evidence of macular ischemia.

7- Monocular patient.

Preoperative evaluation:

- Full medical history (duration of diabetes, controlled or not), other systemic diseases and previous management for DR.
- All eyes were subjected to examination of Best Corrected Visual Acuity (BCVA) using snellen's chart projector at a viewing distance of 3 metres and expressed in Decimal system.
- Slit-lamp examination of anterior segment to exclude corneal abnormalities and significant cataract.
- Intraocular pressure measurement using Goldman applanation tonometry.
- Fundus examination was done using slit lamp biomicroscopy and indirect ophthalmology.
- Pre-interventional fluorescein angiography using Topcon TRC 50IX retinal camera (Topcon Optical Co., Tokyo, Japan).
- Optical Coherence Tomography (OCT) to document macular thickness, morphological pattern of macular oedema and to exclude vitreomacular traction and taut posterior hyaloid using Spectral Domain (SD) OCT (Optovue, Northport loop west Fremont, CA, USA) using the following protocols:
  - *Radial line scans:* 6mm diameter radial lines separated by 30 degrees and centered on the fovea. The line scan comprises 1024 axial scans. Sixteen scans for 16384 total data points averaged to single scan image.
  - *Macular map 5mm (MM5):* Central subfield foveal thickness, defined as the average retinal thickness of 1mm of central scanned area, using macular cube (MM5) in which 5x5mm square grid centered on fixation, the grid spacing is 0.25mm in the inner 3x3mm area and 0.5mm in the outer area. Seventeen horizontal then 17 vertical line scans all centered at fovea.
- If DRT and CMO or SRD were combined, the classifications were CMO or SRD, respectively; and when DRT, CMO and SRD were present, the classification was SRD.

Surgical technique:

- Fourteen cases were done under General Anesthesia (GA) and 11 cases under peribulbar local anesthesia (lignocaine 1%: Bupivacaine 0.5% 1: 1).
- Three 23 gauge one step valved trocars was inserted at infero-temporal, supero-temporal and supero-nasal quadrants and infusion cannula was secured in the infero-temporal trocar.
- Phacoemulsification with 3 piece “acrysof” acrylic hydrophilic intra-ocular lens acrysof (Alcon, Aliso Viejo, California, USA) implantation in the bag (10 eyes) or in the ciliary sulcus (4 eyes) was done in all phakic patients irrespective of lens clarity.

- Core vitrectomy was done using Constellation vitrectomy machine (Alcon, Aliso Viejo, California, USA) using high cutting rate 4500 cut per minute (cpm) and 300mmhg linear vacuum.
- Triamcinilone was injected to stain cortical vitreous adherent to retina.
- Posterior hyaloid detachment was induced using vitrectomy probe by activating vacuum of vitrectomy machine starting from optic disc and extending to posterior border of vitreous base.
- ILM blue (Biriliant blue G 0.025%) (DORC International, Zuidland, the Netherlands) dye was injected under air and left for 30 seconds.
- A scratch was made in stained ILM by 23 guage needle and flap was initiated using disposable 23 guage diamond dusted sweeper (DORC International, Zuidland, the Netherlands).
- ILM peeling was completed using 23 guage disposable ILM forceps (DORC International, Zuidland, the Netherlands).
- Vitreous base shaving was done and endo-laser photocoagulation was performed in cases with proliferative diabetic retinopathy.
- Air fluid exchange was done and trocars were removed and sutures were taken in case of leak.

Results

Demographic data analysis:

Demographic data of the patient are shown in (Table 1). Twenty five eyes of 23 patients, 2 patients for both eyes, 7 males and 16 females were included. All patients were type 2 diabetes mellitus, 3 patients received oral hypoglycemic drugs and 20 patients received insulin. Mean age was 57.5 years (SD±6.87). Eight eyes had proliferative diabetic retinopathy and 17 eyes had non proliferative diabetic retinopathy. Eleven eyes were pseudophakic 6 were cataractous and 8 were nuclear sclerotic. Posterior vitreous detachment was present in 3 eyes. 6 eyes had cystoid macular edema, 10 eyes had diffuse macular edema and 9 eyes had subfoveal neurosensory detachment. Nineteen eyes received only intravitreal anti-VEGF (Bevacizumab) and 6 eyes received both intravitreal bevacizumab and triamcinolone. The mean number of bevacizumab injections was 3.08 (SD±1.41) which was higher in group with CME (Table 1) that was statistically significant (*p*-value 0.041) by Kruskal Wallis test.

1- *Central Subfield Macular Thickness (CSMT):*

Mean pre-operative CSMT was 536.56µ (SD± 134.064) which was highest for neurosensory detachment group. Mean post-operative CSMT was 395.44µ (SD±102.844), 359.16µ (SD±116.005), 321.8µ (SD±111.233) at 6 weeks, 3 months and 6 months respectively. The mean change in CSMT was –141.12µ (SD±122.588), –177.4µ (SD± 127.343) and –214.76µ (SD±124.331) at 6 weeks, 3 months and 6 months respectively this was statistically significant (*p*-value <0.0001) and it was highest for DRT group at 6 months. Mean CSMT and change in CSMT in different OCT groups are shown in (Tables 2,3). The change in CSMT was statistically significant in all groups at different follow-up visits (*p*-value <0.05). There was anatomical improvement (improvement of central foveal thickness) in 23 eyes (92%) and with no improvement in 2 eyes (8%).

2- *Visual acuity:*

Mean pre-operative BCVA (decimal notation) was 0.1 (SD±0.0674) and it was highest in CME group and lowest in DME group that was statistically significant (*p*-value=0.49). Mean BCVA was 0.1182 (SD±0.09700), 0.1382 (SD±0.09881), 0.1598 (SD±0.10273) at 6 weeks, 3 months and 6 months post-operative respectively. Mean post-operative change in BCVA from base line was 0.0149 (SD±0.08749), 0.0349 (SD±0.08808) and 0.0565 (SD±0.09152) at 6 weeks, 3 months and 6 months post-operative respectively which was statistically significant at 6 months (*p*-value=0.008) and this change was highest in DRT group and lowest in CME group and it was statistically significant in DRT group at month 3 and month 6 and in SRD group at month 6 follow-up visits (*p*-value <0.05) (Tables 4,5). There was positive correlation between change in BCVA at week 6 and final change in BCVA at month 6 that was statistically significant (*p*-value=0.007). Mean BCVA and change in BCVA in different OCT groups are shown in tables. There was no visual improvement in 8 eyes (32%) and 17 eyes experienced visual improvement (68%) but this was not statistically significant (*p*-value=1). Visual and anatomical improvement occurred in 16 eyes however, visual improvement without anatomical improvement occurred in one eye and it was due to extraction of a significant cataract. Seven eyes didn't show visual improvement yet they showed anatomical improvement. However, there was one eye that didn't show neither visual nor anatomical improvement.

Complications:

I- *Intra-operative complications:*

There were 2 posterior iatrogenic breaks in 1 eye during induction of PVD however they didn't interfere with ILM peeling and they were treated

by endo-laser photocoagulation and air tamponade and post-operative face down positioning.

II- *Post-operative complications:*

There was 1 case of persistent epithelial defect that treated by bandage contact lens, excessive lubricants and autologous serum and another case developed hypopyon 4 days post-operatively and it was treated by frequent topical steroid under topical antibiotic cover. Vitreous hemorrhage occurred in 1 eye immediately post-operatively and managed conservatively with complete resolution after 10 days.

Table (1): Distribution of number of anti-VEGF injection in different OCT groups.

	Mean	St. deviation	*p*-value
CME	4.33	1.86	4.50
DRT	3.10	.99	3.00
SRD	2.22	.97	2.00

Table (2): Mean CSMT (microns) in different OCT groups at different follow-up visits.

	CME			DRT			SRD		
	Mean	St. deviation	Median	Mean	St. deviation	Median	Mean	St. deviation	Median
CSMT 0	546.00	113.40	590.50	496.50	126.18	447.50	574.78	155.74	566.00
CSMT W6	415.7	134.8	394.5	356.5	85.3	350.0	425.2	94.8	430.0
CSMT M3	393.3	118.4	385.5	308.5	55.6	302.0	392.7	151.0	340.0
CSMT M6	354.5	118.8	352.5	269.2	50.0	278.5	358.4	140.4	310.0

Table (3): Mean change in CSMT in different OCT groups at different follow-up visits.

	CME			DRT			SRD		
	Mean	St. deviation	*p*-value	Mean	St. deviation	*p*-value	Mean	St. deviation	*p*-value
W6 CSMT change	–130.333	93.34809	.028	–140.0000	141.97105	.005	–149.556	129.58888	.011
M3 CSMT change	–152.666	110.5544	.046	–188.0000	153.08386	.005	–182.111	118.41288	.011
M6 CSMT change	–191.500	137.1987	.046	–227.3000	130.50845	.005	–216.333	121.83288	.011

Table (4): Mean change in BCVA in different OCT groups at different follow-up visits.

	CME			DRT			SRD		
	Mean	St. deviation	*p*-value	Mean	St. deviation	*p*-value	Mean	St. deviation	*p*-value
W6 BCVA change	–0.01	.080250	.683	0.0348	.085615	.293	.009444	.098482	.678
M3 BCVA change	0.013	.097091	.715	0.0566	.109008	.046	.025111	.054480	.324
M6 BCVA change	0.02167	.097860	.686	0.0776	.115884	.028	.056222	.050660	.037

Table (5): Mean BCVA in different OCT groups at different follow-up visits.

	CME			DRT			SRD		
	Mean	St. deviation	Median	Mean	St. deviation	Median	Mean	St. deviation	Median
BCVA 0	0.15	0.07	0.16	0.07	0.04	0.05	.11	.07	.10
BCVA W6	.143	.074	.130	.102	.090	.050	.119	.122	.080
BCVA M3	.167	.098	.150	.124	.110	.100	.135	.093	.100
BCVA M6	.175	.108	.150	.145	.119	.100	.166	.090	.160

Clinical cases:

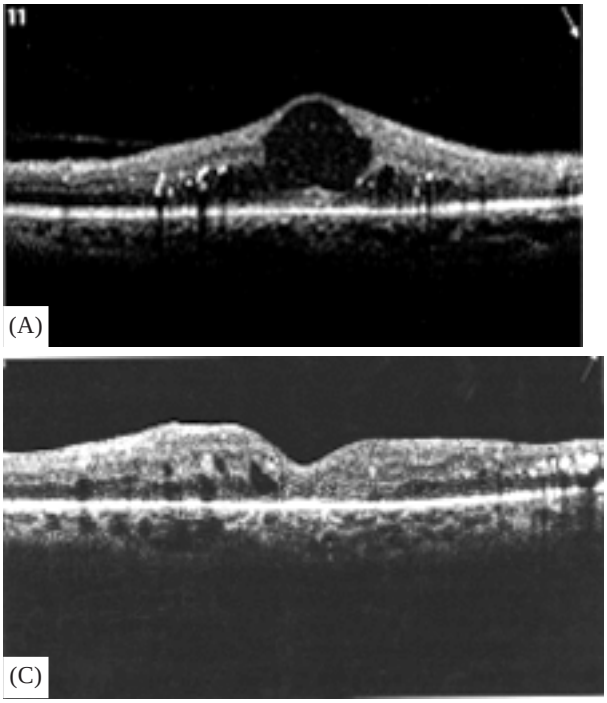

Fig. (1): Male patient 64 years old type 2 diabetes CME pattern (A) Pre-operative BCVA=0.16 and CSMT=577µ. (B) Week 6 post-operative BCVA=0.032 and CSMT=480µ. (C) 3 months post-operative BCVA=0.2 and CSMT=340.

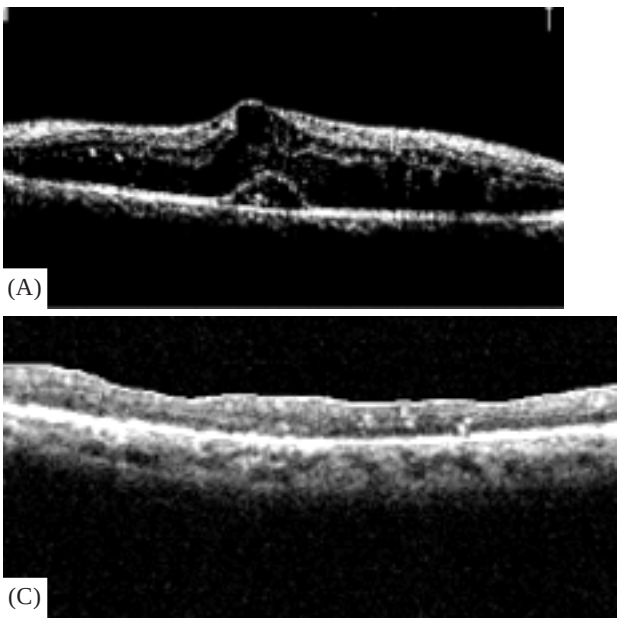

Fig. (2): Male patient 58 years old type 2 diabetes SRD pattern (A) Pre-operative BCVA=0.1 and CSMT=610µ (B) 6 weeks post-operative BCVA=0.2 and CSMT=458µ (C) 3 months post-operative BCVA=0.2 and CSMT=305µ.

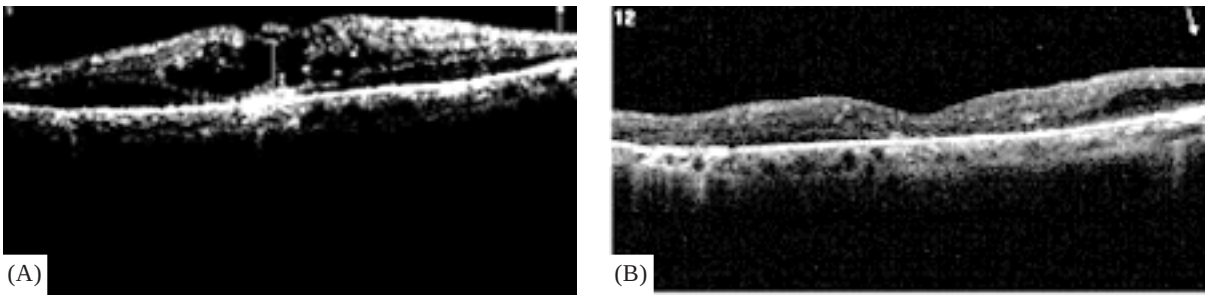

Fig. (3): Female patient 52 years old type 2 diabetes DRT pattern (A) Pre-operative BCVA=0.05 and CSMT=501µ (B) 6 months post-operative BCVA=0.1 and CSMT=206µ.

Discussion

The development of diabetic retinopathy causes structural changes in the vitreous gel. Stitt et al., observed significantly elevated levels of advanced glycation end products in the vitreous of diabetic patients, and noted that these materials caused significant irreversible cross-linking of vitreous collagen **[6]**. Kohno et al., reported that the ILM in the human eye thickens with age, and exhibits a more prominent bilaminated pattern of fibronectin and laminin deposits over time. Such changes can affect the vitreoretinal interface. The primary aim of ILM removal during vitrectomy in patients with DME is to reduce or eliminate tractional forces at the vitreoretinal interface **[7]**.

In our study 23 (92%) eyes showed marked decrease in mean central macular thickness and all eyes showed marked improvement in macular volume compared to pre-operative values. This is in accordance to most published studies **[8-16]**. This anatomical improvement is attributed to surgical removal of the posterior vitreous membrane which causes a hydrostatic pressure gradient and relieves extravascular leakage and edema **[17]**.

Moreover, vitrectomy enhances the intraocular oxygen pressure as it passes from arterial blood in the ciliary processes into the fluid in the vitreous cavity. Vitrectomy also removes substances that enhance vascular permeability such as cytokines **[18]**.

Removal of the posterior hyaloid in the current study was further enhanced by TA injection to ensure complete removal of cortical vitreous **[19]**. The anti-edema effect of TA on the anatomical outcome was minor as total drug aspiration during repeated fluid air exchange was ensured. Besides, the half-life of TA is shorter in vitrectomized eyes (1.57 days) compared to non-vitrectomized eyes (2.89 days) leading to rapid elimination of any residual particles **[20]**. The fact that the anatomical outcome in our study was progressive and maintained till the last follow-up visit negates the effect of TA which is known to provide therapeutic effect for only 3 months with 4mg intravitreal dose in non-vitrectomized eyes **[21]**.

On the other hand, ILM peeling has been considered to relieve macular traction by the vitreous owing to the complete removal of the residual posterior vitreous cortex, and furthermore, it prevents the development of secondary epimacular membrane and eliminates the scaffold for astrocyte reproliferation **[22]**. It is also believed that ILM peeling improves retinal plasticity and facilitates diffusion of water retained in the retina **[23,24]**. Moreover, Didier-Ducournau suggested that ILM removal has two functions; first, it removes the hyaloid fibres entirely and therefore treats the retraction syndrome. Second, it removes the Müller cell end-feet and thereby induces Müller cell gliosis. The Müller cell expression of Glial Fibrillary Acidic Protein (GFAP) has neurotrophic action, fights against the blood retina barrier breakdown and has synaptogenesis properties **[25]**.

In the current study, mean BCVA improvement was limited at all follow-up visits yet it was only statistically significant at 6 months. This limited visual improvement could be attributed to chronicity of the edema that persisted after both grid laser and intravitreal injections with mean pre-operative number of intravitreal anti-VEGF injections 3.08 (SD±1.41). Also, the poor pre-operative BCVA=0.1 (SD±0.0674) correlating with poor prognostic factors on OCT such as high pre-operative CSMT (536.56μ SD±134.064), disrupted IS/OS and ELM lines and cystic spaces in OPL with Muller fiber damage. This limited improvement was in agreement with Stolba et al., Kumar et al., Kumagai et al., and Rosenblatt et al., who reported limited improvement in BCVA and around 50% of cases showed visual improvement **[8,9,11,26]**.

The surgery was effective in reducing the central foveal thickness in all OCT morphological pattern subgroups however it was superior in DRT group. On the other hand visual improvement was statistically significant only in DRT and SRD groups. This can be explained by The sponge-like retinal swelling observed on OCT images appears to reflect this intracytoplasmic swelling of Muller cells in DRT pattern while Chronic macular oedema causes liquefaction necrosis of Muller cells, which forms cystoid cavities leading to CMO **[27,28]**. This was in agreement with Kim et al., how conducted a similar study on macular laser photocoagulation **[29]**. However, shah et al., found that the presence of subretinal fluid on OCT was associated with an adverse visual outcome **[30]**.

Conclusion:

The results showed that PPV with ILM peeling was successful in reducing the retinal thickness in all OCT morphological patterns and this effect was maintained during the follow-up and DRT and SRD patterns of macular edema have more favorable visual outcome after surgery.

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الملخص العربى

ارتشاح ماقولة العين السكرى سبب رئيسى لانعدام الرؤية عند مرضى السكر ويسبب تدهور مستمر فى حدة الابصار مع العلم بأن نصف المرضى يفقدون على الأقل سطرين خلال عامين. ويمكن تصنيفه شكليا عن طريق تصوير قاع العين باستخدام أشعة الفلوريسين الى بؤرى ومنتشر وسببيا بناءا على العلاقة بين سطح الشبكية والجسم الزجاجى الى شدى وغير شدى. وقد ساعد جهاز الماسح المقطعى الضوئى للشبكية الى تحديد النمط الشكلى لارتشاح ماقولة العين السكرى الى زيادة سمك الشبكية المنتشر وارتشاح الماقولة الحوصلى وانفصال الشبكية المصلى. وقد قمنا باعداد دراسة لتقييم استخدام النمط الشكلى لارتشاح ماقولة العين باستخدام جهاز الماسح المقطعى الضوئى للشبكية فى التنبؤ بنتائج الرؤية بعد ازالة الجسم الزجاجى مع ازالة الغشاء الداخلى المحد للشبكية فى علاج الارتشاح السكرى الغير ناتج عن شد الجسم الزجاجى المستمر بعد العلاج الضوئى بالليزر وحقن الجسم الزجاجى بالكورتيزون أو بالأجسام المضادة ضد عامل نمو الأوعية الدموية. وقد كان هذا الاجراء الجراحى ناجح فى الحد من سمك ماقولة العين لجميع أنواع النمط الشكلى لارتشاح ماقولة العين السكرى مع استمرار هذا التأثير خلال فترة المتابعة للحالات. وقد كان نمط زيادة سمك الشبكية المنتشر وانفصال الشبكية المصلى ذو نتائج بصرية افضل بعد الجراحة.