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Macular oedema after uncomplicated phacoemulsification

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Background: Recent development of cataract surgery has led to the improvement of visual outcomes. However, pseudophakic cystoid macular oedema (CME), which is also known as Irvine–Gass syndrome, remains a usual cause of unexpected visual disturbance after both complicated and uncomplicated cataract surgeries. Optical coherence tomography is an important method in detecting changes prior to clinical presentation.

Aim: To assess macular thickness changes after uncomplicated phacoemulsification using spectral domain optical coherence tomography (SD-OCT).

Setting: The study assessed healthy patients who had uneventful phacoemulsification and changes in macular thickness in Ibn Al Haitham Teaching Eye Hospital (tertiary eye center), Baghdad, Iraq.

Methods: Macular thickness of 86 eyes with uncomplicated phacoemulsification were measured by using four OCT examinations: one preoperatively, which was used as a control, and three in the first week and first and second months. Incidence of macular thickness changes was evaluated in the central and para and perifoveal areas to detect which areas of the macular map will be affected more. Significance was tested by using paired *t*-test and $p < 0.05$ was considered significant.

Results: Significant increase in macular thickness postoperatively during the 2-month period reaching the maximum level in the second month; early significant changes were noticed in paracentral area in the first week whilst significant increase in the central and pericentral area was recorded in the first month. Cystoid macular oedema (CME) was detected in six eyes (7%) in the second month.

Conclusion: Significant variation in macular thickness can occur after uneventful phacoemulsification surgery in healthy patients. Cystoid macular oedema was detected in 7% of our patients using SD-OCT. It is rare after uncomplicated phacoemulsification in healthy individuals but should be kept in mind in the follow-up period. A detailed fundus examination with OCT imaging is thus recommended in the first or second month postoperatively for the early detection and treatment of CME.

Keywords: macular oedema; cataract; Irvine–Gass syndrome; phacoemulsification; uncomplicated surgery; OCT; macular thickening; cystoid macular oedema.

Introduction

Recent development of cataract surgery has led to the improvement of visual outcomes. However, pseudophakic cystoid macular oedema (CME), which is also known as Irvine–Gass syndrome, remains a usual cause of unexpected visual disturbance after both complicated and uncomplicated cataract surgeries.[1,2,3,4,5,6] Although the manner of development of CME after cataract surgery is unknown, it appears to be as a result of an increase in perifoveal capillary permeability with accumulation of fluid in the macular inner nuclear and outer plexiform layers. This might be mediated through the release of prostaglandins and leukotrienes[1,7,8,9,10] causing blood-retinal barrier (BRB) rupture, which is responsible for an increase in macular thickness. This oedema might be clinically asymptomatic and only be detected by using optical coherence tomography (OCT), especially after uneventful cataract surgery.[5]

Cystoid macular oedema has been associated with intraoperative risk factors including vitreomacular traction, excessive exposure to ultraviolet (UV) light, capsule rupture, vitreous loss or prolapse, iris prolapse and transient or prolonged hypotony. The risk is believed to be greater in cases with raptured posterior capsule. Other risk factors for CME include uncontrolled

postoperative inflammation, presence of uveitis, pre-existing epiretinal membrane, diabetes and diabetic retinopathy, previous retinal vein occlusion, retinitis pigmentosa and a previous occurrence of CME, secondary intraocular lens (IOL) implantation, prior topical prostaglandin treatment and cataract surgery technique.[1,6,11]

Cystoid macular oedema after uncomplicated cataract surgery is usually visually asymptomatic, but vision can be affected to some extent as a result of changes in contrast sensitivity.[1] Its incidence after uncomplicated phacoemulsification had been noticed to be 0.1% to the 4% in healthy populations,[2,3,4,6,7] usually occurring during the 4th to the 12th weeks after cataract surgery. There were few cases of CME after cataract surgeries that have been reported after many months or years after the surgery. Spontaneous resolution occurs in approximately 95% of uneventful cases within six months.[1,3] Optical coherence tomography is a very helpful method in detecting clinically insignificant macular thickening.[2] Therefore, the incidence of CME increased to 4% to 11% with the use of OCT in detection of early changes after phacoemulsification.[4]

Optical coherence tomography uses high-resolution imaging of the retina to measures changes in the z-plane (depth of the retina). It is a noninvasive, noncontact, transpupillary imaging technique that is able to detect minor changes in retinal thickness that cannot be seen by clinical examination. It has therefore been widely used to assess CME after cataract surgery.[6,8,12] Cystoid macular oedema can be defined in OCT measurements as 3 standard deviations (s.d.) higher than the preoperative mean of the central macular thickness (CMT) or as the presence of intraretinal cystoid spaces.[4,6]

The purpose of this study is to determine macular thickness changes using OCT measurements after uncomplicated phacoemulsification in normal eyes and the pattern of thickness changes over time within a period of two months.

Patients and methods

Patients were selected from those who attended the anterior segment department during the period of October 2017 to May 2019 (the last patient was included in March 2019) and were scheduled for phacoemulsification cataract surgery.

The exclusion criteria included:

- pre-existing macular pathologies: epiretinal membrane, full thickness macular hole, age-related macular degeneration or others
- retinopathies: retinal vascular occlusion or retinal dystrophy and others
- pre-existing eye diseases such as glaucoma or uveitis
- history of ocular trauma, laser treatment or intraocular surgery, except for cataract surgery in the other eye performed within a 1-year duration
- use of topical medication or systemic therapy known to affect retinal thickness such as prostaglandin, steroids, NSAIDs and diuretics
- systemic diseases like diabetes that could affect the eye
- unreliable OCT images.

Preoperative assessment

Preoperative evaluation included general medical and ophthalmological history, complete ophthalmological examination including best corrected visual acuity (BCVA) measurement by Snellen chart, measurement of intraocular pressure (IOP), biometry and spectral domain OCT (SD-OCT) 512 × 128 macular cube scan of both eyes using Cirrus™ High-Definition (HD)-OCT 5000 system (Carl Zeiss Meditec, Inc., CA, United States [US]) SW Ver: 7.0.1.290.

The optical coherence tomography macular map was divided for descriptive purposes into a ***central*** area (1 mm diameter) and two peripheral areas: a ***paracentral*** area (area between 1 mm and 3 mm diameters) and a ***pericentral*** area (area between 3 mm and 6 mm diameters). Both peripheral areas were divided into four quadrants: superior, nasal, inferior and temporal quadrants. All OCT examinations were performed by an OCT operator. The OCT examinations were performed in the morning from 09:00 to 12:00.

Surgical technique

The operations were performed by 10 specialists. One hour before operation, mydriasis was achieved by 1% tropicamide. Under retrobulbar anaesthesia, about 2.8 mm clear corneal incision, intracameral adrenaline, anterior capsulorhexis, hydrodissection, nuclear fragmentation by ultrasonic power using Constellation® Vision system (Alcon®, PA, US), cortex aspiration and foldable IOL implantation in the capsular bag were performed. The clear corneal incision was not sutured. ROTHO Hyron™ Sodium hyaluronate 15 mg/mL and ROTHO Visc™ Hydroxypropyl Methyl Cellulose 2% (ROTHO Pharmaceutical Co., Ltd., Bandung Barat, Indonesia) were used as the viscoelastic devices.

Postoperative management and follow-up

Postoperatively, topical antibiotic drops (fluoroquinolones group) and potent corticosteroid drops on a 2-hourly regimen were started, with oral ciprofloxacin tablets twice daily. After the postoperative first week, oral antibiotics were stopped, and the topical antibiotic and corticosteroid drops were tapered to four times daily for four weeks. Patients were followed up on the first postoperative day, first week and first and second months. In the outpatient clinic, ophthalmologic examination was performed including BCVA in Snellen chart, manifest refraction, IOP, anterior and posterior segment examinations using +90 dioptre double aspheric noncontact slit lamp lens, and macular thickness measurements with OCT were conducted.

Statistical analysis

Statistical analysis was performed by Statistical Package for Social Sciences, IBM® SPSS® (SPSS Inc., Chicago, IL, US)

version 21 for Windows. Significance was evaluated by paired *t*-test; $p < 0.05$ was considered significant.

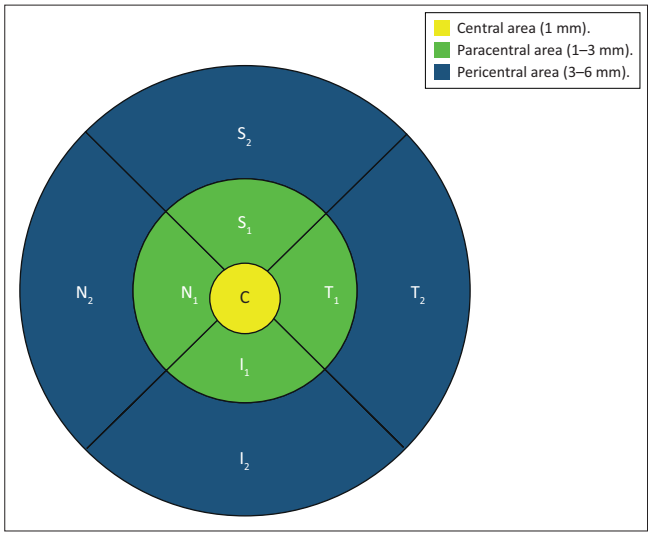
Ethical considerations

Ethical clearance to conduct this study was obtained from the Ethics Supervisory Committee of Ibn Al Haitham Teaching Eye Hospital (ref. no. A/356) and the study participants have given consent to participate as well as consent to publish the data.

Results

Eighty-six eyes of 86 patients were analysed; the mean age (±s.d.) was 55.98 (±13.012) years, ranging from 19 to 87 years. Fifty-four patients were male (62.8%) and 32 were female (37.2%), and 52 right (60.5%) and 34 left (39.5%) eyes were analysed.

In OCT, the macula was divided for descriptive purposes into areas and sectors as shown in Figure 1.



C, central area; N, nasal sector; T, temporal sector; S, superior sector; I, inferior sector.

FIGURE 1: The division of the macula into central, paracentral and pericentral areas; each of the last two areas is subdivided into four sectors in relation to the centre of the macula (nasal, temporal, superior and inferior sectors).

Mean macular thickness, in preoperative and postoperative periods, are shown in Table 1 and Figure 2 and mean changes in macular thickness postoperatively from its preoperative thickness. Its significance is shown in Table 2.

Significant increase in macular thickness ($p < 0.05$) was seen in all sectors of the paracentral area and the nasal and superior sectors of the pericentral area in the first week and in all areas in the first and second months postoperatively. Meanwhile, insignificant changes ($p > 0.05$) were seen in the central area, temporal and inferior sectors of pericentral area in the first week only.

Variations in macular thickness increased with time after the cataract surgery. The changes were higher in the second month than in the first month and first week, respectively. They involved the central area more predominantly, as it had been changed from 0.1% to 11.8% within a period of two months. Whilst the paracentral and pericentral areas showed less increase in thickness during the same period, in the paracentral area it was about 0.8% in the first week and reached about 5.9% in the second month, and it was less than that in the pericentral area.

In the first week postoperatively, the changes in thickness started in the paracentral area mainly (0.8% nasally, superiorly and inferiorly and 0.6% temporally) with slight changes in the central area (0.1%), whilst in the pericentral area, significant changes were seen only in the nasal (1%) and superior (0.8%) sectors, with mild, insignificant decrease in thickness in the temporal sector.

In the first month postoperatively, macular thickness increased mainly in the central area, followed by the paracentral then pericentral areas. In the paracentral area, the changes were slightly higher in the superior sector (3.7%) than in the nasal and the temporal sectors (3.4%) and lowest in the inferior sector (2.9%). In the pericentral area, they were higher in the superior sector (3.6%), followed by nasal (3.1%), inferior (3.0%) and temporal (2.9%), respectively.

TABLE 1: The mean macular thickness in preoperative and postoperative periods in central, paracentral and pericentral areas (Mean ± s.d.).

Area	Preoperatively		Postoperatively					
			One week		One month		Two months	
	Mean	±s.d.	Mean	±s.d.	Mean	±s.d.	Mean	±s.d.
Central 1 mm	242.29	±31.552	242.55	± 31.345	256.64	±47.216	270.76	±74.974
Paracentral (1 mm – 3 mm)								
Nasally	309.19	±27.719	311.72	±27.703	319.84	±28.216	327.52	±34.712
Temporally	299.80	±25.608	301.53	±24.840	309.91	±31.764	317.35	±44.461
Superiorly	309.15	±24.005	311.72	±25.048	320.44	±27.038	327.44	±36.786
Inferiorly	308.07	±25.200	310.63	±24.106	317.01	±27.589	322.27	±32.368
Pericentral (3 mm – 6 mm)								
Nasally	286.29	±21.378	289.07	±20.456	295.23	±23.993	299.65	±24.339
Temporally	262.44	±19.120	261.94	±18.412	270.09	±22.406	275.36	±25.823
Superiorly	272.44	±18.175	274.55	±17.337	282.34	±19.924	286.58	±24.685
Inferiorly	265.78	±20.288	266.94	±18.458	273.66	±20.396	279.07	±25.100

Note: Macular thickness measured in micrometres (µm).
s.d., standard deviation.

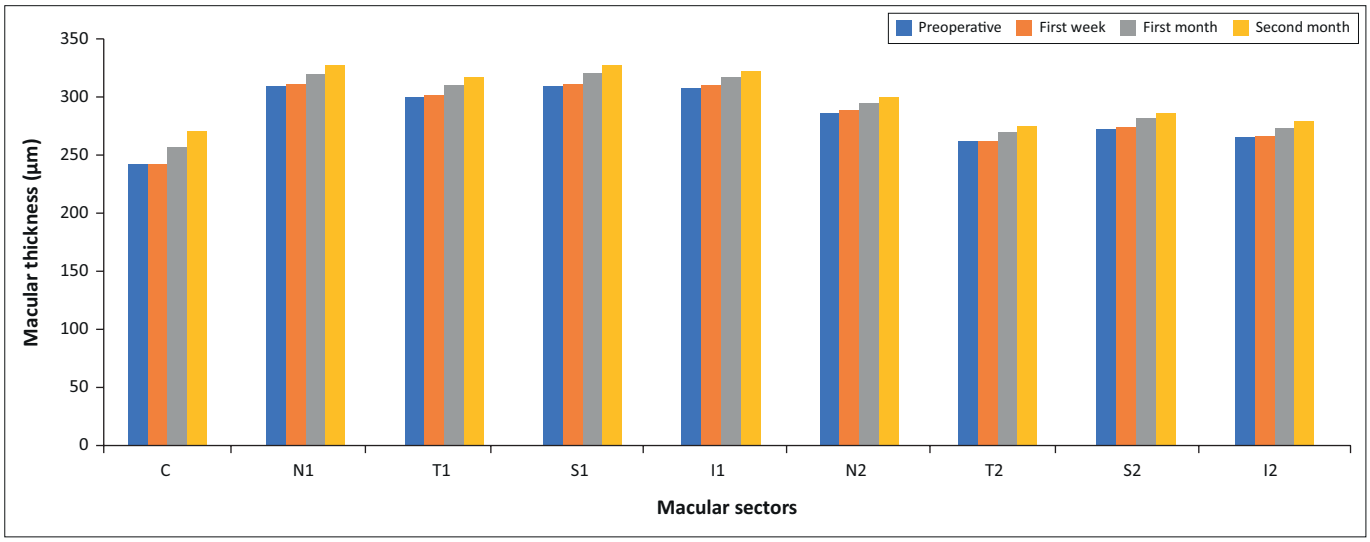
TABLE 2: The mean changes in macular thickness postoperatively and their percentage in central, paracentral and pericentral areas from their preoperative mean.

Area	Postoperative mean macular thickness changes								
	One week		*p**	One month		*p**	Two months		*p**
	n	%		*n*	%		*n*	%	
Central 1 mm	0.26	0.1	0.832	14.35	5.9	0.002	28.47	11.8	0.001
Paracentral (1 mm – 3 mm)									
Nasally	2.54	0.8	0.0100	10.65	3.4	< 0.0001	18.34	5.9	< 0.0001
Temporally	1.73	0.6	0.042	10.11	3.4	< 0.0001	17.55	5.9	< 0.0001
Superiorly	2.57	0.8	0.007	11.29	3.7	< 0.0001	18.29	5.9	< 0.0001
Inferiorly	2.56	0.8	0.003	8.94	2.9	< 0.0001	14.20	4.6	< 0.0001
Pericentral (3 mm – 6 mm)									
Nasally	2.78	1.0	< 0.0001	8.94	3.1	< 0.0001	13.36	4.7	< 0.0001
Temporally	–0.50	–0.2	0.601	7.65	2.9	< 0.0001	12.92	4.9	< 0.0001
Superiorly	2.11	0.8	0.009	9.90	3.6	< 0.0001	14.14	5.2	< 0.0001
Inferiorly	1.16	0.4	0.206	7.88	3.0	< 0.0001	13.29	5.0	< 0.0001

Note: Macular thickness measured in micrometres (µm).

$P < 0.05$ considered significant.

*, Significance of retinal thickness changes of the operated eye after the operation using the paired *t*-test.



C, central area; N1, T1, S1 and I1 are nasal, temporal, superior and inferior sectors in the paracentral area, respectively; N2, T2, S2 and I2 are nasal, temporal, superior and inferior sectors in the pericentral area, respectively.

FIGURE 2: The mean macular thickness in preoperative and postoperative periods in central, paracentral and pericentral areas.

In the second month, the changes in the central area dominated other areas; in the paracentral area, changes in the superior, nasal and temporal sectors were about the same (5.9%), leaving the least change in the inferior sector (4.6%). Meanwhile, in the pericentral area, the changes were highest in the superior sector (5.2%), followed by the inferior (5%), temporal (4.9%) and nasal (4.7%) sectors.

As CME was defined as three s.d. higher than the preoperative mean of CMT in OCT measurements or the presence of intraretinal cystoid spaces, four patients (4.7%) had macular thickness that exceeded three s.d. in the first month postoperatively, and only two patients (2.3%) had cystic changes on OCT; in one of them, the changes disappeared in the second month. Meanwhile, in the second month, five (5.8%) patients out of six patients (7%) had cystic changes with prominent elevation of macular thickness, whilst the other patient (2.3%) showed only increase of macular thickness. Table 3 shows the number and the percentage of patients who had more than 2 s.d. or 3 s.d. of their preoperative mean in each area.

Discussion

Macular oedema can occur after uneventful cataract surgery in patients not at risk.[13] Optical coherence tomography plays an important role in subclinical macular oedema diagnosis, as it can detect small increases in macular thickness.[5,6,7,8,9,12,14,15,16,17,18] In this study, a significant increase in the macular thickness had been reported by OCT in all areas after uneventful phacoemulsification cataract surgery. The changes differed according to the duration after the operation and the involved area or sector in the macula.

Generally, during the 2-month period of the study, the authors noticed that the macular thickness was increasing with time after the operation, reaching the maximum level at the second month in all areas. The central area had the highest level of changes, followed by the paracentral and then the pericentral areas. With regard to sectors, the authors noticed that changes were lower in the inferior sector in the paracentral area and the temporal sector in the pericentral area, with mostly similar changes in the other sectors in each area.

TABLE 3: Number of cases that had changes in thickness, postoperatively measured by the standard deviation of its preoperative mean in each area. (Number of cases [%]).

Area	One week		One month				Two months			
	+2 s.d.	+3 s.d.	+2 s.d.		+3 s.d.		+2 s.d.		+3 s.d.	
			n	%	*n*	%	*n*	%	*n*	%
Central 1 mm	0	0	1	1.2	4	4.7	0	-	6	7.0
Paracentral (1 mm – 3 mm)										
Nasally	0	0	3	3.5	0	-	3	3.5	4	4.7
Temporally	0	0	1	1.2	1	1.2	2	2.3	3	3.5
Superiorly	0	0	4	4.7	0	-	4	4.7	3	3.5
Inferiorly	0	0	2	2.3	0	-	3	3.5	3	3.5
Pericentral (3 mm – 6 mm)										
Nasally	0	0	2	2.3	1	1.2	2	2.3	2	2.3
Temporally	0	0	5	5.8	0	-	4	4.7	3	3.5
Superiorly	0	0	3	3.5	0	-	4	4.7	3	3.5
Inferiorly	0	0	1	1.2	0	-	6	7.0	1	1.2

s.d., standard deviation.

As the authors followed the changes during the first week, first month and second month separately, they noticed during the first week that macular thickness changes involved the paracentral area mainly in all sectors and nasal and superior sectors in the pericentral area, with minimal, insignificant changes in the central area and the remaining sectors. Meanwhile, in the first and second months, all areas increased significantly with higher changes in the central area reaching the maximum in the second month. Regarding sectors, all the increments were significant in all sectors, a little higher in the superior sectors and lower in the inferior sector paracentrally.

Similar results have been shown by Perente et al.,[8] who found that an increment in macular thickness was shown by OCT after uncomplicated phacoemulsification surgery; they found a significant increase in parafoveal area (1 mm – 3 mm) in the nasal, temporal and inferior areas in the first week, whilst it was insignificant in the superior area. At the 1-month follow-up, all areas showed significant increase, continuing until the sixth month follow-up. Biro et al.[17] reported that there was a significant increase of the perifoveal 3.0 mm and 6.0 mm diameter retinal area thickness on days 7, 30 and 60 postoperatively. It was 3.5% after one week, 5.6% after one month and 5.3% after two months. Kusbeci et al.[6] reported that the mean perifoveal 1 mm – 3 mm macular thickness increased significantly in all quadrants from the first postoperative week to the twelfth, and changes were relatively the same in all sectors. However, the highest increase in CMT was seen at the twelfth week. In the study by Gharbiya et al.,[7] they excluded CME cases from the beginning, and they found significant regional increase in macular thickness over time, where the highest changes were revealed in the parafoveal area (1 mm – 3 mm). In addition, it showed a significant increase in all areas, occurring most prominently in the parafoveal area (1 mm – 3 mm), followed by the perifoveal (3 mm – 6 mm) and then the central area, which kept the same pattern through the first week, month and the second month, with a peak at one month for the 3 mm and 6 mm areas and a peak at two months for the central 1 mm area.

Pardianto et al.,[14] found that the macular thickness of all four quadrants, except the inferior one in the paracentral area, were significantly increased. However, peripheral macular thickness also increased significantly in the superior and temporal quadrants.

The difference in macular region response to macular oedema might be correlated to the distribution of retinal fibres around the optic nerve head, as it is thicker at the superior and inferior poles. However, the superior RNFL thickness is found to be slightly lower than the inferior part, and it is therefore more vulnerable than the inferior part.[14] Other studies showed that changes usually appear in the first week postoperatively in the parafoveal area (1 mm – 3 mm) and less in perifoveal area (3 mm – 6 mm),[6,15,19] with minimal differences in foveal thicknesses.[14,19,20]

Cystoid changes in the macula can be seen clinically within 3–12 weeks after uncomplicated cataract surgery. But sometimes its onset may be delayed for months or many years after surgery,[21] whilst subclinical CME can occur earlier and can be detected with the aid of OCT. In this study, CME (3 s.d.) was detected in the first month in four eyes (4.7%), with only two eyes (2.3%) having cystic changes on OCT, whilst in the second month, six eyes (7%) had CME and five eyes (5.8%) had cystic changes. Only one eye with macular thickness more than 2 s.d. and less than 3 s.d. was detected in the first month. As seen in other studies,[3,7,8,12,29,22,23] as CME were noticed in the first month, whilst Kusbeci et al.[6] detect CME in one eye (1.1%) as early as the first postoperative week, Perente et al.,[8] who defined CME as 2 s.d. increase of CMT from its preoperative mean (≥ 255 µm), found it in seven eyes (6.4%) in the first week. Cystoid changes were found in CMT, approximately ≥ 200 µm.[3,8]

The cause of macular changes is uncertain. Different theories have tried to explain macular thickness changes after uncomplicated phacoemulsification. Some explained it as a focal inner BRB disruption and the presence of leaking sites,[10] others as a result of free radicals from light exposure,[8] prostaglandin and interleukin productions.[9] Whilst some correlate its presence to operative factors, irrigation time (IT) under high simulated dynamic IOP may affect it to the subclinical level,[24] as well as IOP fluctuations,[14] manoeuvrability of the surgeons and inflammatory insult of the surgery.[14,16]

Measurement of retinal thickness with OCT can also be affected by lens condition,[12,25] as lens opacity may affect OCT readings, giving false increments as cataracts may cause light scattering that may cause artefacts in OCT measurements' thickness, and a significant decrease was observed when the lens was replaced by an IOL.[7,8] This may explain the thicker pre-operative central retinal thickness in OCT than those in the postoperative period.[12,17,19,20] Therefore, retinal thickness measures by OCT are recommended following the cataract surgery. Van Velthoven et al.[26] also found that image quality and retinal thickness measurements were influenced by cortical cataracts more than nuclear, causing underestimation of retinal thickness.

Unfortunately, our study was limited to two months' period. This allowed us to detect the early changes of macular thickness only. Further studies are recommended to follow the macular thickness changes and their reversibility in a longer period postoperatively, and further evaluation for CME cases is recommended.

Conclusion

Early macular thickness changes can occur following uncomplicated phacoemulsification surgery in healthy patients. Using SD-OCT was helpful in detecting subclinical macular thickness changes and regional pattern distribution in first week, first month and second month postoperatively. Significant increase in macular thickness can occur paracentrally in the first week and involves all the macula in the first and second months reaching the formation of CME in 7% of our patients. Cystoid macular oedema is rare after uncomplicated phacoemulsification in healthy individuals but should be kept in mind in the follow-up period. Thus, a detailed fundus examination with OCT imaging is recommended in the first or second month postoperatively for the early detection and treatment of CME.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

A.D.J. conceived of the presented idea, developed the theory and performed the computations and the analytical methods. All was under supervision of S.A.A. All authors discussed the results and contributed to the final manuscript.

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Data availability

The data that support the findings of this study are available on request from the corresponding author, A.D.J.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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