Original article:

Optical coherence tomography analysis of macula–preoperative & postoperative diabetic patients undergoing cataract surgery

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Abstract

Purpose: To assess the incidence and progression of macular edema (ME) after cataract surgery in diabetic patients using optical coherence tomography (OCT).

Methods: Each eye underwent 7-field fundus photography no more than 1 week before surgery. Optical coherence tomography testing was performed within 1 week before surgery and at 4 and 12 week postoperative visits. Best-corrected visual acuity (BCVA) was recorded at each visit. Macular edema was defined as an increase of foveal thickness on OCT > 30% from preoperative baseline.

Results: The incidence of ME on OCT was 23.33% and progression of ME was 12.5%. The mean change in foveal thickness of > 30% at 4^{th} week and 12^{th} week was 62.5 um and 70.63 um respectively, whereas of foveal thickness < 30% at 4^{th} week and 12^{th} week was 5.91um and 5.57 um, respectively.

Conclusions: Diabetic eyes have a high incidence of increasing foveal thickness on OCT after cataract surgery, associated with decreasing vision at 4 weeks, with gradual visual recovery at 12 weeks. Early interventions with various proved methods of management to overcome this preventable decreasing vision could improve outcome in diabetics after cataract surgery.

Keywords : Optical Coherence Tomography – OCT, FT – Foveal Thickness, BCVA – Best Corrected Visual acuity, Macular Edema – ME

Introduction

New generation SD-OCT has faster acquisition speed and an increased depth of resolution compared to previous generation stratus OCT,[1] because echo time delay of light is measured by taking the fourier transform of the interference spectrum of the light signal. A fourier transform is a mathematical procedure that extracts the frequency spectrum of a signal.[2]The fast acquisition rate of SD-OCT allows for much faster scanning time, reducing motion artifacts, and enabling denser patterns across the ONH. Axial resolution of SD-OCT <6 µm, scan velocity of 27,000 axial scans per second.[2]

Reproducible, three dimensional representation of the human eye is possible using OCT during a routine undilated clinical examination.[3-6]

Although widely recognized, the true incidence of macular edema after cataract surgery has not been clearly defined in literature. Hence this study is taken to assess the incidence and progression of macular edema in diabetic patients after cataract surgery using optical coherence tomography (OCT).

Patients & materials

It was a Hospital based prospective study (Interventional Case Series)

Study participants consisted of a 30 diabetic patients with varying levels of retinopathy- mild and moderate NPDR including the absence of retinopathy, who will be scheduled for routine cataract surgery. Study participants were examined at the NIMS HOSPITAL, Shobha Nagar, Jaipur and enrolled into the study at the preoperative visit from Feb 2015 – July 2016. Each study eye underwent 7-field fundus photography no more than 1 week before surgery and OCT testing no more than 1 week before surgery.

Optical coherence tomography testing was repeated at the 4th and 12th week postoperative visits.

Best-corrected visual acuity (BCVA) was recorded at each visit. Subject characteristics including age, gender, duration of diabetes, hemoglobin A1c, medication use (within broad categories; e.g., angiotensin-converting enzyme inhibitor), and type of diabetes was recorded.

History of previous laser photocoagulation, prior intraocular surgery, and treatment with an intravitreal or sub–Tenon's capsule injection of triamcinolone acetonide was documented from review of the patient's chart.

Age and gender was recorded at the time of the preoperative visit.

Duration of diabetes was estimated by review of the patient's chart in addition to direct patient questioning and subdivided into 2 groups: < 10 years or > 10 years.

Hemoglobin A1c and medication use was recorded from the patient's chart.

Type of diabetes was defined as insulin dependent or non–insulin dependent

Surgical complications, including posterior capsular rupture, vitreous loss, and need for additional surgery, was documented from review of the operative note.

Treatment with intravitreal or sub–Tenon's capsule injection of triamcinolone acetonide at the time of or after surgery was recorded.

All cataract surgeries were small incision cataract surgery/phoacoemulsification with posterior chamber intraocular lens implantation done under local anaesthesia by an experienced surgeon.

The surgical procedure, routinely consisted of a sclera tunnel, capsulorrhexis, manual removal of cataractous lens and posterior chamber intraocular lens placement in the capsular bag. All other surgical procedures, including type of anaesthesia, is dictated by the individual preferences of the surgeon. All preoperative, intraoperative, and postoperative medical management was left to the individual decision making of the surgeon.

Optical coherence tomography, Machine name: SD-OCT RS- 3000 Retina Scan Advance. (NIDEK Navis- EX) testing was performed by a trained technician with close monitoring of patient fixation under direct observation.

Optical coherence tomography images was generated with the use of six 6-mm radial scans in a spoke-like pattern according to the manufacturer protocol as described in the user's manual.[7]

The macular map program analyzed six, 6mm scans radiated through the fovea equally spaced angular (30°) orientation and provides an average retinal thickness map in nine regions of the macula. The OCT macular map is divided into nine zones that correspond to the Early Treatment Diabetic Retinopathy [8]

RESULTS

A total of 30 eyes of 30 diabetic patients on preoperative OCT were enrolled and underwent uncomplicated small incision cataract surgery with posterior chamber intraocular lens implantation. Consequently, 30 study eyes of 30 study subjects completed 1-month follow-up (100% completion), and 30 study eyes completed 3-month follow-up (100% completion).

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Table 5.1 Features of 30 Study Eyes, Described as Continuous Variables

Characteristics	Mean
Age	58.93
Hemoglobin A1c (mean of all pts)	7.18
Hemoglobin A1c (ME eyes)	7.25
Preoperative best-corrected visual acuity[logMAR (Snellen equivalent)]	1.03
1-mo postoperative best-corrected visual acuity [logMAR (Snellen equivalent)]	0.37
3-mo postoperative best-corrected visual acuity [logMAR (Snellen equivalent)]*	0.35

logMAR - logarithm of the minimum angle of resolution; ME - macular edema.

Study eye and study patient characteristics are summarized in Table 5.1 for variables that can be expressed continuously with SDs and Table 5.2 for variables expressed within specific categories, respectively. Overall, mean visual acuity (VA) improved from 1.03 logMAR unit preoperatively to 0.37 and 0.33 logMAR units at 4^{th} and 12^{th} weeks after surgery (Table 5.1). The mean hemoglobin A1c level of the study cohort was 7.18, and the mean hemoglobin A1c of study eyes with ME on OCT at baseline was 7.25. At 4th week, 8 study eyes (26.67 [95% CI, 17%–39%]) experienced an increase in foveal thickness of >30%.

Foveal thicknesses measured at 4th week increased to 58.78 um. This 58.78 um increase in foveal thickness represented an approximate 30% increase over the preoperative study mean. At 12th weeks, foveal thickness remained 70.63 um above the preoperative mean. All 8 study eyes, which experienced an increase in foveal thickness of >30% at 4th week, demonstrated spongy macular edema on OCT—for example, as shown in the OCT of one of the study subjects in Figure 5.1.

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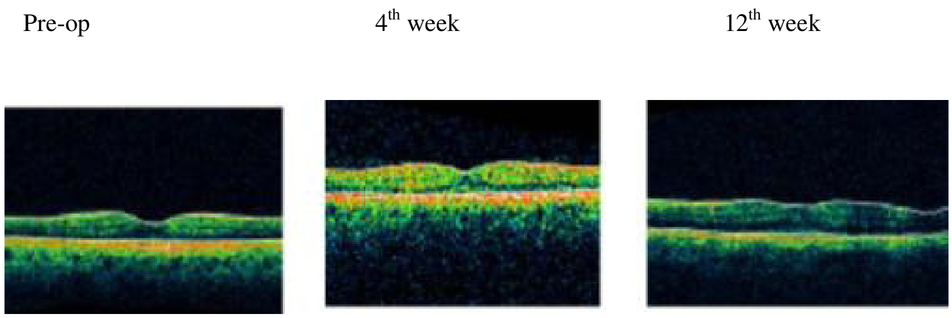

Fig 5.1. Representation of spongy macular edema in one of the study eye, who developed macular edema at 4th week and gradually decreased at 12th week.

The purposes of our study we concluded that an increase of foveal thickness of > 30% was a reasonable and useful cut-off to define ME. In our study, 8 eyes (26.67%) were identified as developing ME at 4th week, of these 8 eyes, all 7 continued to have increases of foveal thickness above their preoperative baseline out to 12th weeks, which limited their visual recovery whereas 1 eye foveal thickness decreased at 12th week. 1 of the study eye which did not had macular edema at 4th week (had increase in foveal thickness but didn't satisfy the criteria of foveal

In our study the degree of macular edema was related to duration of diabetes, types of diabetes and the presence of hypertension unlike the K Hayashi et al[10] but the haemoglobin A_{1C} level at the time of surgery showed association for progression of macular edema. In Figure 5.3, the group with diabetes duration of >10 years had an increase of foveal thickness at 4^{th} week of 25.37 um, whereas the group with <10 years' duration had an increase of only 19.40 um (P=0.73). This difference of 5.97 um (*P* = 0.70) increased to 7.54 um at 12th weeks. The insulin-dependent group had an increase in foveal thickness at 4^{th} week of 29.75 um, whereas the non–insulin dependent group had an increase of 18.90 um (P=0.46). This difference of 10.85 um (*P* =0.065) increased to 31.09 um at 12^{th} week. In Figure 5.4, the group with hypertension had 0.49 logMAR units of VA at 4^{th} week, whereas the group without hypertension had 0.36 logMAR units of VA (*P* = 0.038). At 12 weeks, the group with hypertension had 0.28 logMAR units of VA but the group with hypertension had 0.30 logMAR units of VA (P = 0.54). The group with hypertension had nearly 1 lines drop of at 4^{th} and 12^{th} week. This increase in foveal thickness was correlated inversely with VA improvement. Hemoglobin A1c mean of pts who didn't develop ME was 7.15, whereas Hemoglobin A1c of pts who developed ME was 7.25, which was marginally higher than former group. In addition, Funatsu*et al*[12] reported the amount of vascular endothelial growth factor in the aqueous humour to be a significant predictor for progression of macular

The results of our study are in contrast to the findings of Flesner et al, who concluded that duration of diabetes and level of diabetic retinopathy were not risk factors for ME after cataract surgery in diabetic patients when appropriate postoperative management of diabetic retinopathy was performed. Their dependence on fluorescein angiography instead of OCT to detect ME and a small sample size of 4 eyes developing ME, as they defined it, after cataract surgery may explain some of these differences.

Insulin dependence, duration of diabetes of > 10 years, and level of diabetic retinopathy each correlated with increased foveal thickening at 4th week and, to a lesser extent, at 12th weeks. The increase in foveal thickening observed with these risk characteristics directly translated into poorer VA outcomes. The findings of our study confirm published reports that level of diabetic retinopathy is a risk factor for thickening of the retina after cataract surgery.[13] Optical coherence tomography may be a more sensitive means of detecting postsurgical CME and may explain the relatively high percentage (26.67%) of eyes with increases of foveal thickness> 30% from preoperative values at 4 weeks. The incidence of ME after cataract surgery as defined on fluorescein angiography varies in the literature, but a large prospective study by Mentes et al reported an incidence of 9.1% after uncomplicated phacoemulsification in healthy (nondiabetic) subjects. The definition of postsurgical CME also varies in the literature but, in general, involves clinical or angiographic evidence of perifoveal leakage associated with decreased VA. Reported incidence rates for postsurgical CME associated with VA loss range from 0% to 2% [14] after modern cataract surgery in healthy subjects.

Previous studies showed that diabetic macular edema progressed in approximately 20–40% of eyes that underwent cataract surgery, but, in a considerable percentage of these eyes, the macular edema resolved spontaneously.[15]The preoperative presence of diabetic retinopathy significantly affected the postoperative onset and persistence of CME. Although more than 90% of the patients who have no pre-existing diabetic retinopathy carry a good visual prognosis and eventually have 20/40 or better visual acuity, nearly one-third of patients with pre-existing retinopathy may

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show retinopathy progression. Postoperative macular edema is more common in patients with diabetes but resolves spontaneously in patients with no or minimal diabetic retinopathy. In patients with moderate to severe NPDR or more, clinically significant macular edema tends to persist, may arise de-novo, or even worsen after cataract surgery. Patients with diabetes need a preoperative characterization of their retinopathy and a thorough discussion with the patient about the need for cataract surgery, and the risk of progression of retinopathy is mandated. Currently, early surgery is favoured before the development of significant diabetic retinopathy rather than wait for the cataract to become denser. All efforts should be made to stabilize diabetic retinopathy with appropriate laser treatment before cataract surgery. All diabetic patients need close observation for at least 6 months following surgery to intervene with laser photocoagulation as and when required to prevent visual loss from diabetic maculopathy and other consequences of diabetic retinopathy.[15]

We acknowledge some limitations to our study:

- First, the number of eyes with active DR was small.
- Secondly, the grade of macular edema and the stage of DR evaluated in our study were relatively simple.

- Thirdly we have not compared the mean change in foveal thickness of various categorical characteristics to the mean change in BCVA at 4th week to avoid the confounding factor cataract which is also a cause for decreased vision in the immediate preoperative period. But we have compared the mean change in foveal thickness of various categorical characteristics to the mean change in BCVA

It is estimated that there will be more than 221 million diabetic individuals worldwide by 2010. Diabetic patients due to undergo cataract surgery a) have a good chance of visual improvement compared to a level less than if they were not diabetic, b) have a greater chance of visual loss, c) surgery may initiate or worsen any pre-existing retinopathy and this may affect their vision in the future. [16]

Studies have shown an increased risk of ocular complications in diabetics after cataract surgery, but modern surgical techniques have minimized them, leading to an overall good visual outcome. Macular edema before surgery is the most common condition that limits post-operative visual recovery.

Finally, our study suggested that insulin dependence, duration of diabetes of > 10 years, risk factors like hypertension, HbA1c and level of diabetic retinopathy predict increase in foveal thickness which correlates with poorer visual outcomes at 4th week with gradual recovery at 12 week.OCT-3 provided objective documentation of foveal structural changes in eyes with diabetic retinopathy. Best-corrected visual acuity provided a significant correlation with the retinal thickness at the fovea. These results indicate that OCT can facilitate deciding on the treatment protocol (surgical or medical) and follow-up of diabetic patients, which is especially important in the early stages of diabetic maculopathy when the structural changes are not yet evident with slit-lamp biomicroscopy or angiographically.[17]

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