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Comparison in Macular Thickness between Non diabetic and Uncomplicated Diabetics after Uncomplicated Phacoemulsification

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Abstract:

Background: Phacoemulsification (phaco) is one of the most widely used cataract surgery techniques nowadays. Various factors can influence the tissue structures of the eyeball eg. Ultrasonic energy, fluidics, mechanical effects, compression, and hypoxia on the tissue. Every step of this maneuver can cause direct or indirect effects on ocular tissues. Ultrasonic energy and fluidics produce mechanical effects that cause an inflammatory reaction which affects cornea, retina and choroid. **Objective:** To evaluate the effect of phacoemulsification on retina to compare these effects in diabetic and non-diabetic patient to reach a conclusion whether diabetic patient are more vulnerable to these effects or not. **Patients and Methods:** This is a prospective cohort observational study that included 100 eyes of 100 patients (50 diabetic patients (Type II), 50 non diabetic patients) having immature senile cataract. Patients were recruited from the ophthalmology department of Beni-Suef University. **Results:** In our study results noted a statistically significant increase in the central macular thickness 1day, 1 week & 1 month postoperatively also there was no statistically significant difference in the central macular thickness between the Diabetic and Non-diabetic group neither pre-operatively, nor post-operatively. **Conclusion:** Phacoemulsification affects the macula, phaco power used during the surgery and inflammatory mediators released after the surgery leads to long term increase in Central macular thickness in both diabetic and non-diabetic patients. It was noticed that phacoemulsification causes increase in Central macular thickness noticed at one week & one month post-operatively in both diabetic and non-diabetic patients. Finally we can say that cataract phacoemulsification cause t increase in central macular thickness.

Keywords: Spectral Domain optical coherence tomography,

1. Introduction:

Diabetes is one of the most common leading causes of blindness in 20–74 year old persons. Cataract and retinopathy are well-known as ocular complications of diabetes. Recently, problems involving the ocular surface, dry eyes in particular, have been reported in diabetic patients [(1)].

The worldwide incidence of Diabetes Mellitus is set to rise dramatically from 171 million people in 2000 to an estimated 366 million in 2030 [(2)].

Type I diabetes is due primarily to autoimmune-mediated destruction of pancreatic **β**-cells, which leads to insulin deficiency. The frequency of Type I diabetes is low relative to Type II diabetes, which accounts for approximately 90% of diabetes worldwide. The phrase ‘diabetes epidemic' refers predominantly to Type II diabetes, which is continuing to increase in both developed and developing countries [(3)].

This increase in Type II diabetes is mainly a consequence of increasing sedentary lifestyles, poor diet and obesity. Indeed, it has been estimated that the prevalence of diabetes among people aged more than 16 years will rise by 28.3% between 2010 and 2030, with more than half of this increase being attributed to increased obesity [(4)].

Diabetic retinopathy is the most common cause of vision loss among people with diabetes and a leading cause of blindness among working-age adults [(5)].

Diabetic retinopathy: is a complication of diabetes that damages retinal blood vessels.

There are three main types of diabetic retinopathy:

Non-proliferative retinopathy is an early form of the disease, characterized by microaneurysms, dot and blot haemorrhages and exudates.

Macular oedema is a swelling of the macula, caused by the leakage of fluid from retinal blood vessels. It can damage central vision. About half of all people with diabetic retinopathy will develop DME.

Proliferative retinopathy is an advanced form of the disease and occurs when blood vessels in the retina disappear and are replaced by new fragile vessels that bleed easily, and that can result in a sudden loss of vision when accompanied with Vitreous hemorrhage or Retinal Detachment [(5)].

Cataract: is a clouding of the normally clear lens of the eye. Clouded vision caused by cataracts can make it more difficult to read, drive a car especially at night..

Most cataracts develop when aging or injury changes the tissue that makes up your eye's lens. Some inherited genetic disorders that cause other health problems can increase your risk of cataracts. Cataracts can also be caused by other eye conditions, past eye surgery or medical conditions such as diabetes. Long-term use of steroid medications, trauma, too, can cause cataracts to develop [(6)].

Cataracts are among the earliest complications of diabetes mellitus Adults with diabetes are 2-5 times more likely than those without diabetes to develop cataract. Cataract also tends to develop at an earlier age in people with diabetes [(7)].

Patients with diabetes mellitus have higher complication rates from cataract surgery. Both diabetes and cataract pose an enormous health and economic burden, particularly in developing countries, where diabetes treatment is insufficient and cataract surgery often inaccessible [(8)].

Phacoemulsification:

Charles Kelman performed the first phacoemulsification operation in 1967, but it was not until 1971 that the technique had been sufficiently refined to allow its use by others.

Phacoemulsification and Aspiration: the Kelman Technique of Cataract Removal. One of the most fascinating developments in the history of cataract surgery is the Kelman technique of reducing a cataract to minute particles by ultrasonic vibration and aspirating them by controlled suction [(9)].

Phacoemulsification cataract surgery is a procedure in which an ultrasonic device is used to break up and then remove a cloudy lens, or cataract, from the eye to improve vision. The insertion of an intraocular lens (IOL) usually immediately follows phacoemulsification.

Indications: The most common indication for cataract surgery via phacoemulsification with intraocular lens implantation is the patient's desire to improve vision [(10)].

Preparation and precautions:

Calculation the power of the IOL (Biometry) that will be implanted before the surgery then proper dilatation of the pupil before entering the operation theatre. Proper anesthesia is essential for ocular surgery. Proper sterile precautions are taken to prepare the area for surgery. A plastic sheet with a receptacle helps collect the fluids during phacoemulsification. An eye speculum is inserted to keep the eyelids open [(5)].

2. Aim Of The Work:

To evaluate the effect of phacoemulsification on central macular thickness and to compare these effects in

diabetic and non-diabetic patient to reach a conclusion whether diabetic patient are more vulnerable to these effects or not.

To achieve this study purpose we had to evaluate and compare central macular thickness changes using Spectral Domain optical coherence tomography (SD-OCT, before and after cataract surgery (after one day, after one week and after one month) and compare the results between normal and diabetic patients without retinopathy.

3. Patients And Methods:

This is a prospective cohort observational study that included 100 eyes of 100 patients (50 diabetic patients (Type II), 50 non diabetic patients) having immature senile cataract.

Patients were recruited from the ophthalmology department of Beni-Suef University.

Inclusion criteria: Non diabetic and uncomplicated diabetic patients. Grading of cataract: allowing clear OCT imaging.

Exclusion criteria: Any refractive errors greater than +/- 7 diopters. Any ocular pathology other than cataract including: Complicated diabetic patients with DME. Uveitis. Glaucoma. Retinal detachment. Intraocular inflammation. Previous intraocular surgery. Unexpected intraoperative complications e.g. posterior capsular rupture and vitreous loss. Patients with very dense cataract precluding visualization of fundus.

Methods of ocular examination:

Thorough history taking including: Name(clarified only to the main investigator). Age. Sex. Type and duration of cataract. Detailed visual complaints. Past ocular history (disease, surgery, laser photocoagulation). Other associated systemic diseases and current medications.

Ocular examination:

Detailed ophthalmic examination was performed: Best corrected visual acuity (BCVA), assessed by Snellen's Chart and converted to log MAR using visual acuity conversion tables. Intraocular pressure (IOP), measured by Goldmann applanation tonometer. Crystalline Lens status by slit lamp examination. Fundus examination using indirect ophthalmoscope. Macular status evaluation: including slit lamp biomicroscopy with the +90 D lens. OCT.

Cataract extraction:

The surgical procedure was similar for all patients. all cataract surgeries were performed by phacoemulsification using Infiniti vision system(Alcon, Fort Worth, TX, USA) with clear cornea self-sealing incision and foldable posterior chamber intraocular lens implantation in the capsular bag. Phacoemulsification parameters where different according to the surgeons preference. The surgeries

where performed under local anesthesia. No intraoperative complications were reported. Postoperative medication was the same for all cases and consisted of topical antibiotics and steroids four times daily for 3 weeks.

OCT (optical coherence tomography):

All the patients underwent SD-OCT using the Heidelberg OCT. This was done preoperatively and once (one to four weeks) postoperatively following cataract extraction. The scan pattern used on Heidelberg was the retina cross line which consists of two orthogonally oriented 6mm lines consisting of 1024 A-scans. These scans were marked as the patient's baseline and were used for referencing the subsequent scans using the "follow-up" function of the SD-OCT, assuring us that the scans would be performed in the same position. All images were taken as close to the fovea as possible in order to ensure, to the best extent possible, that the same retinal area was being scanned.

Post intervention Evaluation:

History taking: asking about any recent complaints. Ocular examination including: Slit lamp examination. Slit lamp biomicroscopy. IOP measurement by Goldmann applanation tonometer. BCVA expressed in Log MAR. OCT scanning which was done 1day, 1 week and 1 month).

Statistical analysis

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when parametric. Also qualitative variables were presented as number and percentages. The Comparison between groups with qualitative data were done by using **Chi-square test**. The comparison between two groups with quantitative data and parametric distribution were done by using **Independent t-test**. The comparison between two paired groups with quantitative data parametric distribution were done by using **Paired t- test** The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following: $P > 0.05$: Non significant. $P < 0.05$: Significant. $P < 0.01$: Highly significant.

4. Results:

This study was conducted on 100 eyes of 100 cataracts patients who underwent uneventful phacoemulsification and posterior chamber IOL implantation.

They were divided into 2 groups; group 1 & group 2: Group 1: Diabetes mellitus group (DM group) consisted of 50 eyes (50 diabetic patients). **Group 2:** Control

non-diabetic group consisted of 20 eyes (50 non-diabetic patients).

Table (1): Shows demographic and clinical data of subject included in this study:

		Diabetic group	**Non-diabetic group**	**Test value**	**P-value**	**Sig.**
		No. = 50	**No. = 50**			
Age	Mean ± SD	66.48 ± 7.31	66.16 ± 8.25	0.205•	0.838	NS
	Range	50 – 80	46 – 79			
Sex	Female	18 (36.0%)	10 (20.0%)	3.175*	0.075	NS
	Male	32 (64.0%)	40 (80.0%)			
Eye	OS	24 (48.0%)	22 (44.0%)	0.161*	0.688	NS
	OD	26 (52.0%)	28 (56.0%)			

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)

**:Chi-square test; •: Independent t-test*

Table (2): Comparison between non diabetic group and diabetic group regarding Macular thickness

Macular thickness		**Diabetic group**	**Non-diabetic group**	**Test value•**	**P-value**	**Sig.**
		No. = 50	**No. = 50**			
Pre	Mean ± SD	271.92 ± 33.88	262.72 ± 31.82	1.400	0.165	NS
	Range	216 – 408	198 – 342			
First day post	Mean ± SD	274.48 ± 33.60	270.28 ± 34.72	0.615	0.540	NS
	Range	218 – 408	198 – 348			
1 week post	Mean ± SD	280.88 ± 32.82	267.84 ± 31.07	2.040	0.044	NS
	Range	218 – 409	199 – 348			
1 month post	Mean ± SD	280.00 ± 36.84	270.48 ± 26.48	1.484	0.141	NS
	Range	222 – 411	209 – 340			

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)

•: Independent t-test

Table (3): Comparison between pre and post operative results in diabetic group

Diabetic group		**Pre**	**First day**	**1 week**	**1 month**
		No. = 50	**No. = 50**	**No. = 50**	**No. = 50**
Macular thickness	Mean±SD	271.92 ± 33.88	274.48 ± 33.60	280.88 ± 32.82	280.00 ± 36.84
	Range	216 – 408	218 – 408	218 – 409	222 – 411
Paired t-test		**--**	**2.938**	**6.712**	**2.509**
P-value		**--**	**0.005 (HS)**	**0.000 (HS)**	**0.015 (S)**

NS: Non significant; S: Significant; HS: Highly significant

•*: Paired t-test*

Table (4): Comparison between pre and post operative results in non diabetic group.

Non-diabetic group		**Pre**	**First day**	**1 week**	**1 month**
		No. = 50	**No. = 50**	**No. = 50**	**No. = 50**
Macular thickness	Mean±SD	262.72 ± 31.82	270.28 ± 34.72	267.84 ± 31.07	270.48 ± 26.48
	Range	198 – 342	198 – 348	199 – 348	209 – 340
Paired t-test		**--**	**4.226**	**2.734**	**2.109**
P-value		**--**	**0.000 (HS)**	**0.009 (HS)**	**0.040 (S)**

NS: Non significant; S: Significant; HS: Highly significant

5. Discussion

Cataract surgery by phacoemulsification is an invasive procedure that has become the most popular intraocular surgery and usually improves the visual outcome. However, it is an inflammatory process to the eye and in many cases can lead to worsening of pre-existing retinal diseases such as diabetic macular edema [(11)] or development of new diseases such as Irvine-Gass syndrome. This inflammatory response is mostly induced by the release of prostaglandins [(12)].

There are not a lot of biochemical data regarding the effects of cataract surgery on the retina. In most cases, phacoemulsification does not change the macroscopic funduscopic appearance of the retina. However, some studies confirm that cataract surgery leads to inflammatory changes in the posterior segment of the eye [(13, 14, 15)].

In a rodent model, cataract surgery induced inflammatory gene expression and protein secretion in the retina and choroid. Expression of interleukin-1β genes was up regulated in both the retina and choroid and an increase of interleukin-1β expression was observed in the inner nuclear layer, choroid, and ganglion cell layer of operated eyes. Other animal studies showed that cataract surgery led to an increase in macular thickness and a breakdown in the outer blood–retinal barrier in rhesus monkeys [(14)].

Another study showed that lenticular fragments could lead to a breakdown of the inner blood–retinal barrier [(15)]. These inflammatory consequences of surgery may be associated with the subclinical macular changes that have been reported in uneventful cataract surgery and may also be related to pathologic events such as Irvine-Gass syndrome [(16)].

This has led to the widespread use of topical steroidal and non-steroidal anti-inflammatory drugs in the postoperative period of cataract surgery because these agents decrease the incidence of Irvine-Gass syndrome. As in current medical practice, these anti-inflammatory agents were used in all our patients, blunting the inflammatory insult caused by the surgery. At this moment, researchers are not able to study the effect of phacoemulsification on retinal morphology in patients who are not treated with topical non-steroidal anti-inflammatory drugs and steroids because this would unacceptably increase their risk of developing Irvine-Gass syndrome [(16)].

Because cataract surgery is an inflammatory process to the eye, we investigated the possibility that it may lead to an increase in the macular thickness in uneventful phacoemulsification.

In our case control study OCT scanning of 100 eyes undergoing cataract extraction by phacoemulsification was done using SD-OCT Heildelberg OCT, the macular changes was evaluated before and one to four weeks after cataract extraction.

In a study by Cagini et al. [(17)], performed on 62 eyes they measured macular thickness before and at 3, 6, 12, 20, and 28 weeks after surgery using the OCT technique.

They found during the follow-up that there is a statistically significant increase in the macular volume at the 12th week after surgery. Two eyes developed clinically significant macular edema and there was no correlation between macular changes and best corrected visual acuity (BCVA) or ultrasound time [(17)].

Also Giansanti et al. studied the central foveal thickness on 110 eyes with follow up OCT 1st day, 1st week, 1st, 3rd, and

6th months, Statistically significant increase in macular thickness was detected at the early postoperative periods after the first week, and the mean value was 208.4 ± 27.6 μm ($p<0.001$) [18].

Another study by von Jagow et al. [19] studied macular thickness after uneventful cataract surgery on 33 eyes with follow up OCT 1 day,1 week and 6 weeks postoperatively ocular axial length, anterior chamber depth, phacotime and energy were documented. There was a significant increase in the mean foveal thickness 1 day, 1 week and 6 weeks (1 day: +10.66±20.8μm, P=0,026; 1 week: +15.23±19.7 μm; 6 weeks: +17.33±14.81μm,P<0.001).

They reached a conclusion that after cataract surgery, a mild increase in foveal thickness without impact on visual acuity could be observed. They explained that this increase may be due to both subclinical changes and due to influence of changes in media opacity on the measurement technique. Surgical and biometric parameters such as phacoemulsification time and energy and axial length did not correlate to the degree of macular thickening [19].

All previous studies regarding central macular thickness recorded statistically significant increase in the central macular thickness postoperatively which is compatible with our study results that noticed a statistically significant increase in the central macular thickness 1day, 1 week & 1 month postoperatively also there was no statistically significant difference in the central macular thickness between the Diabetic and Non-diabetic group neither pre-operatively, nor post-operatively,

However, how cataract surgery induces retinal and choroidal inflammation is not understood. It is known that the surgical trauma induces releases of prostaglandins in the aqueous humor that causes a disruption of the blood aqueous barrier. This results in the accumulation of other inflammatory mediators such as endotoxin, immune complex, and cytokines in the aqueous humor [20].

These inflammatory mediators diffuse into the vitreous cavity to reach the retina, where they are responsible for a rupture of the inner blood–retinal barrier resulting in another cascade of inflammatory mediators secretion together with an increased permeability from the perifoveal capillaries [21].

The outer blood–retinal barrier has also been shown to be disrupted as a consequence of post cataract surgery inflammation [14].

6. Conclusion

Phacoemulsification affects the macula, phaco power used during the surgery and inflammatory mediators

released after the surgery leads to long term increase in Central macular thickness in both diabetic and non-diabetic patients. It was noticed that phacoemulsification causes increase in Central macular thickness noticed at one week & one month post-operatively in both diabetic and non-diabetic patients. Finally we can say that cataract phacoemulsification cause increase in central macular thickness.

7. References

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