



EFFECT OF TEAR FILM CHANGES ON VISUAL ACUITY AFTER UNCOMPLICATED PHACOEMULSIFICATION CATARACT SURGERY

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SUMMARY – The aim of the study was to show the effect of tear film instability after uncomplicated ultrasound phacoemulsification cataract surgery in patients without previous tear film instability and to show its impact on the best corrected visual acuity (BCVA) one month after the surgery. The prospective cohort study included 30 patients of both sexes with cataract who underwent uncomplicated ultrasound phacoemulsification cataract surgery. Exclusion criteria included pre-existing ocular surface disease and tear film instability, topical antiglaucoma therapy, lid disorders, punctate epitheliopathy, corneal disorders, post-surgical corneal tear film instabilities, traumatic corneal scars, diabetic patients, posterior segment diseases and retinal surgeries, maculopathy, as well as previous or active uveitis that could compromise postoperative BCVA. All patients underwent full ophthalmic examination, corneal fluorescein staining, tear film break-up time test (TBUT) and visual acuity assessment on the day of surgery and 30 days after surgery. The difference in TBUT before and after phacoemulsification cataract surgery and difference in BCVA before and after cataract surgery were examined. All patients underwent ultrasound phacoemulsification cataract surgery followed by monofocal intraocular lens implantation performed by the same surgeon. The mean age of patients was 73±7 years. The study included 53% of female patients, with no statistically significant sex difference (Fisher exact test, $p=0.72$). BCVA was significantly improved after phacoemulsification cataract surgery with preoperative median BCVA 0.2±0.1 and postoperative median BCVA 1.0 (-0.1) (Wilcoxon test, $p<0.001$). TBUT was significantly worse in comparison to preoperative measurements. Preoperative median TBUT was 10±2 s. Postoperatively, 6 out of 30 patients had TBUT <5 s and 24 out of 30 patients had TBUT measurements between 6 and 10 s (Wilcoxon test, $p<0.001$). Fluorescein staining was negative preoperatively in all patients and positive in 10 out of 30 patients after surgery. Subjective symptoms of dry eye after surgery were reported by 5 out of 30 patients (TBUT <5 s and positive fluorescein staining). There was no significant difference in visual acuity considering dry eye symptoms ($p=0.51$, Mann-Whitney U test). The present study showed that uncomplicated phacoemulsification cataract surgery influenced tear film instability, worsened TBUT measurement and corneal fluorescein staining, but fortunately with no statistically significant impact on postoperative BCVA one month after surgery.

Keywords: *Cataract; Phacoemulsification; Tear film; Visual acuity*

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Introduction

Ultrasound phacoemulsification cataract surgery currently is the gold standard in cataract surgery^{1,2}. The advantages of this method compared to the older method of extracapsular cataract extraction include transition from large 180 degree corneoscleral incision to standard corneal two port side microincisions which are 1.5 mm and 1.8-2.75 mm, 'clear cornea incisions' that are hydrated and not sewn at the end of the procedure. This contributes to reducing postoperative astigmatism, improving the best corrected visual acuity (BCVA), and reducing the incidence of endophthalmitis. Histologically, this incision heals in a maximum of 60 days³. By shifting surgical incision to the cornea, surgeries in over 95% of patients are done in topical anesthesia, which is a huge relief to the patient, as this accelerates vision rehabilitation after surgery, ensures faster return to the workplace, and gives the surgeon the option of guiding the patient through the one-day surgery⁴. The surgery time is shortened and the risk of corneal decompensation due to the loss of endothelial cells is reduced, which is most important in patients with endotheliopathy, but also in patients with healthy eyes whose cornea can also decompensate even after an ideally performed surgical procedure. Fortunately, with advancement of technology and surgical techniques, the problem of endothelial cell loss induced by cumulative dissipated energy has been almost completely solved by the development of viscoelastics of different viscosity, which ensure stabilization of the anterior chamber and easier and safer performance of capsulorhexis, tamponade of the posterior capsule, capsular bag, and reduction of the possibility of capsular bag damage during intraocular lens (IOL) implantation². Ultrasound phacoemulsification cataract surgery includes foldable IOL implantation through a corneal incision in achieving optimal visual acuity targeting emmetropic measurement for distance vision in most of the patients. Those who undergo monofocal IOL implantation need a near vision spectacle prescription. A new era of multifocal IOLs allows more comfort for patient distance, intermediate and near vision with different advantages and disadvantages depending on optical and biomaterial characteristics of IOL, as well as patient needs in everyday life activities. A foldable IOL is implanted according to the

ultrasound or optical biometry measurement with the target emmetropic BCVA and patient wishes with the aim of achieving the desired refractive results for each patient undergoing cataract surgery^{5,6}. In addition to all the advantages, ultrasound cataract surgery can lead to changes in the anterior segment of the eye and quality of the tear film, and prolong the recovery of visual acuity. The intake of ultrasound energy, thermal effect of the probe on the corneal incision, manipulation during the procedure, as well as the necessary corticosteroid topical therapy after the procedure may affect the front surface of the cornea and its recovery and worsen the symptoms of dry eye^{7,8}. Patients often complain of burning, scratching, tearing and blurred vision after an ideally performed surgical procedure, which is most often the result of a thinned lipid layer of tears and their increased evaporation from the surface of the eye^{9,10}. The recovery of the cornea is imperative for the surgeon after the procedure in order to be able to define a valid postoperative refraction^{11,12}.

Patients and Methods

This prospective cohort study included 30 patients of both sexes (women 53% and men 47%) who all underwent uncomplicated ultrasound phacoemulsification cataract surgery followed by monofocal IOL implantation at the Department of Ophthalmology, Osijek University Hospital Center, Osijek, Croatia, in the period from January 2019 to March 2019. All patients were informed in writing about details of the research and signed a consent form to participate in the research. All patients were eligible for surgery after bringing normal blood analysis results, electrocardiography monitoring test, as well as a general practitioner's permission for surgery. The exclusion criteria were pre-existing ocular surface disease and tear film instability, topical antiglaucoma therapy, lid disorders, punctate epitheliopathy, corneal disorders, post-surgical corneal tear film instabilities, traumatic corneal scars, diabetic patients, posterior segment diseases and retinal surgeries, maculopathy, and previous or active uveitis that could compromise postoperative BCVA. All patients underwent full ophthalmic examination, corneal fluorescein staining, tear film break-up time test (TBUT) and BCVA assessment on the day of

surgery and 30 days after surgery. The difference in TBUT before and after phacoemulsification cataract surgery and difference in BCVA before and after cataract surgery were examined. The change of tear film as a diagnosis of dry eye was defined with positive fluorescein test staining and TBUT test <5 s. TBUT test between 6 and 10 s was defined as an instable tear film and TBUT >10 s was defined as a normal tear film finding. BCVA was maximum visual acuity on the day of and 30 days after the surgery, considering that patients underwent uncomplicated cataract surgery with surgically induced astigmatism (SIA) less than 0.5 dcyl. All patients underwent a phacoemulsification cataract surgery followed by monofocal hydrophobic acrylic IOL implantation performed by the same surgeon on the Infinity device (Infinity Alcon 2007, Vision System Operators Manual, U.S. Headquarters, Alcon Laboratories, Inc., Fort Worth, TX, USA) in topical anesthesia. Pupillary dilatation was achieved using a combination of phenylephrine (5%) and tropicamide (0.8%) eye drops before the surgery. Intracameral cefuroxime was instilled at the end of the surgery or subconjunctival Garamycin in cases of allergy. Postoperatively, Maxitrol (dexamethasone, neomycin sulfate, polymyxin B) eye drops and ointment were continued five times a day, and ointment was administered in the evening for one week and then tapered every week for over a month.

Ethics

All the procedures followed in this research were in accordance with ethical standards of the responsible institutional or regional committee on human experimentation, as well as with the Helsinki Declaration of 1975, as revised in 1983. All procedures passed Ethics Committees of the Josip Juraj Strossmayer University in Osijek and Osijek University Hospital Center.

Statistical analysis

Categorical data were presented in absolute frequencies. Numerical data were described by median and interquartile range. Differences in categorical variables were tested by Fisher exact test. The normality of data was tested by the Shapiro-Wilk test. Differences in numerical variables before and after surgery were tested by the Wilcoxon test. Differences in numerical variables between two independent groups were tested by

the Mann-Whitney U test. All p values were two-sided. The significance level was set to $\alpha=0.05$. The MedCalc Statistical Software version 14.12.0 (MedCalc Software bvba, Ostend, Belgium; <http://www.medcalc.org>; 2014) was used on statistical analysis.

Results

This prospective cohort study included 30 patients. The mean age of patients was 73 ± 7 (interquartile range). The study included 53% of female patients, with no statistically significant difference between the sexes and eye that underwent the surgery (Fisher exact test, $p=0.72$). There were 18/30 right eyes and 12/30 left eyes that underwent ultrasound phacoemulsification cataract surgery (Table 1).

Table 1. Patient distribution according to sex and operated eye

	Patients (N)			p*
	Men		Total	
Right eye	9/14	9/16	18/30	0.72
Left eye	5/14	7/16	12/30	
Total	14/14	16/16	30/30	

*Fisher exact test

The BCVA was significantly improved after the phacoemulsification cataract surgery with preoperative median BCVA 0.2 ± 0.1 and postoperative BCVA 1.0 (-0.1) (Wilcoxon test, $p<0.001$). TBUT was significantly worse in comparison to preoperative measurements. Preoperative median TBUT was 10 ± 2 s. Postoperatively, 6 out of 30 patients had TBUT <5 s and 24 out of 30 patients had TBUT measurement between 6 and 10 s (Wilcoxon test, $p<0.001$) (Table 2). Out of 30 patients, 19 of them had spectacle correction after surgery (median -0.75, interquartile range, -0.50 to -1.50). Tear film instability (TBUT 6-10 s) after cataract surgery was measured in 24 out of 30 patients (Table 3). Fluorescein staining was negative preoperatively in all patients and positive in 10 out of 30 patients after the surgery. Subjective symptoms of dry eye after the surgery were reported by 5 out of 30 patients (TBUT <5 s and positive fluorescein staining).

Table 2. Visual acuity and tear break-up test (TBUT) before and after cataract surgery

	Median (interquartile range)		P*
	Before surgery	After surgery	
Visual acuity	0.2 (0.1-0.33)	1.0 (0.9-1.0)	<0.001
TBUT (s)	10 (8-10)	8 (6-10)	<0.001

*Wilcoxon test: p<0.001

Table 3. Dry eye before and after cataract surgery

		Number of patients before surgery (N)		
		Dry eye	Tear film instability	Total
After surgery	TBUT (s) <5	0	6/30	6/30
	Tear film instability	0	24/30	24/30
	Total	0	30/30	30/30

Wilcoxon test: p<0.001; TBUT = tear break-up test

Table 4. Visual acuity according to dry eye symptoms

	Median (interquartile range)		P*
	Dry eye (5/30)	Not dry eye (25/30)	
Visual acuity before surgery	0.2 (0.15-0.4)	0.1 (0.1-0.3)	0.35
Visual acuity after surgery	1.0 (0.75-1.0)	1.0 (0.9-1.0)	0.51

*Mann Whitney U test

There was no significant difference in visual acuity considering dry eye symptoms (p=0.51, Mann-Whitney U test) (Table 4).

Discussion

The aim of this prospective study was to show the incidence of tear film instability after uncomplicated ultrasound phacoemulsification cataract surgery in patients without previous tear film instability and to show its effect on BCVA one month after the surgery. Tear film changes after uncomplicated ultrasound phacoemulsification cataract surgery occur as a consequence of several factors including the composition of tears, surgical impact of ultrasound on ocular

structures, heating of the corneal tunnel and cornea itself, ultrasound probe manipulation on the anterior eye surface during surgery, the time of surgery, the cataract technique used, the experience of the surgeon, the time of the microscope light exposition, as well as the corneal sensitivity to intra- and postoperative topical therapy. Cataract surgery influences the quality of tear film. All this can cause microscopic changes that cause discomfort and aggravate dry eye symptoms even in patients without previous tear film imbalances^{13,14}. Patients more often report red eye, epiphora and foreign body sensation¹⁵. As the cataract surgery is mostly done in older patients who are more sensitive to local topical therapy applied during surgery and in the period after it, lipid layer disturbances are more often reported with symptoms of hyposalivation dry

eye¹⁴. Meibomian gland dysfunction and thinning of the lipid tear layer, as well as lower density of goblet cells are also even more often reported. Lipid tear film dysfunction is responsible for 93% of all types of tear film dysfunction and appears in 1 out of 9 patients after cataract surgery¹⁶. The risk group for tear film imbalances are those patients with TBUT <10 s^{17,18}. In a large systematic review and meta-analysis of the prevalence and characteristics of dry eye disease (DED) after cataract surgery, Miura *et al.* concluded that overall 37.4% (95% CI 22.6-52.3; 206/775) of patients without pre-existing DED developed DED after cataract surgery. The risk factors for DED after cataract surgery were age, female sex, systemic diseases, systemic medications, psychiatric conditions, pre-existing DED, meibomian gland dysfunction, preservatives in eye drops, surgery techniques, and lifestyle. The worst symptoms of DED occurred on postoperative day 1 and persisted for at least 1-12 months following cataract surgery. The authors concluded that consistent follow-up for DED was warranted for at least 1 month after cataract surgery and topical administration of preservative-free tears, as well as that preoperative meibomian gland treatment was effective in preventing and treating DED following cataract surgery to improve satisfaction and vision quality¹⁹. The results of this study correlate with our results where we report tear film disturbances in 30% of patients measuring TBUT from 6 to 10 s on scheduled routine controls after surgery. Another randomized, observer-masked study conducted by Roberts and Elie found that a clinically significant proportion of patients reported experiencing at least some dry eye symptoms after cataract surgery and results were consistent with cataract surgery either inducing dry eye or exacerbating pre-existing dry eye in certain patients²⁰. These results are very similar to our conclusions as 80% of our patients experienced TBUT disturbances and 20% developed DED symptoms. Therefore, in the routine clinical preoperative assessment it is of huge importance to really pay attention to ocular surface findings and disturbances, as well as to corneal irregularities, since DED symptoms even in patients with regular preoperative corneal DED tests may lead to aggravation after the surgery and can negatively affect visual recovery and outcomes even in cases when the surgery was done by the most experienced surgeons.

In our study, 20% of patients who had DED symptoms complained of vision fluctuation throughout the day. Here we should notice that every ophthalmologist should remember that this is the most important diagnostic symptom of ocular surface disease. If a patient complains of these symptoms, the priority should be to think about corneal surface changes and DED and to evaluate his tear film rather than evaluating technical aspects of the surgery. A simple way is to use noninvasive tear break-up time (NIBUT) assessment using handheld lipid layer examination instrument or standard TBUT test²¹.

Preoperative restoring of corneal epithelium is of importance to eliminate the possibility of a biometry measurement error that, if not recognized, may result in a refractive shift and lead to dissatisfied and complaining patients. To avoid such a situation, a detailed preoperative assessment is necessary in order to avoid additional laser refraction treatment, add on IOL implantation or sometimes even explantation of primarily implanted IOL, which is often very demanding for a surgeon as it increases the risk of complications and endophthalmitis²².

In our study, 6 out of 30 patients (20%) developed DED, which is similar to the study by Hamed *et al.*, which showed that 22% of the patients who had undergone uncomplicated phacoemulsification surgery suffered from dry eye with significant results in the 1st postoperative week and improving over time²³. Some investigations also reveal that a grooved incision can aggravate the symptoms during the early postoperative period in patients without dry eye preoperatively. In addition, long microscopic light exposure times can have an adverse effect on the dry eye test values, which should be kept in mind when thinking about technical aspects of the surgical procedure and its effect on tear film stability²⁴. All our patients had improvement in visual acuity although reporting DED symptoms and TBUT changes in the early postoperative period. Cataract surgery has good visual outcomes in patients with DED, without any disconcerting rate of complications. Pre-existing keratopathy is the main determinant of the extent of postoperative visual recovery²⁵. In our study, we recorded reduced postoperative TBUT and positive fluorescein test scores after phacoemulsification, which is in correlation with the study by Oh *et al.*, who found a marked decrease in TBUT in the early

postoperative period in patients who had undergone phacoemulsification surgery but Schirmer test 1 was within the normal range²⁶⁻²⁹. Some authors speculate that corneal incision, especially on horizontal corneal meridian at 3 and 9 o'clock, may reduce tear secretion and production and lead to neurotropic keratopathy³⁰, as well as reduced corneal sensitivity^{31,32}. Combined steroid and antibiotic therapy delays clear cornea tunnel healing after surgery, changes refraction, and thus results in astigmatism and daily fluctuation in vision, and causes epithelial toxicity³³⁻³⁶. Here we must notice that 30% of patients are steroid responders and we should be aware of intraocular pressure elevation and never forget to measure it. Finally, ultrasound phacoemulsification in patients with normal ocular surface prior to surgery may result in surgically induced dry eye or TBUT abnormalities due to many contributing factors. Fortunately, these cornea surface abnormalities, DED and TBUT changes after cataract surgery are reversible and may return to normal in 1 to 3 months, as confirmed in our study, as well as in previous studies³⁷.

Conclusion

All patients in this study who had tear film instability or a fluorescein positive staining test after cataract surgery had normal TBUT and fluorescein tests one month after the procedure. They stopped local corticosteroid and antibiotic topical therapy prescribed within 3 weeks after the surgery and they all continued local eye drop preservative free artificial tear therapy a few times *per* day, in combination with gel eye lubrication before sleep until absence of symptoms and normalization of TBUT and fluorescein staining tests. Therefore, it may be concluded that the surgery induced stress caused transitory changes in tear film stability in a small percentage of patients. Although ultrasound phacoemulsification cataract surgery represents the gold standard in cataract surgery and reduces intraoperative and postoperative complications, as well as accelerates postoperative visual rehabilitation in the early postoperative period, this study proved that there was a statistically significant effect of surgery on tear film changes in this early postoperative period. The present study showed that uncomplicated

phacoemulsification cataract surgery influenced tear film instability, worsened TBUT measurements and corneal fluorescein staining, but fortunately had no statistically significant impact on postoperative BCVA one month after the surgery. This study warns us that although cataract surgery is the most frequently performed surgery in the world, even in the hands of the most experienced surgeons, the patient may be dissatisfied if there are changes to the corneal surface and tear film instabilities that are not recognized and healed. Frequent follow up of all patients after cataract surgery in this early postoperative period is necessary for minimizing subjective discomfort and for improving postoperative visual rehabilitation and restoring ocular surface changes caused by the surgical procedure.

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Sažetak

UTJECAJ PROMJENA SUZNOG FILMA NA VIDNU OŠTRINU NAKON OPERACIJE MRENE ULTRAZVUČNOM FAKOEMULZIFIKACIJOM

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Cilj istraživanja bio je prikazati utjecaj poremećaja suznog filma poslije ultrazvučne operacije mrene kod bolesnika bez prethodno prisutnog poremećaja suznog filma te prikazati utjecaj poremećaja suznog filma na najbolju korigiranu vidnu oštrinu (*best corrected visual acuity*, BCVA) mjesec dana nakon operacije. U ovo prospektivno istraživanje uključeno je 30 ispitanika obaju spolova sukcesivno operiranih zbog mrene postupkom ultrazvučne fakoemulzifikacije. Isključni kriteriji bili su prethodno postojeća bolest prednje površine oka i nestabilnost suznog filma, primjena topičke antiglaukomske terapije, bolesti vjeda, punktatna epiteliopatija, bolesti rožnice, post kirurške nestabilnosti suznog filma, traumatski rožnični ožiljci, dijabetički bolesnici, bolesti stražnjeg segmenta oka i prethodne operacije mrežnice, makulopatija, ranije uveitične upale koje bi mogle kompromitirati vidnu poslijeoperacijsku BCVA. Svim bolesnicima učinjen je kompletan oftalmološki pregled, fluoresceinski test, test prekida suznog filma (*tear break-up test*, TBUT) i pregled BCVA na dan operacije i mjesec dana nakon operacije. Ispitana je razlika TBUT prije i nakon operacije mrene kao i razlika BCVA prije i nakon zahvata. Svim bolesnicima učinjena je ultrazvučna operacija mrene i ugrađena monofokalna intraokularna leća, operirao ih je isti kirurg. Srednja dob ispitanika bila je 73±7 godina, žena je bilo 53%, bez statistički značajne razlike između spolova (Fisherov egzaktni test, $p=0,72$). Nakon operacije značajno je bolja bila BCVA: prijeoperacijski medijan BCVA 0,2 (±0,1) i poslijeoperacijski medijan BCVA 1,0 (-0,1) (Wilcoxonov test, $p<0,001$). TBUT bio je značajno lošiji nakon operacije u odnosu na prijeoperacijsko mjerenje. Prijeoperacijski TBUT medijan iznosio je 10±2 s. Poslijeoperacijski je TBUT iznosio <5 s u 6 od 30 ispitanika te 6-10 s u 24 od 30 ispitanika (Wilcoxonov test, $p<0,001$). Fluoresceinski test bio je negativan kod svih ispitanika prije operacije, a pozitivan kod 10 od 30 ispitanika nakon operacije. Simptome suhog oka nakon operacije imalo je 5 od 30 ispitanika (TBUT <5 s i pozitivan fluoresceinski test). Nije bilo statistički značajne razlike u vidnoj oštrini s obzirom na simptome suhog oka ($p=0,51$, Mann-Whitneyjev U test). Ovo istraživanje potvrdilo je da ultrazvučna operacija mrene može dovesti do nestabilnosti suznog filma pogoršavajući mjerene rezultate TBUT i fluoresceinskog testa, no nasreću bez statistički značajnog utjecaja na poslijeoperacijsku BCVA mjesec dana nakon operacije.

Ključne riječi: *Fakoemulzifikacija; Mrena; Suzni film; Vidna oštrina*