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Effect of tear osmolarity on postoperative refractive error after cataract surgery

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Purpose: *To analyze the effects of tear osmolarity on postoperative refractive error and patient satisfaction after cataract surgery.*

Methods: *The patients were divided into two groups based on the tear osmolarity (group Nr 1-normal tear osmolarity, <310 mOsm/L; group Nr 2-hyperosmolar, >310 mOsm/L). Preoperative and postoperative (1 month after surgery) visual acuities (VAs), refractions, and best corrected VAs (BCVAs) were measured. The postoperative refractive error was measured as the spherical equivalent (SE) (SE = sphere + [0.5 × cylinder]). The postoperative VA, BCVA, and SE were compared between groups.*

Results: *Eighty-one patients were included in the study (group Nr 1=40 patients and group Nr 2=41 patients). The hyperosmolar group had a statistically significant higher postoperative refractive error (p<0.01, mean SE for group Nr 1=0.284; mean SE for group Nr 2=0.604) and lower VA after surgery (p<0.01, mean VA for group Nr 1=0.891; mean VA for group Nr 2=0.762).*

Conclusions: *Increased tear osmolarity can affect the planned outcome of cataract surgery as an unexpected refractive error. Measuring tear osmolarity before routine cataract surgery would help achieve accurate results and improve postoperative patient satisfaction.*

Keywords:

tear osmolarity, dry eye disease, cataract surgery, refractive error

Introduction

Cataract surgery is one of the most common and successful procedures performed worldwide. With the development of surgical techniques and technologies, cataract surgery today is not only a treatment modality but also a refractive procedure. [1, 2, 3].

Nowadays, cataract is observed even in younger patients, and surgery is often performed before significant deterioration of visual acuity (VA). Additionally, patients have lesser visual impairment and higher expectations in terms of the surgical result. [4].

Good refractive outcomes and relative spectacle independence are expected as the primary goal for many cataract surgeons and patients. [5].

The reasons why unexpected refractive errors sometimes occur after cataract surgery have been extensively studied in recent years to obtain the most accurate results possible. [6, 7]. The risk factors for postoperative refractive errors identified in the studies are the corrected VA before surgery and the targeted refraction after surgery, ocular comorbidities, previous ophthalmic surgery, type, and calculation of intraocular lens (IOL) power, and complications during surgery. [5, 7]

Many of these factors could not be changed to achieve the expected VA after cataract surgery (ocular comorbidities), and part of them could not be predicted and easily corrected (complications during surgery). Therefore, it is important to focus on factors that can be improved.

Careful preoperative surgical planning is imperative to achieve the desired emmetropic outcomes, and the most important element is accurate and reliable biometric measurements of axial length (AL) and keratometry. [8, 9]. An error of 1 D in the IOL power calculation gives a 0.67 D refractive error after surgery. A 0.5 D error in AL can cause a 1.25 D error in postoperative refraction, and a 0.5 D error in keratometry can cause a 0.5 D postoperative refractive error. [8].

An essential component for IOL calculation is keratometry. [10]. The average keratometry measurement, together with biometry measurements, is fundamental for calculating the IOL power. [11]. Inaccurate keratometry measurements can affect the accuracy of the IOL calculation, thereby affecting the surgical outcome. [12].

Keratometry measurements are significantly influenced by the quality of the tear film, as reflections from the corneal surface are used as a basis for the measurement.13 The unstable tear film affects the quality of these reflections, resulting in inaccurate keratometry measurements. [13].

In turn, tear film instability and increased osmolarity characterize dry eye disease (DED),14 and it is known that the incidence of DED increases with age. [15]. Studies have shown that DED with altered ocular surface health is common in patients with cataracts.16 Therefore, it would be important to diagnose DED in patients before cataract surgery, as instability of the tear film may result in inaccurate biometry and keratometry measurements. [17]

Methods

This study aimed to analyze the effect of tear osmolarity on residual refractive error after cataract surgery in patients after planned routine cataract surgery. We included 81 patients from one clinical university hospital **(“ ”)** who were scheduled for a standard routine cataract surgery and were willing to participate in this study. The study was performed in accordance with the Declaration of Helsinki and approved by the Institutional Ethics **Review Board of “ ”(ac**ceptance number: 6-3/45, decision date: 10/25/2018). Informed consent was obtained from all participants.

Exclusion criteria were met to avoid the effects of other factors that could significantly affect VA and/or refraction (corneal pathologies, long or short AL (<23 mm or >25 mm), and uncontrolled and uncompensated ophthalmological comorbidities).

All patients underwent standard examination and preparation for routine cataract surgery, as well as additional tear osmolarity measurements (measured before any other examination and eye drop installation), Tear break up time test (TBUT) and keratoconjunctival fluorescein staining to measure grading of corneal and conjunctival staining (Oxford scheme). [18]. Patients were also required to indicate whether they had any symptoms of dry eye syndrome by answering yes or no (foreign body sensation, burning, redness, tearing, blurry vision).

All patients underwent standard cataract surgery: phacoemulsification through a temporal clear corneal incision with foldable monofocal hydrophobic acrylic IOL implantation. All operations were performed by four experienced surgeons with equal distribution in both groups.

IOL calculation was performed using the Haigis formula incorporated in IOLMaster 500 (Carl Zeiss Meditec, Jena, Germany) using, and targeted postoperative refraction was 0 (plano) in all cases.

After surgery, the patients were administered topical levofloxacin/dexamethasone eye drops.

Tear osmolarity was measured using the TearLab Osmolarity System (TearLab Corporation, San Diego, CA, USA). Studies have shown that it is sensitive, objective, and specific in measuring tear osmolarity. [19, 20, 21].

Based on the tear osmolarity, the patients were divided into two groups, group Nr 1-normal tear osmolarity, <310 mOsm/L (40 patients) and group Nr 2-hyperosmolar, >310 mOsm/L (41 patients).

Patients were followed up 1 month after cataract surgery, and VA, refraction, best corrected VA (BCVA), and patient satisfaction with the surgical result were analyzed. Postoperative refractive error was calculated as the spherical equivalent (SE) of postoperative refraction (SE = sphere + [0.5 × cylinder]).

Patient satisfaction with the surgical outcome was divided into three grades: 1-completely satisfied, 2-partially/rather satisfied, and 3-dissatisfied.

Statistical analysis was performed using IBM SPSS program version 27.0 (IBM Corporation, Endicott, New York, U.S.). Groups were compared using the Mann–Whitney U test, chi-square test for nonparametric data, and independent sample t-test for parametric data. The P-value of ≤0.05 was considered statistically significant.

Results

Eighty-one patients were included in the study (group Nr 1 with normal tear osmolarity=40 patients and group Nr 2 with hyperosmolar tears=41 patients). The mean age was 73.49 ± 6.749 years (range, 57-89 years). There were no statistically significant differences between both groups in terms of age, sex, and the operated eye.

The mean BCVA before cataract surgery was 0.470±0.165 (range 0.1-0.8) and there was no statistically significant difference between the groups as well.

Keratometry and biometry

We analyze three parameters from IOL calculation-AL, average keratometry (K) and anterior chamber depth (ACD).

The mean AL was 23.58 ± 0.527 (range 23.00-24.97) and the mean ACD was 2.79 ± 0.27 (range 2.17-3.40). There were no statistically significant differences between both groups in terms of AL and ACD. The mean average K was 43.47 ± 1.07 (range 42.03-47.45) and there was a statistically significant difference between both groups (p<0.03)- the mean average K in group Nr 1 was 42.94 ± 0.66, but in group Nr 2 was 43.99 ± 1.14.

DED tests

The main factor for DED in this study we chose tear osmolarity, but we also measured TBUT, keratoconjunctival fluorescein staining and, we asked patients to indicate whether they had any symptoms of dry eye syndrome by answering yes or no.

There was a statistically significant difference in TBUT between both groups (p<0.01). The mean TBUT in group Nr 1 was 12.45 ± 2.24, but in group Nr 2 was 9.02 ± 1.75.

Also, we found a statistically significant difference in keratoconjunctival fluorescein staining using grades from Oxford scheme (p<0.01). Majority of patients from group Nr 1 had 0 grade of Oxford scheme (30 patients or 75%), while in group Nr 2 21 patient had I grade (51,2%), 16 patients had 0 grade (39%) and 4 patients had II grade (9.8%).

Additionally, patients were required to indicate whether they had any symptoms of dry eye syndrome by answering yes or no (foreign body sensation, burning, redness, tearing, blurry vision). There was a statistically significant difference in patient's answers about DED symptoms (p<0.01). That is, patients from group Nr 2 tended to answer positive (29 patients or 70.7%), while group Nr 1 had the opposite tendency (35 patients or 87.5% answered “no’).

VA and SE after cataract surgery

There was a statistically significant difference in the uncorrected VA after surgery between both groups (p<0.01). The mean VA after cataract surgery in group Nr 1 was 0.891 ± 0.118, but in group Nr 2 was 0.762 ± 0.139.

Uncorrected VA after cataract surgery was 1.0 in group Nr 1 in 13 cases (32.5%), while it was 1.0 in group Nr 2 only in four cases (9.7%).

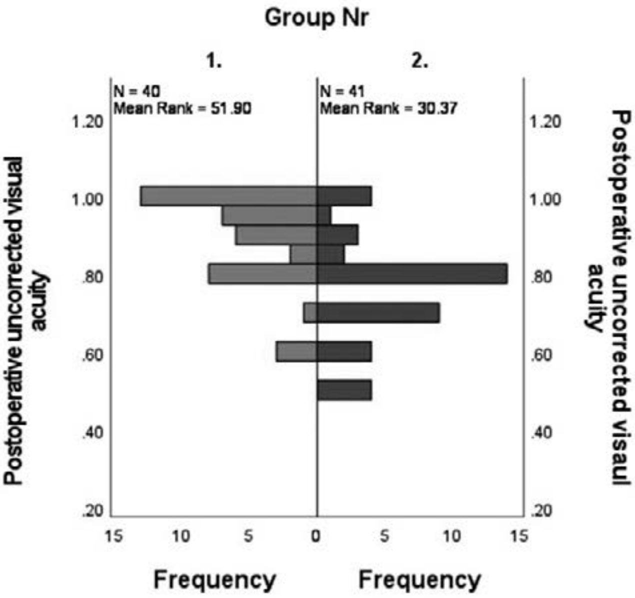


Figure 1. Postoperative uncorrected visual acuity

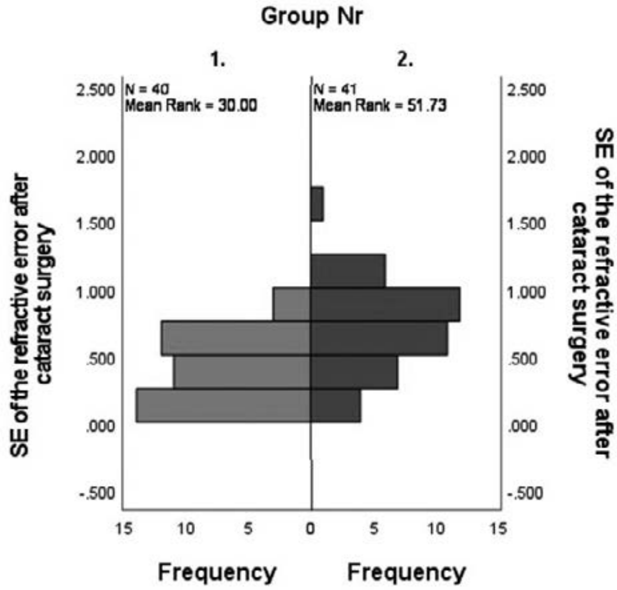


Figure 2. SE of the refractive error after cataract surgery

There was no statistically significant difference in the BCVA after cataract surgery between the groups (p=0.793). The mean BCVA in group Nr 1 was 0.985, and group Nr 2 was 0.982.

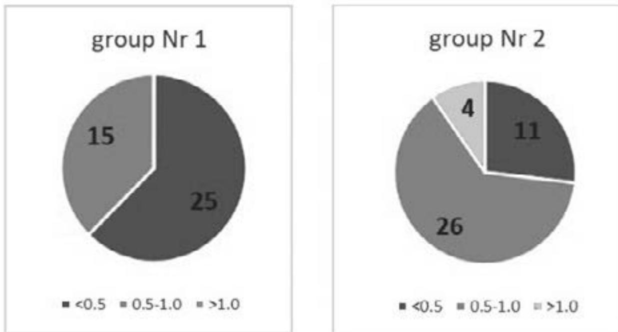
Additionally, a statistically significant difference was found in the SE after cataract surgery (p<0.01). The mean SE in group Nr 1 was 0.284 ± 0.253 (range, 0.0-0.875), but in group Nr 2 was 0.604 ± 0.338 (range, 0.0-1.5).

In group Nr 1, most patients had a SE of the refractive error after cataract surgery of up to 0.5 D (25 patients [62.5%]), and none of the patients had a SE of the refractive error of >1.0 D. While in the hyperosmolar group, 26 patients (63.4%) had a SE error in the range of 0.5-1.0 D and in four cases the SE of the refractive error was >1.0 D.

Based on the statistical analysis, a moderately significant correlation was observed between TearLab measurements and the SE of the refractive error after cataract surgery (Spearman's correlation coefficient=0.45).

Patient overall satisfaction with the surgical results.

One month after surgery, the VA, refractive measurements, and patient overall satisfaction with the surgical result were analyzed. Patients needed to choose one of the three options: 1-completely satisfied, 2-partially/rather satisfied, or 3-dissatisfied. Significant differences were observed at this point. A total of 60% (24 patients) of the patients from group Nr 1 reported that they were completely satisfied with the surgical result, and only one patient was dissatisfied with the overall surgical outcome. A different situation was reported in the hyperosmolar group (group Nr 2); 48.8% (20 patients) of the patients were partially/rather satisfied with the surgical result, 34.1% (14 patients) of the patients were completely satisfied, while seven patients (17.1%) were dissatisfied.



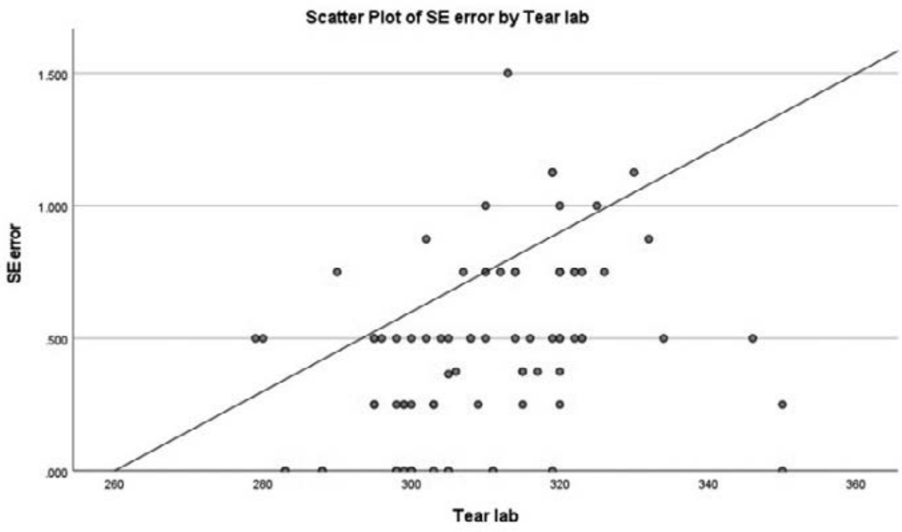
Abbreviation: SE, spherical equivalent

Figure 3. Significance of the SE of the refractive error after cataract surgery

Discussion

This study reveals that patients with higher tear osmolarity can more often have lower uncorrected VA, unexpected refractive error, and lower satisfaction with the overall surgical result compared with the control group (patients with normal tear osmolarity). This confirms the findings of previous studies of how the ocular surface health can impact IOL measurements and overall results of cataract surgery. [14, 22, 23].

In this study, we chose tear osmolarity as the main diagnostic factor of DED for several reasons. First, in our opinion, it is a more objective method than other tests, because it does not include the subjective component of the doctor. Other diagnostic methods of DED, such as TBUT and staining with fluorescein, always involve the subjective view of the doctor and if the examination is done by



Abbreviations: SE, spherical equivalent

Figure 4. Correlation between TearLab measurements and the SE of the refractive error after cataract surgery)

another person, the result could be different. Second, increased tear osmolarity is the leading mechanism and key point in the development of DED. [24]. Thirdly, determination of tear osmolarity with the TearLab system is a quick and convenient method for both the doctor and the patient. [19, 20, 21].

So that tear osmolarity was not the only diagnostic test for DED, we also performed TBUT, keratoconjunctival fluorescein staining and simple evaluation of DED symptoms. We found statistically significant differences in all performed DED tests between both groups. This confirms that the study group indeed included patients with DED.

A good visual outcome, without unexpected refractive errors, plays a significant role in patient satisfaction with the surgical outcome. However, the level of dissatisfaction does not always correlate with the surgical outcome of the residual refractive error and visual outcome. Not all patients dissatisfied with the surgery had a significant refractive error; however, most patients had increased tear osmolarity with dry eye symptoms. This proves how DED and its symptoms play a significant role in overall patient satisfaction. [25, 26, 27].

Furthermore, previous studies have revealed that cataract surgery can aggravate already existing DED symptoms, and DED can develop after cataract surgery. [17, 28, 29, 30].

Research also revealed that patients with higher VA before surgery were more often dissatisfied with the surgery outcome than patients who had significantly decreased vision due to cataracts. Therefore, this could be another factor that should be considered before surgery. [31]

Analysis of the results reveals that younger patients with DED symptoms and higher VA before surgery are at risk for lower satisfaction with the surgical results.

While cataract surgical technologies and IOL calculation are constantly evolving, expectations for perfect surgical outcomes are increasing in surgeons and patients. [32]. Therefore, our goal and responsibility should be to reduce exposure to residual refractive error influencing factors that can be controlled. In this context, it would be useful to include DED diagnostical tests before routine cataract surgery, not only in cases when premium IOL implantation is planned. [33] Based on this research, TearLab can be used as an objective, convenient, and easily performed alternative to other DED tests in patients before cataract surgery. This could help in better identification of patients who are at a higher risk for unexpected refractive error.

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