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Changes in Tear Osmolarity after Cataract Surgery

Tsutomu Igarashi[1], Hisatomo Takahashi[2], Maika Kobayashi[1], Tomoyuki Kunishige[1], Takeshi Arima[1], Chiaki Fujimoto[1], Hisaharu Suzuki[1], Takahisa Okuda[3] and Hiroshi Takahashi[1]

[1]Department of Ophthalmology, Nippon Medical School, Tokyo, Japan
[2]Department of Ophthalmology, Omagari Kousei Medical Center, Akita, Japan
[3]Division of Legal Medicine, Department of Social Medicine, Nihon University School of Medicine, Tokyo, Japan

Background: The purpose of this study was to examine changes in the ocular surface before and after phacoemulsification with small incisions and to examine the changes in tear osmolarity.
Methods: This was a prospective, observational study involving 55 eyes of 39 patients (19 male, 20 female patients; average age 72.0±7.3 years) who had cataract surgery at a Nippon Medical School Hospital between December 2013 and June 2018. Compromised tear dynamics were determined by the Schirmer test or the tear break-up time (BUT). An abnormal ocular surface was identified by positive vital staining with fluorescein or lissamine green. Moreover, tear osmolarity (Tosm) and corneal sensitivity were measured. All assessments were done preoperatively and 1 and 4 weeks (P1W and P4W) after the surgery.
Results: None of the operations had any complications. Operating time was 17.8±9.3 minutes. BUT was significantly decreased at P1W, and it recovered at P4W. The Schirmer test did not change significantly. The fluorescein staining score (FSS) increased significantly at P1W and recovered at P4W. The Lissamine green score (LSS) did not change significantly. Tear osmolarity increased significantly at P1W and did not recover at P4W. Corneal sensitivity decreased significantly at P1W and recovered at P4W.
Conclusion: In the present study, there were temporary changes in dry eye-related examinations including tear osmolarity after cataract surgery. In particular, tear osmolarity increased significantly 4 weeks after surgery compared to before surgery, and it showed long-term changes, unlike other factors. After cataract surgery, tear osmolarity, BUT, and FSS increase, resulting in dry eye symptoms. Therefore, it is necessary to pay attention to discomfortable eye symptoms of patients after cataract surgery.
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Key words: dry eye, tear osmolarity, cataract surgery, phacoemulsification

Introduction

According to the definition of dry eye in the 1995 National Eye Institute (NEI) / Industry Dry Eye Workshop, dry eye is defined as a chronic disease of tears and keratoconjunctival epithelium due to various factors, with eye discomfort and visual function disorders[1]. In addition, the 2007 Dry Eye Work Shop (DEWS) report pointed out the importance of increased tear osmolarity and ocular surface inflammation for dry eye[2]. The epidemiology subcommittee of the International Dry Eye Workshop (2007) reported that there were many studies citing aging as a crucial risk factor for dry eye[3]. Aging causes cataracts in many people, and many patients with cataracts undergo phacoemulsification in developed countries. Since postoperative dry eye contributes to postoperative pain, diagnosis and treatment of the postoperative eye surface is important[4]. Laser in Situ Keratomileusis (LASIK) is known to cause the most dry eye symptoms[5] and increase the tear osmolarity[6] after ophthalmic surgery, but cataract surgery has also been suggested to be a cause of

Correspondence to Tsutomu Igarashi, MD, PhD, Department of Ophthalmology, Nippon Medical School, 1–1–5 Sendagi, Bunkyo-ku, Tokyo 113–8602, Japan
E-mail: tutomu@nms.ac.jp
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postoperative dry eye symptoms[7,8]. Eye drops used postoperatively can cause dry eye[9,10]. Phacoemulsification has been shown to reduce tear meniscus height, tear breakup time (BUT), and corneal sensitivity[9,11], decrease goblet cell density[8], and promote squamous metaplasia in conjunctival impression cytology[10]. Several factors such as increased inflammatory mediators due to postoperative inflammation[12], toxicity due to the use of eye drops containing benzalkonium chloride[13], toxicity due to light exposure of operating microscope[14,15] and damage to corneal sensory nerves[13] can be considered related to the mechanism of deterioration of the condition of the ocular surface after cataract surgery.

The purpose of this study was to examine changes in the ocular surface before and after phacoemulsification in small incisions, which are common in developed countries, and to examine the changes in tear osmolarity, a new dry eye parameter.

Materials and Methods

Study Population

This was a prospective, observational study that followed the tenets of the Declaration of Helsinki and was approved by the Drug Ethics Committee of the Nippon Medical School Hospital (#225004). Informed consent was obtained in writing from all of the patients. Before subjects were enrolled, the study was registered at the Japanese University Hospital Medical Information Network Clinical Trials Registry (clinical trial identifier: UMIN 000011112; accessed 2013/07/03).

A total of 55 eyes of 39 patients (19 male and 20 female patients; average age 72.0 ± 7.3 years; range, 52 - 84 years) who had cataract surgery at Nippon Medical School Hospital between December 2013 and June 2018 were evaluated. None of the patients had a history of ocular surface diseases preoperatively or surgical complications after surgery by one surgeon (T.I.). Inclusion criteria are those who have agreed to clinical research and who can continue to visit our hospital for 4 weeks after surgery. Excluded from the study were contact lens wearers, patients with diabetes or pterygia, and eye drop users, including dry eye patients and glaucoma patients, patients with nuclear color grade 5 or more according to the Lens Opacities Classification System III (LOC III) classification and patients with severe ophthalmic disease such as corneal dystrophy, degenerative retinal diseases, and uveitis.

Cataract Surgery

Before cataract surgery, 1.5% levofloxacin (Santen Pharmaceutical Co. Ltd. Osaka, Japan) eye drop was instilled 4 times daily for 1 day. Tropicamide and phenylephrine hydrochloride (Santen Pharmaceutical Co. Ltd.) eye drop was used 3 times over half an hour to dilate the pupils before cataract surgery. Topical anesthesia was achieved with 0.4% oxybuprocaine hydrochloride (Santen Pharmaceutical Co. Ltd) and 4% lidocaine (AstraZeneca K.K, Osaka, Japan). Aspirating Speculum did not used in all cases. Two incisions were made on the cornea during the surgery. The first, of approximately 1 mm, was at about 90° from the first along the corneal diameter. The second incision was a transconjunctival sclerocorneal incision at the superior, initially 2.4 mm wide. The lens nucleus was removed by the divide-and-conquer phacoemulsification technique[16] using the following settings: ultrasound power in conventional longitudinal mode, 35%; vacuum, 50 (sculpting program) -200 (nucleus program) mmHg; and irrigation bottle height, 75 cm using Stellaris device (Bausch & Lomb, Rochester, NY, USA). After inflating the capsular bag with Opegan High, a foldable intraocular lens (iSert Micro 255; Hoya Surgical Optics, Tokyo, Japan) was implanted. Both of these incisions were self-healing. The operation time was recorded. Postoperative management of the patients included 1% betamethasone sodium phosphate (Shionogi, Osaka, Japan) and 1.5% revofloxicin (Santen Pharmaceutical Co. Ltd) four times a day and 0.1% bromfenac sodium two times a day for 4 weeks.

Clinical Evaluation of Dry Eye

Compromised tear dynamics were determined by the Schirmer test or the BUT[17]. An abnormal ocular surface was identified by positive vital staining with fluorescein or lissamine green. Moreover, tear osmolarity (Tosm) was measured using the Tearlab® system (Tearlab, San Diego, CA)[18], and corneal sensitivity was measured using a Cochet-Bonnet aesthesiometer (Richmond Products, Albuquerque, NM)[19]. All assessments were done preoperatively and postoperatively at 1 and 4 weeks after the surgery.

Statistical Analysis

In this experiment, each result was calculated for each eye, not for each patient. The means and standard deviations (SDs) of these measurements were calculated for each group. Regarding the statistical analysis, Student-Newman-Keuls (SNK) methods was performed for a significant difference between factors in the case of a significant difference in repeated measures ANOVA (Excel; Microsoft, Tokyo, Japan). A p value of <0.05 was considered significant.

Table 1 Profiles of parameters

Charasteristic	Pre-ope	1W post ope	4W post ope
Tear function			
Break-up time (BUT)	4.6 ± 1.9	4.1 ± 2.0	4.6 ± 2.6
Schirmer test (SCH)	10.2 ± 7.0	9.0 ± 7.5	9.1 ± 5.9
Ocular surface condition			
Fluorescein score (FSS)	0.3 ± 0.8	0.5 ± 1.1	0.3 ± 0.8
Lissamine Green score (LSS)	0.3 ± 1.0	0.4 ± 0.9	0.3 ± 0.8
Tear osmolarity (Tosm)	286.4 ± 8.3	290.9 ± 10.0	289.0 ± 8.8
Corneal sensitivity (CS)	5.7 ± 0.5	5.5 ± 0.7	5.7 ± 0.5

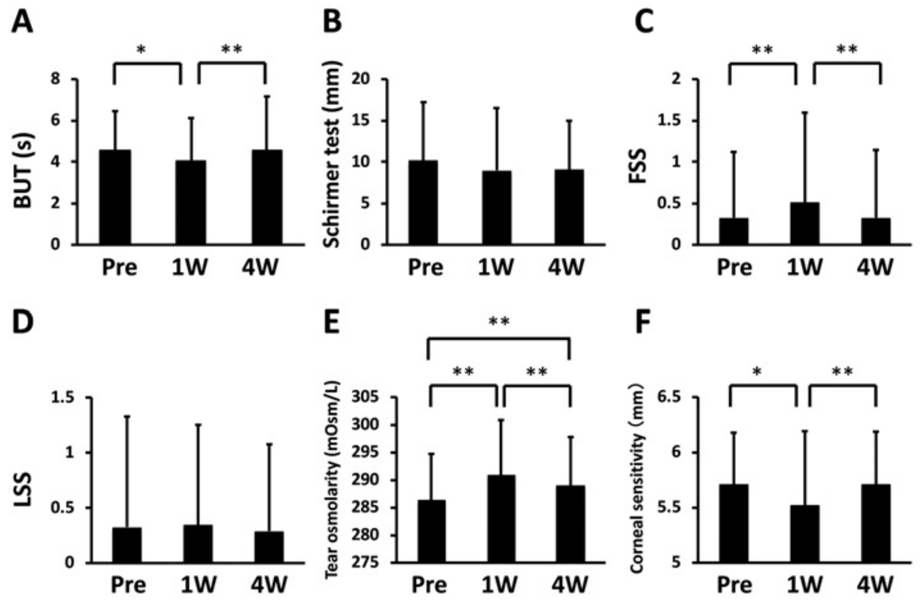

Fig. 1 Each parameter of dry eye (DE). All parameters are compared preoperatively, and at 1 and 4 weeks postoperatively. (A) Tear break-up time (BUT), (B) Schirmer test, (C) fluorescein staining score (FSS), (D) Lissamine green score (LSS), (E) Tear osmolarity, (F) Corneal sensitivity. (**p<0.01, *p<0.05)

Results

None of the operations had any complications. Operating time was 17.8±9.3 minutes. All assessment parameters were obtained preoperatively and at 1 and 4 weeks after the surgery (P1W and P4W) (**Table 1**). BUT was significantly decreased at P1W, and it recovered at P4W (**Fig. 1 A**). The Schirmer test did not change significantly (**Fig. 1 B**). The fluorescein staining score (FSS) increased significantly at P1W and recovered at P4W (**Fig. 1C**). The Lissamine green score (LSS) did not change significantly (**Fig. 1D**). Tear osmolarity increased significantly at P1W and did not recover at P4W (**Fig. 1E**). Corneal sensitivity decreased significantly at P1W and recovered at P4W (**Fig. 1F**).

Discussion

Previous reports of dry eye before and after cataract surgery stated that BUT and corneal sensitivity were most aggravated on the first day after surgery and improved to the same level as before surgery one month later[8,9]. On the Schirmer test, one study found that there was no significant difference between before and after surgery[8], and another study showed that the tear dynamics recovered within one month after surgery[9]. The present results showed similar trends to those previously reported. Tear osmolarity can be an objective examination for diagnosing dry eye[20–23]. There is a correlation between tear osmolarity above 316 mOsm/L and dry eye, and tear osmolarity was the only quantifiable factor in the DEWS report[24]. However, few have reported a high correlation between high tear osmolarity and dry eye. In our previous study, the tear osmolarity of dry eye was 288 mOsm/L, which was not different from that of normal people[18]. The present study focused on dry eye after cataract surgery and evaluated changes in tear osmolarity before and after cataract surgery. It was found that tear osmolarity increased significantly 1 week after surgery (p <0.01) and remained significantly elevated 4 weeks later compared to preoperatively (p <0.01) (**Fig. 1E**). Elksnis et al reported that tear osmolarity increased significantly at the first week after surgery, but it decreased to the preoperative level four weeks after surgery[25]. However, González-Mesa et al reported no differences in tear osmolarity between before and after the operation[26]. In this experiment, the reason why the tear osmolarity changed before and after the operation was not considered to be due to the change in tear volume, because no change was seen on the Schirmer test. It is thought that postoperative inflammation led to an increase in tear osmolarity.

BUT was examined as a parameter of tear film stability, but it decreased significantly 1 week after surgery (p <0.05) and returned to the same level as before surgery after 4 weeks (**Fig. 1A**).

The recovery period of postoperative corneal sensitivity ranges from 3 weeks to 9 months in LASIK[27,28] and 3 months for refractive keratotomy[28,29]. Microincision surgery such as phacoemulsification is considered less likely to cause a decrease in corneal sensitivity than refractive surgery or extracapsular cataract extraction[30]. In cataract surgery, the loss of corneal sensitivity depends on the size of the incision. Kohlhaas M et al reported that using a 7 mm incision, corneal sensitivity did not return after 12 months[31]. Khanal S et al reported that using a 4.1 mm incision, it did not return after 3 months[9]. Oh T et al reported that using a 2.8 mm incision, it returned after one month[8]. In our experiment, it returned after one month using a 2.4 mm incision. The decrease in corneal sensitivity after ocular surgery is thought to be due to the corneal incision size[32]. Since the corneal sensitivity of 2.8 mm incision decreased from 58.6 mm to 52.3 mm (89%) after 1 week and 2.4 mm incision decreased from 57.1 mm to 55.2 mm (96%) after 1 week, a smaller incision may have less effect on corneal sensitivity.

In the present study, there were temporary changes in dry eye-related examinations including tear osmolarity after cataract surgery. In particular, tear osmolarity increased significantly 4 weeks after surgery compared to preoperative levels, and it showed long-term changes, unlike other factors. The transient increase in tear osmolarity, an important factor for dry eye in the DEWS report, was confirmed by cataract surgery that caused dry eye.

Conflict of Interest: The authors declare no conflict of interest.

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