

Influence of Sodium Hyaluronate Concentration on Corneal Aberrations in Soft Contact Lens Wearers

Jong Soo Lee¹, Jong Moon Park², Hyun Kyung Cho², Su Jin Kim², Hyoun Do Huh², Young Min Park²

¹Department of Ophthalmology, Pusan National University Hospital, Pusan National University School of Medicine and Medical Research Institute, Yangsan, Korea

²Department of Ophthalmology, Gyeongsang National University Changwon Hospital, Gyeongsang National University School of Medicine, Changwon, Korea

Purpose: This study aimed to evaluate the influence of varying concentrations of sodium hyaluronate (SH) eye drops on corneal aberrations in normal individuals wearing silicone hydrogel contact lenses.

Methods: Normal individuals wearing silicone hydrogel contact lenses were enrolled in this study. Subjects were classified into two groups depending on the concentration of the preservative-free SH used (group 1, 0.1% SH; group 2, 0.3% SH). All subjects were asked to blink five times after instillation of the SH eye drop and before the Galilei measurements. Corneal aberrations were measured over the contact lenses before and after SH eye drop instillation. Visual acuity (VA) over the contact lenses was also measured both before instillation of the SH eye drop and after the subjects completed the five blinks.

Results: There was no change in VA after SH instillation in group 1; however, group 2's VA significantly deteriorated after SH instillation. Changes in VA after SH instillation compared to baseline were significantly higher in group 2 than in group 1. Similarly, the increase in corneal aberrations after SH instillation was significant in group 2 but not significant in group 1. Among the significantly increased corneal aberration parameters, defocus was the main type in group 2. Changes in corneal aberrations after SH instillation compared to baseline were significantly higher in group 2 than in group 1.

Conclusions: A 0.3%-concentration of SH increases corneal aberration and decreases VA in soft contact lens wearers. Defocus is the main type of aberration that increased in the 0.3% SH instillation group.

Key Words: Contact lenses, Hyaluronic acid, Visual acuity, Wavefront aberration

Contact lens-induced tear film abnormalities are a common reason for patients to discontinue use of their contact lenses [1].

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Corresponding Author: Young Min Park, MD, PhD. Department of Ophthalmology, Gyeongsang National University Changwon Hospital, Gyeongsang National University School of Medicine, #11 Samjeongja-ro, Seongsan-gu, Changwon 51472, Korea. Tel: 82-55-214-3851, Fax: 82-55-214-3257, E-mail: loveis293@naver.com

Approximately 50% of contact lens wearers experience symptoms of contact lens-induced tear film abnormality such as lacrimation, discomfort, dryness, burning, itching, blurry vision, and foggy vision [1-3]. Dryness and ocular symptoms are often relieved by application of ocular lubricants. Approximately 20% of lens wearers use ocular lubricants, and many practitioners opt for ocular lubricants as first-line treatment [4]. In addition, lubrication drop instillation is considered the most common strategy in the management of contact lens-induced

tear film abnormality [5-7].

Sodium hyaluronate (SH) is a glycosaminoglycan that consists of a naturally occurring linear biopolysaccharide with exceptional hygroscopic, lubricating, and viscoelastic properties [8]. SH eye drops are known to increase tear film stability, maintain corneal moisture, and reduce tear evaporation, which all promote increased healing time for the corneal epithelium [9-11]. When SH is classified according to concentration, a relatively increased number of high-order aberrations (HOAs) are observed after instillation of 0.3% SH eye drops [12].

This study aimed to evaluate the influence of various concentrations of SH eye drops on the corneal aberrations in normal individuals wearing silicone hydrogel contact lenses.

Materials and Methods

Study design and subjects

Normal fifty individuals wearing silicone hydrogel contact lenses (Acuvue Oasys, Vistakon; Division of Johnson & Johnson Vision Care, Jacksonville, FL, USA; 14-mm diameter, 8.4-mm base curve, and 0.070-mm central thickness) were enrolled in this study (Fig. 1). Subjects were included in this study if they were found to have a best-corrected visual acuity of 10 / 10, a healthy ocular surface,

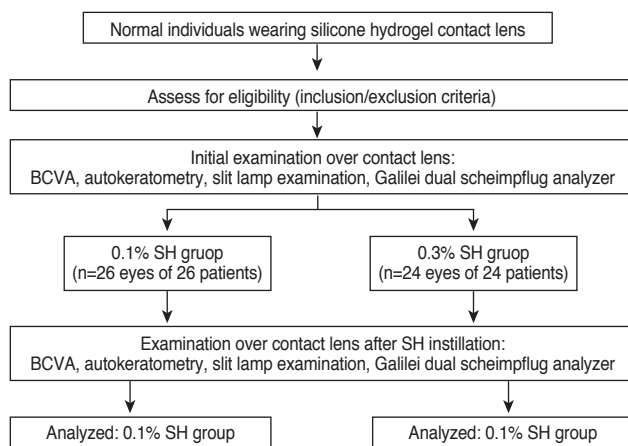


Fig. 1. Flow chart of the current study. Subjects wearing silicone hydrogel contact lenses were classified into two groups based on the concentration of preservative-free sodium hyaluronate (SH) used (group 1, 0.1% SH; group 2, 0.3% SH). Corneal aberrations were measured over the contact lenses before and after each SH eye drop instillation. BCVA = best-corrected visual acuity.

a keratometry range between 41 and 45 diopters (D), a maximum spherical refraction of 0.25 D (minus and plus), and a cylindrical refraction of 0.50 D (minus). Subjects with signs of microbial keratitis, including corneal stromal infiltration, purulent discharge, conjunctival and episcleral hyperemia, and anterior chamber reaction before or during lens wear were excluded from the study. Moreover, all subjects with a previous history of corneal refractive surgery, dry eye syndrome, or blepharitis were excluded from the study. We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research study.

Measurements over contact lenses

The right eyes of all contact lens wearers were initially examined by assessment of best-corrected visual acuity, autokeratometry, and slit-lamp examination, as well as measurement of corneal aberrations using the noninvasive Galilei Dual Scheimpflug Analyzer system (Ziemer, Port, Switzerland). The scanning process of the Galilei system acquires a series of Scheimpflug images and two Placido images, each 90 degrees apart. The Galilei system displays all corneal wavefront aberrations calculated from the front and back surfaces, while centered on the pupil. The following values were recorded with a 6.0-mm pupil: root-mean-square total, low-order aberrations, HOAs of the third to sixth orders, and spherical aberrations. Corneal aberrations were measured over the contact lenses before and after SH eye drop instillation. All measurements were performed with non-dilated pupils under identical lighting conditions.

Subjects wearing silicone hydrogel contact lenses were classified into two groups based on the concentration of the preservative-free SH used (group 1, 0.1% SH; group 2, 0.3% SH). All subjects were asked to blink five times after instillation of the SH eye drop and before the Galilei measurements, which were performed according to the manufacturer's guidelines. The device was brought into focus, and the patient's eye was aligned along the visual axis using a central fixation light. Visual acuity (VA) over the contact lenses after instillation of the SH eye drop was also measured after the subjects completed the five blinks.

Statistical analysis

All data are presented as mean ± standard deviation. The

differences between pre-instillation and post-instillation values were analyzed using the Wilcoxon signed-rank test. A p -value <0.05 was considered statistically significant. The Mann-Whitney U -test was used to compare the results between groups. All calculations were performed using SPSS ver. 12.0 (SPSS Inc., Chicago, IL, USA).

Results

The right eyes of 50 subjects wearing silicone hydrogel contact lenses (23 males and 27 females; mean age, 30 ± 5.7 years) were included in this study (group 1, 26 subjects; group 2, 24 subjects). VA measured over the contact lens before SH instillation was recorded as 0 ± 0 logarithm of the minimum angle of resolution (logMAR) in both groups. In group 1, there was no change in VA after SH instillation (0.03 ± 0.06 logMAR; Wilcoxon signed-rank test, $p > 0.05$). However, group 2 showed significantly deteriorated VA after SH instillation (0.08 ± 0.11 logMAR; Wilcoxon signed-rank test, $p = 0.04$). Changes in VA after SH instillation compared to baseline were significantly higher in group 2 than in group 1 (0.08 ± 0.06 , 0.03 ± 0.02 logMAR, respectively; Mann-Whitney U -test, $p = 0.03$).

Similarly, the increase in corneal aberrations after SH instillation was significant in group 2 but not in group 1 (Wilcoxon signed-rank test) (Fig. 2A, 2B). Among the significantly increased corneal aberration parameters, defocus was the main type in group 2 (Fig. 2, 3A, 3B). Unlike group 1, the defocus aberrations of group 2 increased significantly from 0.073 to $0.857 \mu\text{m}$ after SH instillation (Wilcoxon signed-rank test, $p = 0.04$) (Fig. 2). Changes in corneal aberrations after SH instillation compared to baseline were significantly higher in group 2 than in group 1 (Fig. 4).

Discussion

In order to reduce the symptoms of contact lens-induced tear film abnormalities, soft contact lens wearers commonly use lubricating eye drops [5-7]. Among lubricating eye drops, SH is a frequently used agent. Although a previous study on naked eyes showed that highly viscous SH drops resulted in significantly higher HOAs than did less viscous SH drops [12], no study has investigated the influence of SH concentration on corneal aberration or VA in contact

lens wearers.

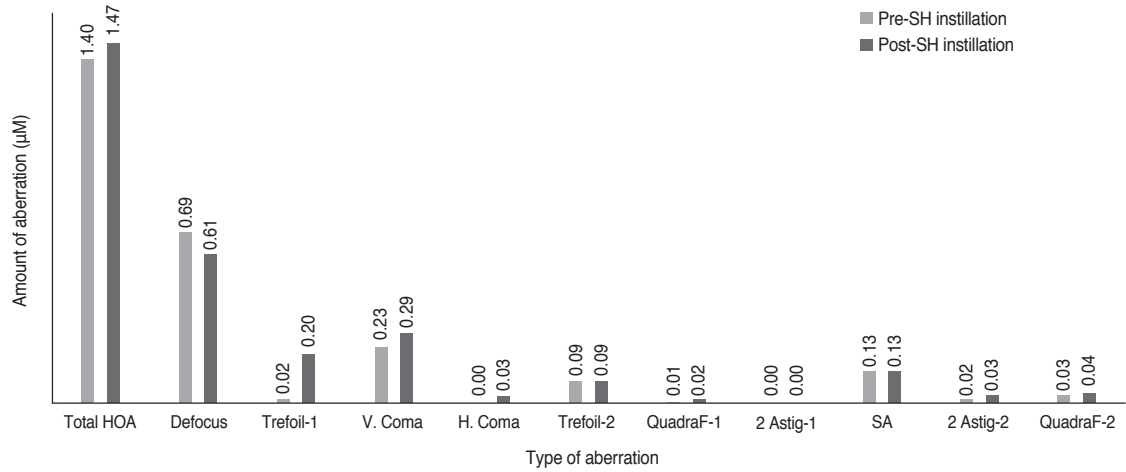
In the current study, 0.3% SH eye drops significantly deteriorated the VA of normal individuals wearing silicone hydrogel contact lenses, while 0.1% SH eye drops did not. In addition, significantly increased corneal aberration was observed only in the 0.3% SH instillation group, with a particular increase in defocus aberrations. Taken together, the results of the current study suggest that defocus might be the main cause of increased corneal aberrations and decreased VA in the 0.3% SH instillation group.

Defocus is a low-order aberration that encompasses both myopia (positive defocus) and hyperopia (negative defocus). In the current study, positive defocus was significantly induced in the 0.3% SH instillation group. There are two possible explanations for the increased defocus in this group. Given that a high concentration of SH is known to have a longer pre-corneal residence time [12,13], the pre-lens residence time of the 0.3% SH instillation group might have been longer than that of the 0.1% SH instillation group. Second, because 0.3% SH resides for a longer time on the ocular surface, there is a higher possibility of 0.3% SH infiltrating into the space between the posterior lens surface and the cornea during lens movement. Moreover, the fluid space between the lens and the cornea might move the lens anteriorly, resulting in the increased positive defocus aberration. The increase in positive defocus also explains the decreased distant VA of subjects in the 0.3% SH instillation group.

The interblink interval in normal eyes is reported to be 5.97 seconds [14]. After the instillation of SH, all subjects were asked to blink five times before the measurements were performed. This means that the increase in corneal aberration and decrease in VA can last for at least 24 seconds. In addition, this finding is consistent with the study by Koh et al. [12] on naked eyes. The limitations of the current study are the inability to measure the actual time until vision is restored and the time until aberrations improve. Future research will be conducted to investigate the actual precorneal residence time of 0.3% SH in contact lens wearers.

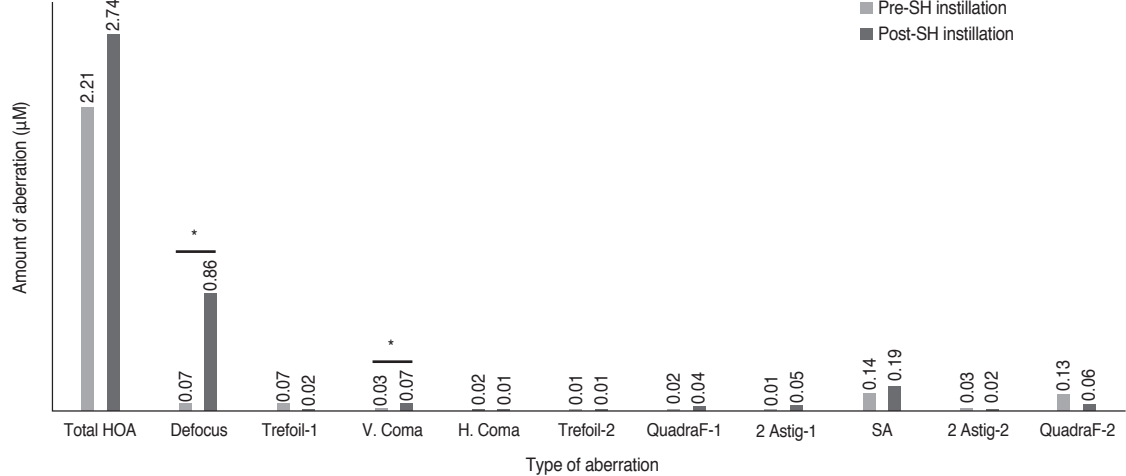
The current study shows that 0.3% SH increases corneal aberration and decreases VA in soft contact lens wearers. We think it is advisable to prescribe low-concentration SH to contact lens wearers engaged in occupations that require rapid reactions, such as vocational drivers.

A



	Total HOA	Defocus	Trefoil-1	V.Coma	H.Coma	Trefoil-2	QuadraF-1	2 Astig-1	SA	2 Astig-2	QuadraF-2
Pre-SH instillation	1.40 ± 0.45	0.69 ± 0.46	0.02 ± 0.35	0.23 ± 0.34	0.00 ± 0.35	0.09 ± 0.28	0.01 ± 0.17	0.00 ± 0.07	0.13 ± 0.05	0.02 ± 0.06	0.03 ± 0.14
Post-SH instillation	1.47 ± 0.35	0.61 ± 0.73	0.20 ± 0.39	0.29 ± 0.32	0.03 ± 0.13	0.09 ± 0.25	0.02 ± 0.08	0.00 ± 0.05	0.13 ± 0.11	0.03 ± 0.04	0.04 ± 0.16
p-value*	0.55	0.62	0.08	0.59	0.32	0.95	0.53	0.90	0.95	0.42	0.08

B



	Total HOA	Defocus	Trefoil-1	V.Coma	H.Coma	Trefoil-2	QuadraF-1	2 Astig-1	SA	2 Astig-2	QuadraF-2
Pre-SH instillation	2.21 ± 0.53	0.07 ± 0.95	0.07 ± 0.10	0.03 ± 0.15	0.02 ± 0.15	0.01 ± 0.19	0.02 ± 0.14	0.01 ± 0.07	0.14 ± 0.14	0.03 ± 0.11	0.13 ± 0.11
Post-SH instillation	2.74 ± 1.23	0.86 ± 1.60	0.02 ± 0.13	0.07 ± 0.28	0.01 ± 0.19	0.01 ± 0.19	0.04 ± 0.20	0.05 ± 0.14	0.19 ± 0.27	0.02 ± 0.12	0.06 ± 0.19
p-value*	0.03	0.04	0.06	0.00	0.21	0.99	0.16	0.06	0.41	0.67	0.09

Fig. 2. Comparison of corneal aberrations before and after sodium hyaluronate (SH) instillation in contact lens wearers. (A) 0.1% SH and (B) 0.3% SH. HOA = high-order aberration; SA = spherical aberration. *Wilcoxon signed-rank test.

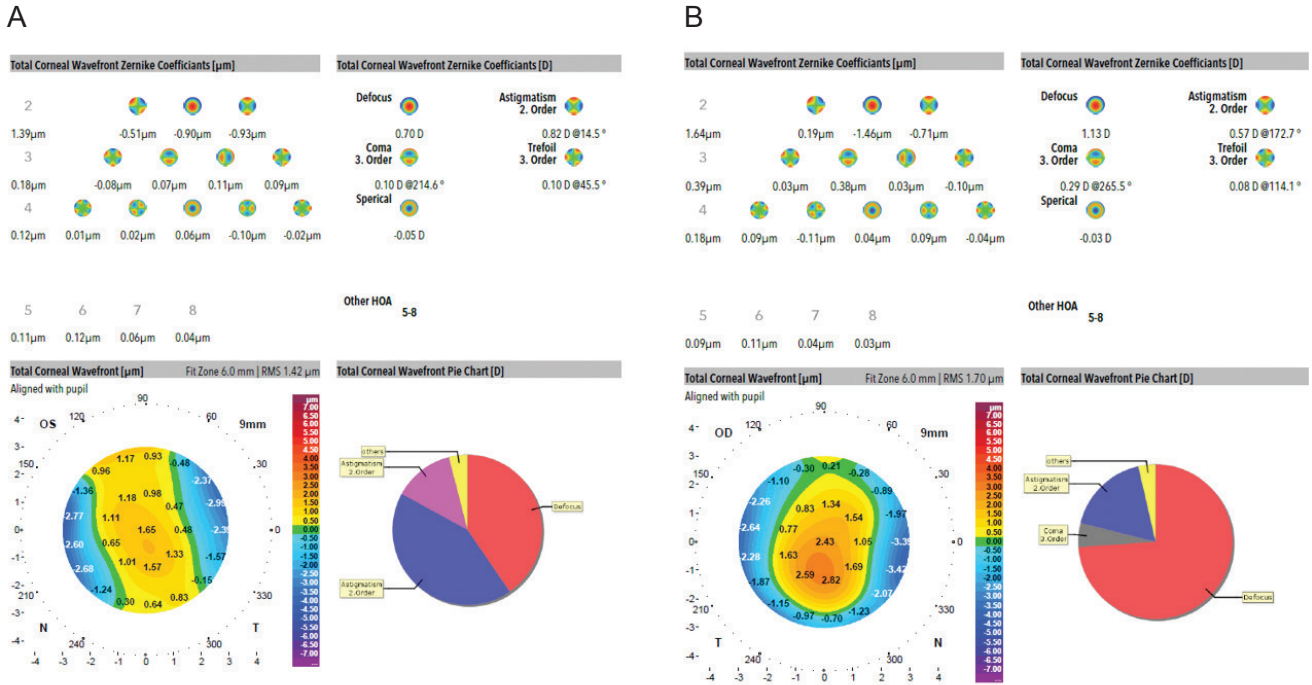
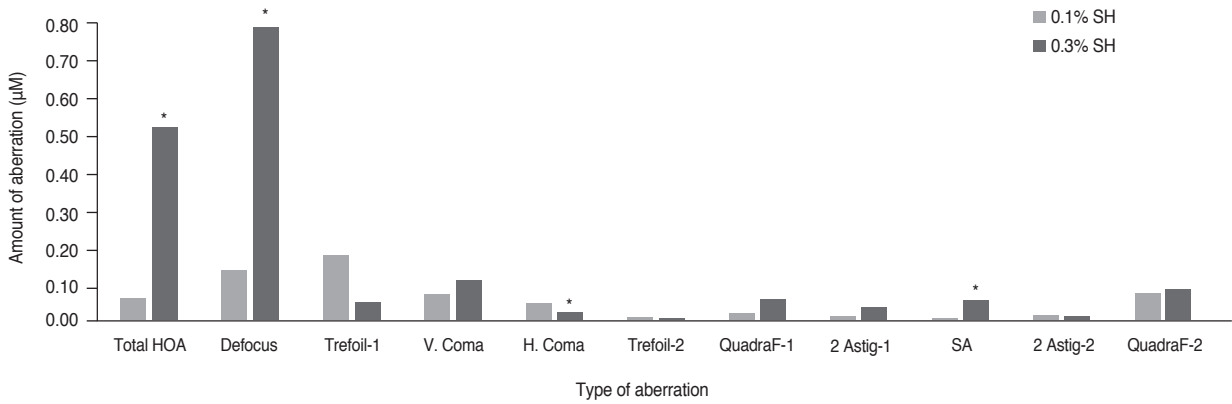


Fig. 3. Corneal aberration changes after 0.3% sodium hyaluronate (SH) instillation. (A) Before 0.3% SH instillation and (B) after 0.3% SH instillation. HOA = high-order aberration.



	Total HOA	Defocus	Trefoil-1	V.Coma	H.Coma	Trefoil-2	QuadraF-1	2 Astig-1	SA	2 Astig-2	QuadraF-2
0.3% SH	0.53 ± 1.11	0.78 ± 1.75	0.05 ± 0.12	0.11 ± 0.16	0.03 ± 0.10	0.00 ± 0.28	0.06 ± 0.19	0.04 ± 0.10	0.05 ± 0.29	0.01 ± 0.11	0.08 ± 0.21
0.1% SH	0.06 ± 0.53	0.13 ± 0.7	0.17 ± 0.50	0.07 ± 0.48	0.04 ± 0.17	0.00 ± 0.41	0.02 ± 0.15	0.00 ± 0.09	0.00 ± 0.09	0.01 ± 0.07	0.07 ± 0.18
p-value*	0.03	0.04	0.13	0.34	0.04	0.49	0.08	0.04	0.20	0.46	0.42

Fig. 4. Changes in corneal aberrations (Δ) after sodium hyaluronate (SH) instillation compared to baseline in contact lens wearers. HOA = high-order aberration; SA = spherical aberration. *Mann-Whitney *U*-test.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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