European Journal of Ophthalmology / Vol. 16 no. 6, 2006 / pp. 785-790

The effects of artificial tear application on contrast sensitivity in dry and normal eyes

T. AKIN[1], K. KARADAYI[1], U. AYKAN[2], I. CERTEL[1], A. HAMDI BILGE[1]

[1]Department of Ophthalmology, GATA Gulhane Military Medical Academy, Haydarpasa Training Hospital
[2]Department of Ophthalmology, Gumussuyu Military Hospital, Istanbul - Turkey

PURPOSE. *To investigate the effects of artificial tear application on contrast sensitivity in dry and normal eyes.*

METHODS. *A total of 55 patients with normal (10/10) corrected or uncorrected visual acuity referring to GATA Gulhane Military Medical Academy Haydarpasa Ophthalmology Outpatient Clinic were evaluated in regard to dry eye diagnostic criteria, and assigned into the dry eye group (Group 1; 35 patients) and the control group (Group 2; 20 patients). All patients were given a contrast sensitivity testing at low and high spatial frequencies using the gradual contrast sensitivity chart before and at 5 minutes after application of artificial tears, and the two groups were compared. Wilcoxon test was used in statistical analysis, accepting a p value of <0.05 as significant.*

RESULTS. *In the dry eye group, there was a statistically significant increase in contrast sensitivity scores both at low and high frequencies after application of artificial tears ($p<0.05$). In the control group, although there was a significant increase in low frequency scores after artificial tear application ($p< 0.05$), there was not a significant change in high frequency scores ($p>0.05$).*

CONCLUSIONS. *The decreased contrast sensitivity in dry eyes improves with application of artificial tears. Therefore, the impeded quality of vision seen in dry eye patients could be restored closer to normal with artificial tear therapy. Besides, contrast sensitivity testing could be used in the follow-up of artificial tear therapy. (Eur J Ophthalmol 2006; 16: 785-90)*

KEY WORDS. *Artificial tear, Contrast sensitivity, Dry eye*

Accepted: May 23, 2006

INTRODUCTION

Dry eye syndrome is a relatively common chronic ophthalmologic disease which develops as a result of negative changes in the tear film in quality and quantity due to decrease in tear production or increased evaporation (1-3). The incidence of dry eye syndrome is reported to vary between 5.7% and 33.7% in different populations and to increase with age (4-6). The complaints are sensation of a foreign body in the eye, sensation of burning and dryness, photophobia, sensation of heaviness of the eyelids, increase in these complaints during reading or activities that need concentration, watering, pain and sensitivity to wind, air condition, cigarette smoke, dust, and closed environments. Another complaint decreasing daily patient comfort is disturbance in the quality of vision.

The disturbed visual quality of a dry eye patient cannot be corrected adequately using optical devices such as glasses. The initial treatment following the diagnosis of dry eye is the prescription of artificial tears, which relieves the complaints of the patients and eradicates most of the symptoms, of which the decrease in the quality of vision comes in first place. The effect of artificial tears on correcting the quality of vision depends on the fact that it eliminates the irregularities on the corneal surface that develop in consequence to dry eye and provides a smooth

 1120-6721/785-06$15.00/0

Fig. 1 - *The contrast sensitivity scale with the trademark Gradual (Opsia®, France).*

Fig. 2 - *The contrast sensitivity scale with the trademark Gradual (Opsia®, France) in a dark examination room.*

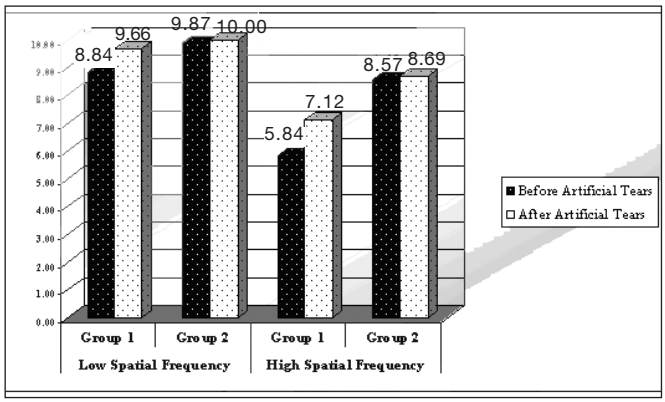

Fig. 3 - *Comparison of contrast sensitivity values at high and low spatial frequencies before and after the application of artificial tears.*

tear film and therefore it provides a better optical refraction on the corneal surface (7, 8). Many patients on artificial tear therapy are satisfied with the improvement in visual quality in varying degrees and report this to the physician. This visual improvement is not always detectable with standard clinical tests.

The world of functional vision is composed of objects that have different sizes and contrasts. The human visual system requires different amounts of contrasts in order to detect patterns with various spatial frequencies. Contrast sensitivity is defined as the ability to detect the presence of minimal luminance differences between objects or areas (9). It is something entirely different than visual acuity that we can measure with a standard eye chart. Contrast is quantitatively defined as the ratio of the difference in luminance between the object and background and the total luminance (9, 10).

The term functional vision describes the impact of sight on quality of life. Recognizing faces and facial expressions, reading a newspaper, driving at night, performing vocational tasks, and participating in recreational pursuits all bear a relation to functional vision for ophthalmic patients. Multiple scientific studies have demonstrated that contrast sensitivity represents a robust indicator of functional vision (11). Contrast sensitivity tests provide sensitive detection in changes in visual quality under different luminescence conditions. Because the traditional visual accuracy tests show only the smallest spatial details of the stimuli with high contrast, they are insufficient in detecting the ability of the visual system to recognize and differentiate objects with different sizes and contrasts.

In the present study, we aimed to detect the effects of application of artificial tears on visual quality by using contrast sensitivity tests.

METHODS

A total of 55 subjects referred to GATA Gulhane Military Medical Academy Haydarpasa Training Hospital Outpatient Clinic were included in the study. Thirty-five were dry eye cases (Group 1) and 20 were healthy volunteers (Group 2). All participants had a visual acuity of 10/10 by Snellen chart with or without correction. The dry eye subjects all had dry eye symptoms, and were included in the dry eye group according to the diagnostic criteria for dry eye syndrome (1, 2). The diagnostic criteria for dry eye syndrome were the presence of dry eye symptoms (sensation of dryness, grittiness, burning, foreign body sensation and itching, redness, photophobia, and temporarily blurred or unstable vision) and three pathologic results in the diagnostic tests for dry eye. These diagnostic tests that we routinely use in our clinic were fluorescein breakup time (shorter than 10 seconds was regarded as patho-

logic), Schirmer I test (less than 10 mm in 5 minutes was regarded as pathologic), tear meniscus height (TMH), and debris were evaluated. An absence of meniscus or a decreased TMH, which is an indirect indicator of decreased tear volume and increased tear film debris, which is an indirect sign of decreased tear circulation, was considered as a sign of dry eye (12, 13). The TMH was measured using the variable beam height (narrow straight vertical beam at 0.2–1.0 mm) at the slit lamp biomicroscope (Topcon SL-D7, Topcon Co., Japan) as the distance from the edge of the lower lid margin to the top of the tear meniscus (14-16). Various literature sources indicate a normal TMH to be between 0.2 and 0.5 mm (16-19). In this study, a cut-point of less than or equal to 0.2 mm was considered to be an abnormal TMH.

In the control group (Group 2), all subjects had a Schirmer I result that was longer than 10 mm in 5 minutes, fluorescein break-up time over 10 seconds, TMH more than 0.2 mm, and they were free from any dry eye symptoms. None of the participants had history of contact lens wear or any use of eyedrops. Subjects with a spherical refraction over 5 diopters (D) and/or an astigmatic refraction over 2 D and subjects with any corneal opacity were excluded.

A contrast sensitivity scale Gradual (Opsia®, France) was used for contrast sensitivity measurements (Fig. 1). This scale is 55x110 cm and is placed 140 cm above the floor. The letters are in 10 columns with decreasing contrast from left to right (the letters in the first column have the highest contrast whereas the letters at the tenth column have the lowest) and 11 rows with decreasing sizes from top to bottom (the letter at the top is equivalent to the Snellen letter that corresponds to 0.05 visual acuity and the letter in the bottom is equivalent to the Snellen letter that corresponds to 1.0 visual acuity) and they are classified into three groups according to their spatial frequencies:

1. Low spatial frequency: The letters up to 0.2 Snellen row
2. Moderate spatial frequency: The letters between 0.3 and 0.6 Snellen rows
3. High spatial frequency: The letters between 0.7 and 1.0 Snellen rows

The screen of the scale had three brightness options: low light level (low photopic level; 5cd/m^2), moderate light level (mesopic photopic level; 85 cd/m^2), and high light level (high photopic level; 700 cd/m^2). The low photopic level corresponds to the twilight, the moderate light level corresponds to the light level in cloudy weather or a normally lighted room, and high photopic level corresponds to the automotive headlights or bright sunlight.

The subjects were positioned 3 meters away from the scale with the test eye open and the other eye covered, and were evaluated under moderate light level (mesopic photopic level) of 85 cd/m^2. This test mechanism was placed in a room with an enlightening equal to a dark examination room (approximately 1.4 log cd/m^2) and this condition was provided in all measurements (Fig. 2). The subjects from both groups were asked to read the letter sequences that correspond to the spatial frequency which would be tested. The test was continued until the last letter that a subject could read; this letter was marked on the score paper and the numerical value which corresponds to that letter was evaluated as the contrast sensitivity value for that eye. The contrast sensitivity scores for the right eyes of all subjects from the dry eye and control groups at low and high spatial frequencies were measured before and 5 minutes after the application of preservative-free artificial tear drops containing 2% polyvinylpyrrolidone (Protagent® SE, Alcon-Couvreur, Puurs, Belgium).

Wilcoxon test was used for the comparison of contrast sensitivity scores before and after the drops and a p value lower than 0.05 was accepted as significant.

RESULTS

The mean age of subjects in the dry eye group (Group1) was 57.9±9.5 (between 38 and 79 years); the mean age of subjects in the control group (Group 2) was 54.1±7.9 (43–66 years). Sixteen subjects were male (45.7%) and 19 were female (54.3%) in Group 1 whereas 9 were male (45%) and 11 were female (55%) in Group 2.

The average contrast sensitivity scores in low spatial frequency before the application of artificial tear drops in Group 1 and Group 2 were 8.84±1.00 and 9.87±0.33, respectively. The average contrast sensitivity scores at low spatial frequency at the fifth minute following the application of artificial tear drops at Group 1 and Group 2 were 9.66±0.59 (p=0.006) and 10 (highest score) (p=0.046) (Fig. 3).

The average contrast sensitivity scores in high spatial frequency before the application of artificial tear drops in Group 1 and Group 2 were 5.84±1.82 and 8.57±0.56, respectively. The average contrast sensitivity scores at high spatial frequency at the fifth minute following the application of artificial tear drops at Group 1 and Group 2 were

observed to be 7.12±1.31 ($p<0.001$) and 8.69±0.63 ($p=0.43$), respectively (Fig. 3).

The statistical analysis revealed that in the dry eye group, the contrast sensitivity scores at both high and low spatial frequencies were significantly higher after the application of artificial tear drops ($p<0.05$). In the control group, the scores at low spatial frequency were significantly higher ($p<0.05$) whereas the scores at high spatial frequency revealed no significant differences ($p>0.05$).

When the differences in contrast sensitivity scores in the dry eye group and the control group before and 5 minutes after the application of artificial tear drops were compared, a score increase of 0.82±0.41 and 1.28±0.51 was observed in the dry eye group at low and high spatial frequencies, respectively. The increase in scores in the control group was 0.13±0.33 and 0.12±0.07 at low and high spatial frequencies, respectively. The statistical analysis of these findings showed that the increases in contrast sensitivity scores were significantly higher in the dry eye group at both frequencies compared to those of normal controls ($p<0.05$).

DISCUSSION

The advanced forms of dry eye including keratoconjunctivitis sicca or punctuate epithelial keratopathy are known to reduce visual acuity (20). Although the mild and moderate forms of dry eye are more common, their effects on the quality of vision are not well-known (21).

Visual quality may be improved in patients with dry eye by restoring the contrast sensitivity to normal with the aid of artificial tear drops. Huang et al reported that contrast sensitivity values increased significantly in subjects with punctuate epithelial keratopathy following the administration of artificial tear drops whereas significant differences were detected only at low spatial contrast sensitivity values in subjects without epitheliopathy (10). In our study, there was no significant difference at the high spatial frequencies with or without preservative-free artificial tear drops containing 2% polyvinylpyrrolidone (Protagent® SE, Alcon-Couvreur, Puurs, Belgium) in the healthy control group whereas the difference between low spatial frequencies was significant. Rolando et al evaluated the contrast sensitivity tests comparatively in patients with keratoconjunctivitis sicca and in healthy subjects using Vistech Multivision Contrast Tester 8000 equipment at low spatial frequency and found that the contrast sensitivities of patients with keratoconjuctivitis sicca were 35–70% lower than those of normal controls and the contrast sensitivity values increased in all patients with keratoconjunctivitis sicca following artificial tear therapy (22). Similarly, Rieger detected in his study that contrast sensitivity was significantly enhanced in patients with keratoconjunctivitis sicca after artificial tear therapy (20). In our study, the contrast sensitivity values in dry eye patients were found to increase significantly both at low and high spatial frequencies following the application of preservative-free 2% polyvinylpyrrolidone artificial tear drops (Protagent® SE) ($p<0.05$). Although a significant increase in contrast sensitivity values was detected in the control group at low spatial frequency after application of artificial tears ($p<0.05$), there was no significant increase in high spatial frequency values ($p>0.05$).

Tutt et al defined a 20–40% increase in the contrast sensitivity scores of dry eye patients after the application of artificial tears in their studies (23). In our study the rate of increase was found to be about 15%. In another study, patients who developed dry eye symptoms after laser in situ keratomileusis (LASIK) and thus required intensive artificial tear therapy benefited from punctum obstruction as the amount of tear increased. The authors found a 20% decrease in corneal aberrations, and this improvement was also shown to have positive effects on contrast sensitivity tests (8). Applegate et al showed that corneal irregularity due to keratoconus, refractive surgery, and pterygium excision reduced visual performance and contrast sensitivity in all spatial frequencies especially in cases with wide pupils (low light conditions) (24). Because tear deficiency decreases the regularity of the anterior corneal surface, low light conditions that cause dilation of the pupils affect the contrast sensitivities of these patients at a higher rate than high and moderate light conditions. Ridder et al reported that tear layer breakup caused a decrease in contrast sensitivity and visual acuity (25, 26). They also reported that contrast sensitivity and visual performance increased in silicone-hydrogel contact lens wearers with dry eye syndrome after the use of low-viscosity artificial tear drops (25). The improvement in contrast sensitivity may be the result of tear stabilization. Wavefront analysis has demonstrated an increase in higher-order aberrations for patients with dry eye compared with normal subjects (27). These aberrations decrease after the instillation of artificial tears (7).

No difference in visual acuity was detected in our study because only the subjects with normal visual acuity with

or without correction were included in the study. The contrast sensitivity values increased after the application of preservative-free 2% polyvinylpyrrolidone (Protagent® SE) both in the dry eye and control groups. The increase at both frequencies was statistically significant in the dry eye group whereas only the scores at low spatial frequency increased significantly in the control group. When the increase in contrast sensitivity values in the two groups was compared, the increase was found to be significantly higher in the dry eye group at both frequencies according to the control group ($p<0.05$).

In conclusion, decreased contrast sensitivity can be enhanced by the application of artificial tear drops, therefore the disturbed visual quality in cases with dry eye syndrome may be increased by artificial tear application that increases and normalizes the contrast sensitivity. Also, measurements of contrast sensitivity may be used for the follow-up of the efficiency of artificial tear therapy in patients with dry eye syndrome.

The authors have no commercial or proprietary interest in the materials used in this study.

Reprint requests to:
Tugrul Akin, MD
Tibbiye cad. GATA Lojmanlari E-Blok Daire:9
Uskudar
34668 Istanbul, Turkey
akintugrul@yahoo.com

REFERENCES

1. Lemp MA. Report of the National Eye Institute/Industry Workshop on Clinical Trials in Dry Eyes. CLAO J 1995; 21: 221-32.
2. Tu EY, Rheinstorm S. Dry eye. In: Yanoff M, Duker JS, eds. Clinical Ophthalmology. St. Louis, MO: Mosby, 2004; 520-6.
3. Johnson ME, Murphy PJ. Changes in the tear film and ocular surface from dry eye syndrome. Prog Retin Eye Res 2004; 23: 449-74.
4. Schaumberg DA, Sullivan DA, Buring JE, Dana MR. Prevalence of dry eye syndrome among US women. Am J Ophthalmol 2003; 136: 318-26.
5. Schein OD, Munoz B, Tielsch JM, Bandeen-Roche K, West S. Prevalence of dry eye among the elderly. Am J Ophthalmol 1997; 124: 723-8.
6. Lin P-Y, Tsai S-Y, Cheng C-Y, Liu J-H, Chou P, Hsu W-M. Prevalence of dry eye among an elderly Chinese population in Taiwan. Ophthalmology 2003; 110: 1096-101.
7. Montes-Mico R, Caliz A, Alio JL. Changes in ocular aberrations after instillation of artificial tears in dry-eye patients. J Cataract Refract Surg 2004; 30: 1649-52.
8. Huang B, Mirza MA, Qazi MA, Pepose JS. The effect of punctal occlusion on wavefront aberrations in dry eye patients after laser in situ keratomileusis. Am J Ophthalmol 2004; 137: 52-61.
9. Amesbury EC, Schallhorn SC. Contrast sensitivity and limits of vision. Int Ophthalmol Clin 2003; 43: 31-42.
10. Huang FC, Tseng SH, Shih MS, Chen FK. Effect of artificial tears on corneal surface regularity, contrast sensitivity and glare disability in dry eyes. Ophthalmology 2002; 109: 1934-40.
11. Packer M, Fine IH, Hoffman RS. Functional vision, contrast sensitivity, and optical aberrations. Int Ophthalmol Clin 2003; 43: 1-3.
12. Lemp MA. Diagnosis and the treatment of tear deficiencies. In: Tasman W, Jaeger EA, eds. Duane's Ophthalmology CD-ROM. Vol. 4, Chapter 14. Philadelphia, PA: Lippincott Williams & Wilkins, 2002.
13. Karadayi K, Ciftci F, Akin T, Bilge AH. Increase in central corneal thickness in dry and normal eyes with application of artificial tears: a new diagnostic and follow-up criterion for dry eye. Ophthalmol Physiol Opt 2005; 25: 485-91.
14. Doughty MJ, Laiquzzaman M, Oblak E, Button N. The tear (lacrimal) meniscus height in human eyes: a useful clinical measure or an unusable variable sign? Cont Lens Anterior Eye 2002; 25: 57-65.
15. Lamberts DW, Foster CS, Perry HD. Schirmer test after topical anesthesia and the tear meniscus height in normal eyes. Arch Ophthalmol 1979; 97: 1082-5.
16. Oguz H, Yokoi N, Kinoshita S. The height and radius of

the tear meniscus and methods for examining these parameters. Cornea 2000; 19: 497-500.
17. Mainstone JC, Bruce AS, Golding TR. Tear meniscus measurement in the diagnosis of dry eye. Curr Eye Res 1996; 15: 653-61.
18. Miller WL, Doughty MJ, Narayanan S, et al. A comparison of tear volume (by tear meniscus height and phenol red thread test) and tear fluid osmolality measures in non-lens wearers and in contact lens wearers. Eye Contact Lens 2004; 30: 132-7.
19. Marquardt R. Diagnostic tests in the evaluation of the tear film. Klin Monatsbl Augenheilkd 1986; 189: 87-91.
20. Rieger G. Contrast sensitivity in patients with keratoconjunctivitis sicca before and after artificial tear application. Graefes Arch Clin Exp Ophthalmol 1993; 231: 577-9.
21. Goto E, Yogi Y, Matsumoto Y, Tsubota K. Impaired functional visual acuity of dry eye patients. Am J Ophthalmol 2002; 133: 181-6.
22. Rolando M, Iester M, Macri A, Calabria G. Low spatial-contrast sensitivity in dry eyes. Cornea 1998; 17: 376-9.
23. Tutt R, Bradley A, Begley C, Thibos LN. Optical and visual impact of tear break-up in human eyes. Invest Ophthalmol Vis Sci 2000; 41: 4117-23.
24. Applegate RA, Hilmantel G, Howland HC, Tu EY, Starck T, Zayac EJ. Corneal first surface optical aberrations and visual performance. J Cataract Refract Surg 2000; 16: 507-14.
25. Ridder WH 3rd, Tomlinson A, Paugh J. Effect of artificial tears on visual performance in subjects with dry eye. Optom Vis Sci 2005; 82: 835-42.
26. Ridder WH 3rd, Lamotte JO, Ngo L, Fermin J. Short-term effects of artificial tears on visual performance in normal subjects. Optom Vis Sci 2005; 82: 370-7.
27. Montes-Mico R, Caliz A, Alio JL. Wavefront analysis of higher order aberrations in dry eye patients. J Cataract Refract Surg 2004; 20: 243-7.