European Journal of Ophthalmology / Vol. 17 no. 1, 2007 / pp. 1-6

Dry eye after LASIK for myopia: Incidence and risk factors

M.R. SHOJA, M.R. BESHARATI

Department of Ophthalmology, Shahid Sadoughi University of Medical Science, Yazd - Iran

PURPOSE. *Patients frequently experience dry eye symptoms after laser-assisted* in situ *keratomileusis (LASIK). The purpose of this study was to determine the incidence and risk factors of dry eye after myopic LASIK.*

METHODS. *In this retrospective case series 190 eyes that underwent LASIK were examined for a dry eye syndrome. All patents were asymptomatic for dry eyes before surgery. Assessments included subjective complaints of dry eye, tear break-up time (TBUT), corneal staining, corneal sensitivity test, and Schirmer I test. All values were compared before and at 1 week and 1.3 and 6 months after surgery.*

RESULTS. *For the 190 eyes, chronic dry eye persisting 6 months or more after LASIK was diagnosed in 20 percent of the eyes. Mean patient age was 31 ± 8 years. The risk for chronic dry eye was significantly associated with higher attempted refractive correction, greater ablation depth, and female sex ($p=0.001$). Subjective score for dryness was increased after LASIK. The greatest change from preoperative levels for all parameters was noted at 1 week. There were obvious decreases in TBUT and Schirmer value at 1, 3, and 6 months postoperatively relative to preoperative level ($p<0.05$). The Schirmer I test result was higher at 1 day but without statistical significance ($p>0.05$), but lower at 1 week and 3 and 6 months ($p<0.05$) after LASIK. Corneal sensitivity was decreased at 1 month and 3 months, and returned to the preoperative level at 6 months after LASIK. There was a statistically significant effect of age, sex, and mean spherical equivalent refraction on corneal sensitivity ($p<0.001$).*

CONCLUSIONS. *Patients undergoing LASIK for myopia develop dry eye with compromised tear function at least 6 months after surgery. Women and patients requiring higher refractive correction have an increased risk for developing dry eye. (Eur J Ophthalmol 2007; 17: 1-6)*

KEY WORDS. *LASIK, Dry eye, Myopia*

Accepted: July 17, 2006

INTRODUCTION

Laser-assisted *in situ* keratomileusis (LASIK) is a popular surgical procedure for correction of myopia, with more than 1 million patients undergoing this procedure in the United States each year (1, 2). The visual outcome of this surgery is excellent, with more than 90% of patients achieving 20/25 or better visual acuity without glasses (3, 4).

LASIK is considered a safe and effective procedure to correct low to moderately high (up to 10 diopters) myopia. Refractive stability is generally achieved 1 to 3 months after LASIK.

Recent studies highlight that LASIK can cause sus-

 1120-6721/001-06$15.00/0

tained dysfunction of the integrated ocular surface in lacrimal gland functional unit, resulting in chronic dry eye.

In a 2001 survey of members of the American Society of Cataract and Refractive Surgeons, the most common complication of LASIK was dry eye (5, 6).

Dry eye is considered by refractive surgeons to be among the most common complications of LASIK surgery (7). Cutting a LASIK flap and performing a stromal ablation disrupts the corneal innervations and produces a relative loss of corneal sensation for up to 6 months after surgery (8-10). This loss of corneal sensation appears to be a significant contributing factor to the reduction in tear secretion, tear film stability, tear clearance, blink rate, and conjunctival goblet cell density, and the increase in tear osmolarity and punctate epitheliopathy of the post LASIK eye (11, 12).

In patients with dry eye before LASIK, in long-term contact lenses wearers, and in those having deeper surgical ablations and superior hinged flaps, the return of corneal sensation to levels observed before surgery appears to take longer than 6 months and is associated with more persistent dry eye signs and symptoms (13-15).

Recent studies have suggested that dry eye is more prevalent in Asian populations than in white patients (16). Several studies report an association between refractive regression and dry eye symptoms (17).

The purpose of our study was to investigate the incidence of dry eye in patients undergoing myopic LASIK. A secondary objective of this study was to determine the significant risk factors for developing dry eye in these patients.

METHODS

The study was a retrospective analysis of 190 eyes that had LASIK for correction of low to moderate myopia at the Excimer Laser Center, Yazd, Iran, between September 2002 and December 2005.

Eligibility criteria included myopia in the range of –2.00 to 10.00 diopters (D), no immune or metabolic disease, no intraocular disease or previous ocular surgery, not pregnant or lactating, stable refraction for at least 12 months prior to LASIK, and no signs or symptoms of dry eye.

All LASIK was performed by one surgeon (S.M.R.) with Bausch and Lomb Excimer Laser (Technolos). An 8.5 or 9.5 mm diameter suction ring and a 160 mm microkeratome head were used for all patients. An optical zone of 5.5 to 6.5 mm and a transition zone of 7.5 mm was used. After surgery all eyes received chloramphenicol 0.5% and betamethasone 0.1% four times daily for 1 week, then tapering over 1 month.

Assessments

The following assessments were performed in each patient at the 2-week and 1-, 3-, and 6-month follow-up visits.

1. Tear film break up time (TBUT), a parameter of tear film stability, was measured by fluorescein dye under slit-lamp microscopy.
2. Schirmer I test, a measure of reflex tear secretion, was performed without anesthesia. This test was performed by placing Schirmer strips over the lower lid margin; the strip wetting was measured and recorded in millimeters.
3. Corneal fluorescein staining evaluation on a scale of 0 to 5 was performed as recommended by Lemp (18).
4. Central corneal sensation was examined.
5. Dry eye symptoms patients were classified as having dry eye disease if they reported experiencing one or more of the primary symptoms (soreness, scratchiness, dryness, grittiness, burning) often or constantly, the TBUT value was less than 10 seconds, and they had a fluorescein corneal staining score of greater than 3/5, and in Schirmer test I there is less than 10 mm wetting of filter paper for a period of 6 months or more after surgery.

The 6-month cut-off point was chosen because at 6 months, the majority of studies indicate that dry eye symptoms, tear film stability, ocular surface staining, tear, volume tear secretion, and corneal sensation have returned to preoperative levels.

The primary outcome evaluated was the incidence of dry eye defined as a corneal fluorescein staining score ≥3 at any postoperative evaluation time. Visual acuity was also evaluated.

Statistical analysis

Parametric tests were used to analyze refractive data. Other ocular variables were analyzed using nonparametric tests because of the non-normal distribution of the data. Comparisons between groups and between variables were made using the Pearson chi square test for categorical data and the analysis of variance for continuous data. Differences were considered significant when $p<0.05$.

RESULTS

All 190 patients who completed the 6-month follow-up were included in this analysis. Mean patient age was 31±8 years (range 20–49 years).

Sixty percent (114/190) of patients were female. The mean spherical equivalent refraction was –6.50±2.6 D. Mean ablation depths for all patients was 68±25 µm (minimum 18; maximum 172). Following surgery 20% (38/190) of patients were affected by chronic dry eye. Of these patients 25 (63.7%) were women (Tab. I).

The greatest change from preoperative levels for all parameters was noted at 1 week. Prevalence of dry eye symptoms was significantly increased at months 1, 3, and 6 after surgery compared to preoperative value.

There were obvious decreases in BUT at 1 week, 1, 3, and 6 months postoperatively relative to the preoperative level ($p<0.05$).

Tear film stability and volume were significantly reduced at all times after surgery.

Compared with non dry eye patients, tear secretion was significantly reduced at 1, 3, and 6 months after LASIK in dry eye patients (Tab. II).

The Schirmer I test result was higher at 1 day but without statistical significance ($p>0.05$), but lower at 1 week and 3 months ($p<0.05$) after LASIK.

Basic secretion value (8.41±7.21) decreased at 1 month (6.70±3.44 mm; $p=0.05$) and at 3 months (544±632; $p=0.07$).

Ocular surface fluorescein staining was greater in post LASIK dry eye patients. Corneal sensitivity was significantly decreased immediately after surgery and returned to preoperative levels by 6 months ($p<0.0001$). There was a statistically significant effect of age, sex, and mean spherical equivalent refraction on corneal sensitivity ($p<0.0001$).

Risk factors for dry eye

Patients developing dry eye after LASIK were significantly more likely to be female, and older in comparison with non dry eye patients. The dry eye group had a significantly higher attempted refractive correction and a greater ablation depth.

DISCUSSION

Dry eye syndrome is the most frequent complication after LASIK. It is usually benign, but may cause significant visual impairment in rare cases (19). Dry eye may result in decreased optical quality of the cornea, but is transient, lasting up to 1 year (20, 21). The cause mainly involves decreased corneal sensation, resulting in decreased feedback to the lacrimal gland and reduced tear production

TABLE I - CHARACTERISTICS OF PATIENTS WITH AND WITHOUT DRY EYE BEFORE AND AFTER LASIK SURGERY

Preoperative	**Dry eye (n=38, 20%)**	**No dry eye (n=152, 80%)**	**p value**
Mean age, y, ± SD	35.19±8	31.22±6	<0.001
Female, n (%)	114 (60)	76 (40)	0.34
Preop spherical equivalent, mean ± SD	–6.50±1.71	–5.4±2.31	0.01
Ablation depth, mean ± SD	79±22	72±18	0.04

LASIK = Laser-assisted *in situ* keratomileusis

TABLE II - COMPARISON OF OCULAR SURFACE VARIABLES AND TEAR FILM IN PATIENTS WITH AND WITHOUT DRY EYE

Variable	**Dry eye (n=38)**	**No dry eye (n=152)**	**p value**
TBUT	4.0±3	9±4	0.02
Schirmer I test (mm)	14±8.76	22.35±11.56	0.002
Corneal fluorescein staining score	1.85±0.50	0.5±0.3	NS
Corneal sensitivity	6.3±1.2	9.1±1.1	NS

Values are mean ± SD.

TBUT = Tear break-up time; NS = Not significant at the 5% level

(19-21). Other causes may include increased evaporation, inflammation, or toxicity of medications (20, 22).

Dry eye may result infrequently in impaired wound healing and decreased optical quality of the cornea, but it is transient, lasting from a few weeks up to 1 year.

The greatest changes in mean tear film stability and corneal fluorescein staining were observed at 1 week after surgery (23).

To our knowledge, this is the first study that evaluates the complication of dry eye after LASIK in this center.

The unique aspect of this study was to determine the incidence of dry eye over the 6-month postoperative observation. This study shows that dry eye after LASIK is more severe and sustained in our country as Asian, compared to white patients (16).

In our study chronic dry eye persisting 6 months or more after LASIK was diagnosed in 20%, in agreement with the Albietz et al (16) study in Asian patients and in contrast with previous studies (24, 25) with rates of 6% and 8.5% respectively. This higher likelihood of chronic post-LASIK dry eye in Asian groups (Iran) is due to more females, more contact lens wears, and lower preoperative tear volume in this group compared to white patients. All of these factors result in delayed recovery of corneal sensation to preoperative levels (9, 10, 26).

As in our study, previous findings demonstrated deeper stromal ablation result in a slower return of corneal sensation to levels observed before surgery (7, 8, 26).

The increased risk of dry eye accompanying increased ablation depth and flap thickness could certainly be explained by the effects of these factors on the corneal sensory nerves.

Other risk factors for dry eye were the preoperative level of myopia and sex. Smith's study (27) found no sex-related differences in development of dry eye after LASIK, in contrast with our study. The increased risk of dry eye accompanying ablation depth may be because the effects of dry eye symptoms and diagnosed dry eye in the general population appears to be greater in Asian countries than in other countries. Dry eye prevalence in Japanese patients presenting to an ophthalmology clinic was 17% (28); Australian and Danish studies gave dry eye prevalence of 11% and 8%, respectively (29, 30).

The prevalence of dry eye symptoms occurring often or constantly was 34% in 1361 elderly Taiwanese residents (31) and 15% in 2420 elderly US residents (32).

Our findings suggest that LASIK carriers a considerable risk for developing dry eye that may persist in one-quarter of patients to at least 6 months after surgery.

Based on current evidence, LASIK should be approached cautiously in patients with pre-exiting dry eye and associated contact lens intolerance. Patients with chronic dry eye symptoms after surgery also have less satisfaction with LASIK (33).

Recently, a significant correlation between female sex and the occurrence of corneal punctuate epitheliopathy after LASIK was reported (Mayo GL, Strack T. LASIK-induced neurotrophic keratopathy (LINK): incidence and associated risk factors. Presented as a poster at the annual meeting of the Association for Research in Vision and Ophthalmology; Ft. Lauderdale, Florida; May 2002). These results highlight the strong influence of hormone levels on the ocular surface/lacrimal gland function unit (26).

Consistent with our results, other studies show that a delay in the return of corneal sensation to the level achieved before surgery can be associated with dry eye before LASIK, high refraction correction, and deeper ablation (34, 35). The return of corneal sensation to levels observed before surgery appears to take up to 12 months.

Further clinical studies will be required to identify strategies for preventing or minimizing the severity and duration of the post-LASIK loss of corneal sensation.

While dry eye is now recognized as a common complication of LASIK, chronic dry eye after LASIK for myopia increases the risk for refractive regression (36, 37). Intensive ocular surface management may be the preferred initial management strategy in eyes with chronic dry eye and regression. Our study found an increase incidence of dry eye in women. Several studies have reported no gender relative reference (38-40).

The major limitation of our study was small sample size.

CONCLUSIONS

Dry eye occurs commonly after LASIK surgery in patients with no history of dry eye. The risk of developing dry eye is correlated with the degree of preoperative myopia and the depth of laser treatment. Patients should be counseled about the risk of developing dry eye after LASIK, particularly those with high myopia. Use of artificial tears in the early postoperative period may help to prevent symptoms and ocular surface damage.

Proprietary interest: None.

Reprint requests to:
Mohammad Reza Shoja, MD
Shaheed Beheshty Post Office
PO Box 583
Yazd, Iran
shoja99@yahoo.com

REFERENCES

1. Solomon KD, Holzer MP, Sandoval HP. Refractive surgery survey 2001. J Cataract Refract Surg 2002; 28: 346-55.
2. Duffey RJ, Leaming D. US trends in refractive surgery: 2002 ISRS survey. J Refract Surg 2003; 19: 357-63.
3. Solomon KD, Holzer MP, Sandoval HP, et al. Refractive Surgery Survey 2001. J Cataract Refract Surg 2002; 28: 346-55.
4. Yo C. Asian Americans: myopia and refractive surgery. Int Ophthalmol Clin 2003; 43: 173-87.
5. Lee AJ, Lee J, Saw SM, et al. Prevalence and risk factors associated with dry eye symptoms: a population based study in Indonesia. Br J Ophthalmol 2002; 86: 1347-51.
6. Toda I, Asano-Kato N, Komai-Hori Y, Tsubota K. Dry eye after laser in situ keratomileusis. Am J Ophthalmol 2001; 132: 1-7.
7. Lee JB, Ryu CH, Kim J, Kim EK, Kim HB. Comparison of tear secretion and tear film instability after photorefractive keratectomy and laser in situ keratomileusis. J Cataract Refract Surg 2000; 26: 1326-31.
8. Linna TU, Vesaluoma MH, Perez-Santonja JJ, Petroll WM, Alio JL, Tervo TM. Effect of myopic LASIK on corneal sensitivity and morphology of subbasal nerves. Invest Ophthalmol Vis Sci 2000; 41: 393-7.
9. Benitez-del-Castillo JM, del Rio T, Iradier T, Hernandez JL, Castillo A, Garcia-Sanchez J. Decrease in tear secretion and corneal sensitivity after laser in situ keratomileusis. Cornea 2001; 20: 30-2.
10. Nassaralla BA, McLeod SD, Nassaralla JJ Jr. Effect of myopic LASIK on human corneal sensitivity. Ophthalmology 2003; 110: 497-502.
11. Tsubota K, Dartt DA, Sullivan RM, Bromberg BB, eds. Lacrimal Gland Tear Film and Dry Eye Syndromes. New York, NY: Kluwer Academic/Plenum Publishers; 2002: 711-26.
12. Lui MM, Silas MA, Fugishima H. Complications of photorefractive keratectomy and laser in situ keratomileusis. J Refract Surg 2003; 19: S247-9.
13. Lin PY, Tsai SY, Cheng CY, Liu JH, Chou P, Hsu WM. Prevalence of dry eye among an elderly Chinese population in Taiwan: the Shihpai Eye Study. Ophthalmology 2003; 110: 1096-101.
14. Battat L, Macri A, Dursun D, Pflugfelder SC. Effects of laser in situ keratomileusis on tear production clearance, and the ocular surface. Ophthalmology 2001; 108: 1230-5.
15. Schaumberg DA, Sullivan DA, Buring JE, Dana MR. Prevalence of dry eye syndrome among US women. Am J Ophthalmol 2003; 136: 318-26.
16. Albietz JM, Lenton LM, McLennan SG. Dry eye after LASIK: Comparison of outcomes for Asian and Caucasian eyes. Clin Exp Optom 2005; 88: 89-96.
17. Albietz JM, Lenton LM. Chronic dry eye and regression in myopic LASIK. J Cataract Refract Surg 2004; 30: 675-84.
18. Lemp MA. Report on the National Eye Institute/industry Workshop on clinical Trials in Dry Eye. CLAO, 1995; 21: 221-32.
19. Toda I, Asano-Kato N, Komai-Hori Y, Tsubota K. Dry eye after laser in situ keratomileusis. Am J Ophthalmol 2001; 132: 1-7.
20. Ang RT, Dartt DA, Tsubota K. Dry eye after refractive surgery. Curr Opin Ophthalmol 2001; 12: 318-22.
21. de Paiva CS, Chen Z, Koch DD, et al. The incidence and risk factors for developing dry eye after myopic LASIK. Am J Ophthalmol 2006; 141: 438-45.
22. Lenton LM, Albietz JM. The effect of carmellose-based artificial tears on the ocular surface. J Refract Surg 1999; 15 (Suppl): S227-31.
23. Battar L, Marci A, Dursun D, Pflugfelder SC. Effect of laser in situ keratomileusis on tear production, clearance, and the ocular surface. Ophthhalmology 2001; 108:1230-5.
24. Stonecipher KG. Dry eyes and refractive surgery. J Cataract Refract Surg 1996; 22:1130.
25. Hovanesian JA, Shah SS, Maloney RK. Symptoms of dry eye and recurrent erosion syndrome after refractive surgery. J Cataract Refract Surg 2001; 27: 577-84.
26. Sullivan DA, krenzer KL, Sullivan BD, et al. Decrease in tear secretion and corneal sensitivity after laser in situ keratomileusis. Cornea 2001; 20: 30-2.
27. Smith JA, Vitale S, Reed GF, et al. Dry eye signs and symptoms in women with premature ovarian failure. Arch Ophthalmol 2004;122: 151-6.
28. Hikichi T, Yoshida A, Fukui Y, et al. Prevalence of dry eye in Japanese eye centres. Graefes Arch Clin Exp Ophthalmol 1995; 233: 555-8.
29. Albietz JM. Prevalence of dry eye subtypes in clinical optometry practice. Optom Vis Sci 2000; 77: 357-63.
30. Bjerrum KB. Keratoconjunctivitis sicca and primary Sjögren's syndrome in a Danish population aged 30–60 years. Acta Ophthalmol Scand 1997; 75: 281-6.
31. Lin PY, Tsai SY, Cheng CY, Liu JH, Chou P, Hsu WM. Prevalence of dry eye among an elderly Chinese population in Taiwan: the Shihpai Eye Study. Ophthalmology 2003; 110: 1096-101.

32. Schein OD, Munoz B, Tielsch JM, Bandeen-Roche K, West S. Prevalence of dry eye among the elderly. Am J Ophthalmol 1997; 124: 73-88.
33. Miller AE, McCulley JP, Bowman RW, Cavanagh HD, Wang XH. Patients satisfaction after LASIK for myopia. CLAO J 2001; 27: 84-8.
34. Schaumberg DA, Sullivan DA, Buring JE, Dana MR. Prevalence of dry eye syndrome among US women. Am J Ophthalmol 2003; 136: 318-26.
35. Sakamoto R, Bennett ES, Henry VA, et al. The phenol red thread tear test: a cross-cultural study. Invest Ophthalmol Vis Sci 1997; 34: 3510-4.
36. Lenton LM, Albietz JM. The effect of carmellose-based artificial tears on the ocular surface. J Refract Surg 1999; 15: S227-31.
37. Bernardino CR, Rubin PAD. Asian Americans: cultural and anatomical considerations for periocular surgery. Int Ophthalmol Clin 2003; 43: 151-71.
38. De Paiva CS, Chen Z, Koch DD, et al. The incidence and risk factors for developing dry eye after myopic LASIK. Am J Ophthalmol 2006; 141: 438-45.
39. Yo C. Asian Americans: Myopia and refractive surgery. Int Ophthalmol Clin 2003, Fall; 43: 173-87.
40. Wilson SE. Laser *in situ* keratomileusis induced (presumed) neurotrophic epitheliopathy. Ophthalmology 2001; 108: 1082-7.