

## Dry eye after LASIK: Comparison of outcomes for Asian and Caucasian eyes

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**Background:** Dry eye is a common complication of LASIK surgery. Our clinical impression was that post-LASIK dry eye was more problematic for our Asian patients. The aim of this study was to determine if dry eye after LASIK is more prevalent, more sustained and more severe in Asian eyes compared with Caucasian eyes.

**Methods:** This study was based on a retrospective analysis of a clinical database. Data (n = 932 eyes, 932 patients) was collected before and after (week 2 and months 1, 3 and 6) LASIK surgery. Patients were defined as Asian if both parents were of East Asian ethnic origin. Assessments included dry eye symptoms, ocular surface staining, tear volume, tear secretion, tear film stability and corneal sensation.

**Results:** Asian eyes had greater ocular surface staining, poorer tear film stability and lower tear volume before LASIK and at all times after LASIK. Dry eye symptoms occurring 'often or constantly' were more prevalent at all time points after LASIK in Asian eyes. Chronic dry eye persisting six months or more after LASIK was diagnosed in 28 per cent of Asian eyes and 5 per cent of Caucasian eyes ( $p < 0.001$ ). Asian patients with chronic dry eye were predominantly female, reported dry eye symptoms, had greater ocular surface staining and lower tear secretion, stability and volume before surgery. After LASIK, Asian eyes had a slower return to pre-operative values for ocular surface staining, tear volume and corneal sensation.

**Discussion:** The risk of chronic dry eye after LASIK was significantly higher in Asian eyes. Contributing factors could include racial differences in eyelid and orbital anatomy, tear film parameters and blinking dynamics and higher attempted refractive corrections in Asian eyes.

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Dry eye preventing safe and comfortable contact lens wear is a major motivating factor for patients considering refractive surgery.<sup>1</sup> Dry eye is considered by refractive surgeons to be the most common complication of LASIK surgery.<sup>2</sup> Cutting a LASIK flap and performing a stromal ablation disrupts the corneal innervation and produces a relative loss of corneal sensation

for up to six months after surgery.<sup>3,6</sup> 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, conjunctival goblet cell density and the increase in tear osmolarity and punctate epitheliopathy of the post LASIK eye.<sup>4,6-11</sup> In patients with dry eye before LASIK,<sup>11</sup> in long-term contact

lenses wearers<sup>4,9</sup> and in those having deeper surgical ablations<sup>5</sup> and superior hinged flaps,<sup>6</sup> the return of corneal sensation to levels observed before surgery appears to take longer than six months and is associated with more persistent dry eye signs and symptoms.<sup>4,6,9</sup>

Recent studies<sup>12-14</sup> have suggested that dry eye is more prevalent in Asian

populations than in Caucasians. Clinically, we had formed the impression that sustained dry eye after LASIK was more common in our Asian patients. This observation was of concern to us as the prevalence of myopia is much higher in Asians than in Caucasians<sup>15,16</sup> and appears to be increasing in urbanised Asian communities.<sup>17</sup> LASIK continues to be the dominant refractive surgery procedure for myopia,<sup>18</sup> therefore it is likely that increasing numbers of myopic Asians will seek refractive surgery. In this study, we analysed our clinical patient database to compare Asian and Caucasian patients after LASIK. The aims of the analysis were to determine if dry eye after LASIK is more prevalent, more severe and more sustained in Asian eyes.

## METHODS

The study was a retrospective analysis of 932 patients who underwent LASIK for correction of myopia and myopic astigmatism at Excimer Laser Vision Centre, Brisbane, Australia, between August 1998 and December 2002. Our database tracks surgical outcomes for all myopic LASIK procedures and contained a total of 1,886 LASIK procedures, of which 1,846 were primary LASIK procedures on 1,026 patients. Of these, 932 patients met the inclusion criteria and had complete data for at least one eye for 12 months. Data analysis was based on these 932 patients. In patients who had surgery on both eyes, only the right eye data were analysed, provided the data were complete and the inclusion criteria were met. All patients received a detailed explanation of the procedures involved in the study and provided written informed consent. The Queensland University of Technology Human Research Ethics Committee provided written approval of the study protocol.

The eligibility criteria used in the study were:

- no autoimmune disease, metabolic disease or uncontrolled systemic disease
- no active disease of the external eye or adnexae
- no intraocular disease
- no degenerative or neurotrophic corneal disease

- no pre-operative or post-operative use of topical medications other than those prescribed
- no previous ocular surgery or trauma
- not pregnant or breastfeeding
- stable refraction for at least 12 months prior to LASIK
- stable keratometry and pachymetry following cessation of contact lens wear
- no lenticular opacities identified before or after surgery that were deemed to have a significant effect on the refractive outcome
- compliance with prescribed tear film and ocular surface management before and after surgery.

Patients were defined as Asian if one or both parents were of East Asian ethnic origin (for example, Chinese, Japanese, Thai, Filipino, Vietnamese, Korean, Taiwanese, Singaporean, Malaysian). To avoid complicating the analysis, we excluded patients who had partial Asian ancestry. We also excluded patients of Indian Asian ancestry.

Pretreatment of the tear film and ocular surface was performed on indication where specific tear film and ocular surface problems were identified before LASIK. Pre-treatment measures included:

1. Non-preserved artificial tears, gels or ointments; non-preserved steroid (prednisolone sodium phosphate 0.5 per cent or 1 per cent hydrocortisone ointment) for ocular surface inflammation and/or eyelid margin inflammation.
2. Silicone punctal plugs (Flexplug, Eagle Vision, Memphis USA) for tear deficiency, where artificial lubricants alone were insufficient.
3. Lid hygiene procedures for eyelid disease.

All LASIK procedures were performed by one experienced LASIK surgeon (LL) using a surgeon-adjusted ablation nomogram. The lamellar flaps were created using the automatic corneal shaper (Chiron Vision, Irvine, USA) and the excimer laser (Nidek EC-5000, Nidek, Gamagori, Japan) performed the stromal ablations. The flaps were 8.5 mm wide and 130 µm thick with an optic zone of 5.5 to 6.5 mm and a transition zone of 7.5 mm. After surgery, all eyes received a standard treatment of non-preserved chloramphenicol 0.5 per cent

(Chauvin Pharmaceuticals, Essex, UK) four times per day for three days and fluorometholone acetate 0.1 per cent (Flucon, Alcon Laboratories, Fort Worth USA) four times per day, tapering one drop per week over one month. All patients were instructed to use non-preserved artificial tears (Cellufresh [sodium carboxymethylcellulose 0.5 per cent in lactate buffer, non-preserved, Allergan, Irvine USA] and/or Bion Tears [hydroxypropyl methylcellulose 0.3 per cent, Dextran 70 0.1 per cent in bicarbonate buffer, Alcon Laboratories, Fort Worth USA]) at least every two hours for the first month after surgery and then at least four times per day for the 12 months after surgery.

Patients were also instructed to use sodium carboxymethylcellulose 1.0 per cent in lactate buffer, non-preserved (Celluvisc, Allergan, Irvine USA) for at least one week after LASIK as a night-time lubricant and, if long-term night-time lubrication was required, then Celluvisc or carbomer gel, non-preserved (Polygel, Alcon Laboratories, Fort Worth USA) or paraffin plus lanolin, non-preserved ointment (Polyvisc, Alcon Laboratories, Fort Worth USA) were prescribed. Silicone punctal plugs were inserted in the inferior puncta of tear deficient eyes non-responsive to the lubricant therapy described above.

## Assessments

The following assessments were performed on each patient before surgery and at two weeks, and one, three and six months post-LASIK with the results recorded in the clinical database:

1. **Fluorescein break-up time (FBUT)**: a measure of tear film stability, was performed using the method described by Cho and Brown.<sup>19</sup>
2. **Schirmer I test** (Colorbar, Eagle Vision, Memphis USA): a measure of reflex tear secretion was performed without anaesthetic using standard methods.<sup>20</sup> The Schirmer test was not performed at week 2 to avoid interference with flap healing.
3. **Phenol red thread tear test (PRT)** (Zone Quick Menicon Co Ltd, Nagoya Japan): a measure of tear secretion, volume and turnover was performed using the methods previously described.<sup>21</sup>

Nationality	Number of subjects (n = 54 total)
Chinese	25
Vietnamese	7
South Korean	6
Indonesian	5
Japanese	4
Taiwanese	2
Singaporean	2
Malaysian	2
Filippino	1

**Table 1. Nationality of ancestry in Asian patient group**

4. **Ocular surface staining:** fluorescein ocular surface staining was graded by the Oxford grading scheme on a scale of zero to five using methods previously described.<sup>22</sup>

5. **Corneal sensation:** central corneal sensation was measured using the Cochet-Bonnet aesthesiometer (Luneau Ophthalmologie, Charters, France).<sup>23</sup>

6. **Dry eye symptoms:** dry eye symptoms were assessed using the McMonnies Dry Eye Symptom Survey, a validated dry eye symptom survey.<sup>24</sup> Patients were classified as having dry eye symptoms (either before or after surgery) if they reported experiencing one or more of the primary symptoms in the survey (soreness, scratchiness, dryness, grittiness, burning) occurring often or constantly.

7. **Refractive outcome:** defined as the difference between the spherical equivalent refraction and the target spherical equivalent refraction.

Patients were questioned on their history of contact lens wear. Patients were classified as contact lens wearers before surgery, if they wore lenses on a regular basis (minimum average wearing time of 30 hours per week) and had worn contact lenses for at least the past year. Occasional or intermittent contact lens wearers were regarded as non-contact lens wearers for the purpose of this study.

In accordance with standard criteria,<sup>20</sup>

patients were diagnosed as having dry eye before or after surgery, if they experienced one or more of the McMonnies dry eye primary symptoms occurring 'often' or 'constantly', their FBUT was less than 10 seconds and they had a fluorescein corneal staining score of one or more. Patients were diagnosed as having chronic dry eye if they had dry eye (according to the definition above) for a period of six months or more after surgery. The six-month cut-off point was chosen because at six months, the majority of studies indicate that dry eye parameters such as dry eye symptoms,<sup>8</sup> tear film stability,<sup>8,10</sup> ocular surface staining,<sup>8,9</sup> tear volume,<sup>8</sup> tear secretion<sup>9,10</sup> and corneal sensation<sup>3-6</sup> have returned to pre-operative levels.

#### Statistical analysis

Parametric tests were used to analyse refractive data. Other ocular variables were analysed using non-parametric 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 ANOVA or the Kruskal-Wallis ANOVA tests for continuous data. Differences were considered significant when  $p < 0.05$ .

## RESULT

#### Overall patient demographics

For the 932 patients, the mean spherical equivalent refraction was  $-4.6 \pm 2.8$  D (sphere  $-3.78 \pm 2.19$  D [minimum  $-1.00$ ; maximum  $-16.50$ ], cylinder  $-0.68 \pm 0.91$  D [minimum  $0.00$ ; maximum  $-6.50$ ]). Mean ablation depth for all patients was  $59 \pm 27$   $\mu$ m (minimum 15; maximum 161).

Mean patient age was  $36 \pm 9$  years (minimum 18; maximum 65) and 56 per cent (522/932) of patients were female. Before LASIK surgery five per cent (47/932) of the patients were diagnosed with dry eye and a further 16 per cent (151/932) reported dry eye symptoms but did not have significant dry eye signs. Following surgery, seven per cent (65/932) of patients were affected by chronic dry eye.

#### Comparison of patient characteristics: Asian and Caucasian groups

Asian patients comprised six per cent (54/932) of patients. Chinese patients formed 46 per cent of the Asian group. The breakdown of nationalities of the Asian patients is given in Table 1. Patient characteristics for Asian and Caucasian patients are presented in Table 2. The Asian group had significantly more females, higher attempted refractive corrections and greater total ablation depths compared to the Caucasian group. There were significantly more contact lens wearers in the Asian group. The percentage of subjects diagnosed with dry eye before surgery and the percentage receiving pretreatment was not significantly different between the groups.

#### Comparison of intra-operative and post-operative complications and refractive outcomes: Asian and Caucasian groups

There were no significant differences between Asian and Caucasian eyes with respect to intra-operative and post-operative complications (Table 3). The difference between the spherical equivalent of refraction and the target refractive outcome was not significantly different between Asian and Caucasian eyes at any time after surgery.

#### Comparison of chronic dry eye prevalence after LASIK

Asians eyes had a higher prevalence of chronic dry eye after LASIK (28 per cent [15/54] compared with five per cent [41/878] for Caucasian eyes, [ $p < 0.001$ ]). Asian patients with chronic dry eye were predominantly female, reported dry eye symptoms, had greater ocular surface staining and poorer tear secretion, tear film stability and tear volumes before surgery (Table 4).

#### Comparison of dry eye outcomes in Asian and Caucasian groups matched for surgical ablation depth

To eliminate bias in the results due to the Asian patients having a greater pre-operative myopic correction and therefore greater total ablation depth compared to

the Caucasians, we examined a subgroup of patients where the Asian (n = 48) and Caucasian (n = 407) patients were matched for surgical ablation depth. The subject demographics of this subgroup are given in Table 5. With this adjustment for refractive ablation, the prevalence of chronic dry eye was 25 per cent (12/48) in Asian eyes and seven per cent (29/407) in Caucasian eyes. Comparisons of the prevalence of dry eye symptoms and of tear film and ocular surface parameters before and after surgery for the surgical ablation depth matched Asian and Caucasian groups are given in Table 6.

Before LASIK, there were no significant differences in the percentages of patients in the Asian and Caucasian groups reporting dry eye symptoms often or constantly. Dry eye symptoms were significantly more prevalent in Asian eyes at all times after surgery. Tear film stability and volume were significantly reduced before surgery and at all times after surgery in Asian eyes. Ocular surface fluorescein staining was greater in Asian eyes before surgery and at all times after surgery. Compared with Caucasian eyes, tear secretion was significantly reduced at one month and three months after surgery in the Asian group. Central corneal sensation was significantly reduced in Asian eyes at three and six months compared with Caucasian eyes.

Asian eyes had a slower recovery to pre-operative values for some of the pre-operative dry eye parameters (Table 6). In Asian eyes, dry eye symptoms were more prevalent compared to pre-operative values at all times after surgery. In Caucasian eyes, the prevalence of dry eye symptoms was significantly increased at months 1, 3 and 6 after surgery compared to pre-operative values. Ocular surface staining was significantly increased at all times after surgery in Asian eyes but increased only at week 2 after surgery in Caucasian eyes. The PRT test was significantly reduced from pre-operative values at week 2 in Caucasian eyes and week 2, month 1 and month 3 in Asian eyes. Corneal sensation recovered to pre-operative levels by month 6 in Caucasian eyes whereas in the Asian group the recovery of corneal sensation did not occur until month 12.

Variable	Asian n = 54 (6%)	Caucasian n = 878 (94%)	p value*
Age ± SD (years)	34 ± 8	36 ± 9	NS§
% Female	73	55	p = 0.006
Attempted spherical equivalent correction ± SD (D)	-5.32 ± 2.28	-4.00 ± 2.23	p < 0.001
Attempted spherical correction ± SD (D)	-5.21 ± 2.23	-3.60 ± 2.26	p < 0.01
Attempted cylinder correction ± SD (D)	-0.77 ± 0.73	-0.89 ± 0.95	NS
Ablation depth ± SD (µm)	76 ± 29	58 ± 26	p < 0.001
Mean pre-op keratometry ± SD (D)	44.69 ± 1.68	44.60 ± 1.93	NS
% Contact lens wear pre-op	95	78	p = 0.002
% Soft lens wearers	92	94	NS
Length of time wearing contact lens ± SD (years)	11 ± 9	11 ± 8	NS
% Diagnosed with dry eye	28	25	NS
% Receiving pre-treatment	37	30	NS

\* Based on a comparison between Asian and Caucasian groups  
 § NS = not significant at the 5% level

**Table 2. Comparison of pre-operative demographics and tear film and ocular surface variables in Asian and Caucasian eyes (all subjects included)**

Variable	Asian n = 54	Caucasian n = 878	p value*
Incomplete flap	0	1 (0.1%) <sup>†</sup>	NS§
Intra-operative epithelial defect	2 (3.6%)	31 (3.5%)	NS
Complete flap	0	1 (0.1%)	NS
Interface inflammation (grade 1-2)	6 (10.7%)	90 (10.3%)	NS
Interface inflammation (grade 3-4)	0	11 (1.3%)	NS
Epithelial ingrowth	0	10 (1.1%)	NS
Loss of best corrected acuity of ≥ 1 line	0	1 (0.1%)	NS

\* Based on a comparison between Asian and Caucasian groups  
 † Number of subjects experiencing the complication  
 § NS = not significant at the 5% level

**Table 3. Comparison of inter-operative and post-operative complications in Asian and Caucasian eyes**

## DISCUSSION

To our knowledge, this is the first study that directly compares LASIK outcomes in Asian and Caucasian eyes. This study has demonstrated that Asian patients have a significantly increased risk of experienc-

ing chronic dry eye after LASIK. It also suggests that the dry eye after LASIK is more severe and more sustained in Asian compared to Caucasian patients. These findings are due, at least in part, to Asian eyes having higher myopic corrections and therefore requiring greater refractive

Pre-operative variable	Asian patients with chronic dry eye n = 15 (28%)	Asian patients no chronic dry eye n = 39 (72%)	p value*
% Female	87	68	p = 0.05
Age ± SD (years)	33 ± 9	34 ± 8	NS <sup>§</sup>
Pre-operative spherical equivalent of refraction ± SD (D)	-5.59 ± 1.81	-5.78 ± 2.38	NS
Total ablation depth ± SD (µm)	75 ± 26	80 ± 30	NS
% Contact lens wear	88	95	NS
Duration of contact lens wear ± SD (years)	11 ± 8	13 ± 8	NS
% Dry eye symptoms	38	11	p = 0.002
Schirmer 1 test ± SD (mm/5 mins)	8 ± 4	16 ± 8	p = 0.01
PRT test ± SD (mm/15 s)	15 ± 8	18 ± 7	p = 0.02
FBUT ± SD (s)	4 ± 3	7 ± 3	p = 0.04
Corneal sensation ± SD (mm)	5.3 ± 1.3	5.6 ± 1.1	NS
Staining score ± SD	1.3 ± 2.5	0.1 ± 0.3	p = 0.002

\* Based on a comparison between Asian patients with and without chronic dry eye  
 § NS = not significant at the 5% level

**Table 4. Association of chronic dry eye after LASIK in Asian eyes with pre-operative variables**

Pre-operative variable	Asian n = 48	Caucasian n = 407	p value*
% Female	74	60	p = 0.04
Age ± SD (years)	35 ± 8	36 ± 9	NS <sup>§</sup>
Pre-operative spherical equivalent of refraction ± SD (D)	-5.62 ± 2.25	-5.66 ± 2.07	NS
Total ablation depth ± S (mm)	77 ± 29	78 ± 21	NS
% Contact lens wear	90	89	NS
Length of time in contact lens wear ± SD (years)	11 ± 7	12 ± 9	NS
% Diagnosed with dry eye	27%	22%	NS

\* Based on a comparison between Asian and Caucasian groups  
 § NS = not significant at the 5% level

**Table 5. Patient demographics of ablation depth matched Asian and Caucasian subgroups**

ablations to achieve emmetropia. We have previously demonstrated deeper stromal ablations to be a risk factor for chronic dry eye after myopic LASIK.<sup>25</sup> Deeper stromal ablations result in a slower return of corneal sensation to levels observed before surgery.<sup>5,26</sup> This loss of sensory innervation

has been identified as one of the leading causes of tear film and ocular surface anomalies after LASIK surgery.<sup>3,7,9,27</sup>

After controlling for surgical ablation depth, other pre-operative characteristics of our Asian group could predispose this group to a higher likelihood of develop-

ing chronic post-LASIK dry eye. The Asian group had significantly more females, more contact lens wearers, lower pre-operative tear volume, less tear film stability and greater pre-operative ocular surface staining scores compared to the Caucasian group. All of these factors have been associated with a delayed recovery of corneal sensation to pre-operative levels.<sup>4,5,9,11,25</sup> Indeed, corneal sensation was decreased in the Asian group compared to the Caucasian group at all times, with these differences being significant at months 3 and 6 after surgery.

Additionally, anatomical differences between the Asian and Caucasian eye may produce a more severe and sustained post-LASIK dry eye. The prevalence of dry eye symptoms and diagnosed dry eye in the general population appears to be greater in Asians than in Caucasians. For example, the dry eye prevalence determined by diagnostic criteria of chronic dry eye symptoms, ocular surface staining and tear film instability or insufficiency in Japanese patients presenting to an ophthalmology clinic was 17 per cent.<sup>28</sup> Australian and Danish studies using similar dry eye diagnostic criteria to the Japanese study gave dry eye prevalence of 11 per cent and eight per cent, respectively.<sup>29,30</sup> Self-reporting of one or more dry eye symptoms experienced often or all the time occurred in 33 per cent of 598 Japanese patients<sup>31</sup> and 18 per cent of 1,548 Australian subjects.<sup>29</sup>

In elderly patients (65 years or older), dry eye symptoms are also more prevalent in Asian participants. The prevalence of self-reported dry eye symptoms occurring often or constantly was 34 per cent in 1,361 elderly Taiwanese residents<sup>32</sup> and 15 per cent in 2,420 elderly US residents.<sup>33</sup> A large scale study involving nearly 39,876 participants in the US Women's Health Study aged 45 to 84 years, determined that compared to Caucasians, Asian participants were more likely to report severe dry eye symptoms (odds ratio 1.77, confidence interval 1.17-2.69).<sup>34</sup> While several authors have commented on the greater prevalence of dry eye in Asian eyes, they have been unable to offer any real explanation other than to state that the differences may be due to racial and/or environmental



factors and that further research is required.<sup>32,34</sup>

Few published studies have compared dry eye parameters between Asian and Caucasian subjects. Cho and Brown<sup>19</sup> found that Asians (Hong Kong Chinese) had significantly lower FBUT (mean eight seconds) compared to 11 to 15 seconds for Caucasian eyes. These researchers attributed the lower tear film stability in Asian eyes to differences in the eyelid anatomy and their interactions with the tear film.<sup>19</sup> No significant differences in tear volume measured by the PRT test were found between young normal non-contact lens wearing Asian (Japanese) and Caucasian (US) eyes, although the Japanese group had a lower mean PRT test value ( $18.8 \pm 8.6$ ) versus ( $23.9 \pm 9.5$ ).<sup>35</sup> We also found that our Asian patients had significantly lower PRT and FBUT than our Caucasian patients at all times before and after surgery.

Blink rates and completeness of blinking can significantly affect tear film dynamics and ocular surface health.<sup>20,29</sup> Differences in blink rates between Asian and Caucasian eyes have not been evaluated but it is our observation that our Asian patients, both before and after surgery, have a lower blink rate and a greater tendency to incomplete blinking. This would produce the characteristic band of inferior staining observed in our Asian patients with chronic post-LASIK dry eye (Figures 1 and 2).

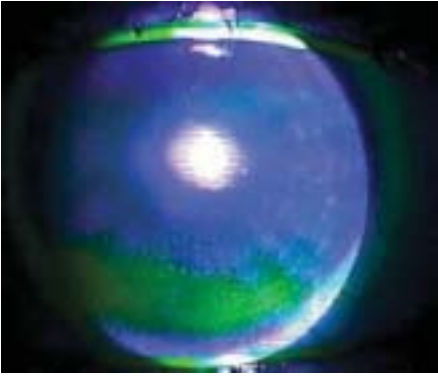
We feel that the blinking and lid surfacing anomalies observed in Asian eyes are due to anatomical differences in the eyelid and orbit, possibly exacerbated by long-term contact lens wear, which is acknowledged to cause blinking anomalies,<sup>20</sup> and the delayed return to pre-operative values for corneal sensation in Asian eyes. Toda and colleagues<sup>10</sup> found that blink rates after LASIK were reduced at months 3, 6 and 12 after LASIK in their Japanese subject group. To date, no published study has evaluated blink rate in Caucasians after LASIK. Therefore, further studies to compare blink rates in Asians and Caucasians before and after LASIK are warranted.

Surgical trauma when cutting the flap is another potential factor contributing to

Dry eye assessments	Time from surgery	Asian n = 48	Caucasian n = 407	p value*
% Dry eye symptoms	Pre-op	23	20	NS†
	Week 2	51 <sup>  </sup>	29	p < 0.001
	Month 1	50 <sup>  </sup>	32 <sup>  </sup>	p = 0.007
	Month 3	48 <sup>  </sup>	38 <sup>  </sup>	p = 0.04
	Month 6	55 <sup>  </sup>	39 <sup>  </sup>	p = 0.001
	Month 12	43 <sup>  </sup>	29	p = 0.009
FBUT ± SD (seconds)	Pre-op	6 ± 3	8 ± 4	p = 0.02
	Week 2	3 ± 3 <sup>§</sup>	6 ± 3 <sup>§</sup>	p = 0.02
	Month 1	3 ± 3 <sup>§</sup>	6 ± 3 <sup>§</sup>	p = 0.06
	Month 3	4 ± 3	6 ± 5	p = 0.03
	Month 6	4 ± 3	7 ± 3	p = 0.02
	Month 12	4 ± 2	7 ± 5	p = 0.006
PRT ± SD (mm/15s)	Pre-op	17 ± 8	20 ± 8	p = 0.01
	Week 2	14 ± 7 <sup>§</sup>	16 ± 8 <sup>§</sup>	p = 0.04
	Month 1	12 ± 9 <sup>§</sup>	18 ± 7	p = 0.003
	Month 3	13 ± 5 <sup>§</sup>	18 ± 8	p = 0.006
	Month 6	16 ± 8	19 ± 8	p = 0.06
	Month 12	19 ± 7	24 ± 8	p = 0.005
Schirmer 1 ± SD (mm/5 min)	Pre-op	15 ± 8	16 ± 8	NS
	Month 1	6 ± 8 <sup>§</sup>	11 ± 8 <sup>§</sup>	p = 0.009
	Month 3	9 ± 5 <sup>§</sup>	12 ± 11 <sup>§</sup>	p = 0.03
	Month 6	13 ± 8	15 ± 10	NS
	Month 12	14 ± 10	16 ± 11	NS
Staining score ± SD	Pre-op	0.5 ± 1.5	0.3 ± 1.0	p = 0.04
	Week 2	1.7 ± 3.0 <sup>  </sup>	0.6 ± 1.8 <sup>  </sup>	p < 0.001
	Month 1	1.1 ± 2.7 <sup>  </sup>	0.5 ± 1.7	p = 0.008
	Month 3	0.9 ± 1.8 <sup>  </sup>	0.5 ± 1.7	p = 0.03
	Month 6	1.1 ± 1.9 <sup>  </sup>	0.4 ± 1.4	p = 0.005
	Month 12	1.0 ± 2.1 <sup>  </sup>	0.4 ± 1.4	p < 0.001
Corneal sensation ± SD (mm)	Pre-op	5.3 ± 0.6	5.4 ± 1.0	NS
	Week 2	0.3 ± 1.6 <sup>§</sup>	0.5 ± 1.8 <sup>§</sup>	NS
	Month 1	1.0 ± 1.9 <sup>§</sup>	1.1 ± 2.0 <sup>§</sup>	NS
	Month 3	2.2 ± 2.1 <sup>§</sup>	3.4 ± 2.0 <sup>§</sup>	p = 0.03
	Month 6	3.8 ± 2.0 <sup>§</sup>	4.9 ± 1.8	p = 0.04
	Month 12	4.7 ± 2.1	5.1 ± 1.5	NS

\* Based on a comparison between Asian and Caucasian patient groups  
 † NS = not significant at the 5% level  
 || Significantly increased (at the 5% level) from pre-operative value  
 § Significantly decreased (at the 5% level) from pre-operative value

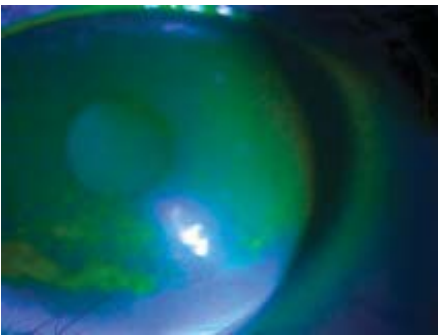
**Table 6. Comparison of dry eye assessments before and after myopic LASIK surgery in Asian and Caucasian groups matched for pre-operative refractive target and total laser ablation depth**



**Figure 1.** Chronic LASIK dry eye in a female Asian patient at nine months post LASIK for -11 D myopic correction. There is significant inferior punctate epitheliopathy and a less severe band of staining superior to the central ablation zone.



**Figure 2.** Significant inferior punctate epitheliopathy in an Asian eye with inferior entropion and trichiasis one month post-LASIK. Contact lens wear before surgery masked the condition.



**Figure 3.** Diffuse staining in a female Asian patient at week 2 after LASIK for -6 D myopic correction. The patient had not been using post-operative lubrication routinely.



**Figure 4.** Superior entropion and trichiasis masked by contact lens wear in a pre-operative LASIK candidate. The patient was advised to remain in contact lenses or consider entropion repair prior to undergoing any form of keratorefractive surgery.

ocular surface damage and dry eye after LASIK.<sup>36</sup> In general, Asian eyes have a shallower orbit, smaller vertical orbital dimensions and differences in the upper eyelid anatomy compared to Caucasians. Asian eyes also have narrower palpebral fissures.<sup>37,38</sup> These factors can predispose Asian eyes to greater likelihood of flap cut problems.<sup>38</sup> Asano-Kato and co-workers<sup>39</sup>

found that Asian eyes were more disposed to problems with suction with the microkeratome. They concluded that the narrow palpebral fissures commonly found in Asian populations might be a risk factor for insufficient fixation of a microkeratome in LASIK. Although our Asian patients did not experience a higher incidence of flap cut complications, our

surgeon did find that intra-operative preparation for the flap cut took longer for Asian eyes compared with Caucasian eyes, due to these eyelid and orbital issues. Longer intra-operative times and a tight fit with the suction ring and keratome, even in the absence of flap cut complications, could add to the intra-operative damage to the ocular surface and the perilimbal goblet cell loss and be a contributing factor to the high degree of ocular surface staining seen after LASIK in Asian patients (Figure 3).

Epiblepharon and entropion can be features of Asian eyelids and, in severe cases, are associated with trichiasis and corneal punctate epithelial erosions.<sup>37</sup> Contact lens wear will mask the effects of trichiasis (Figures 4) and these patients may need to consider eyelid surgery to correct the eyelid anomalies before LASIK if significant trichiasis and punctate erosions are present, or alternatively remain in their contact lenses if ocular health permits.

The greater prevalence, duration and severity of dry eye in our Asian group is concerning, particularly given that we employ intensive ocular surface management strategies before, during and after surgery in an attempt to reduce the incidence and severity of LASIK induced dry eye,<sup>8,25,36</sup> and given that the prevalence and severity of myopia in Asian eyes is increasing. Asian LASIK candidates with increased risk of developing dry eye (females, dry eye before surgery, higher attempted corrections and long-term contact lens wearers) should be counselled pre-operatively regarding their increased risk of developing chronic dry eye after LASIK and alternative corrective options should be considered. It may be prudent for Asian patients who are safely and comfortably wearing contact lenses to remain in their contact lenses or to consider photorefractive keratectomy which has a lower long-term incidence of chronic dry eye symptoms and signs.<sup>1,7,40</sup>

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