ARTICLE

Infectious keratitis after laser vision correction: Incidence and risk factors

Julie M. Schallhorn, MD, MS, Steven C. Schallhorn, MD, Keith Hettinger, MS, Stephen Hannan, OD

Purpose: To describe the incidence and risk factors associated with microbial keratitis in a large population of laser vision correction (LVC) patients.

Setting: Optical Express centers, Glasgow, United Kingdom.

Design: Retrospective case series.

Methods: Records were searched to identify all cases of presumed microbial keratitis after LVC between January 1, 2008, and April 1, 2015. Consecutive patients having primary or enhancement LVC during that time served as controls. Data on preoperative age, sex, refraction, procedure, and surgery specifics were collected. A multivariate Cox proportional hazards model was used, and hazard ratios were calculated.

Results: Definite or probable microbial keratitis occurred in 26 of 564 165 eyes after laser in situ keratomileusis (LASIK) and in 11 of 81 792 eyes after photorefractive keratectomy (PRK) during the study period, for an overall incidence of 0.0046% (1 case per 21 697 procedures) after LASIK and 0.0013% (1 case per 7434 procedures) after PRK. A multivariate analysis found that those having PRK had a significantly higher incidence of microbial keratitis than those having LASIK (hazard ratio, 2.92; 95% confidence interval, 1.42-6.00; $P = .004$). No other analyzed factors were significant.

Conclusion: Although the incidence of infectious keratitis was higher after PRK, the overall risk after any LVC procedure was very low.

J Cataract Refract Surg 2017; 43:473–479 © 2017 ASCRS and ESCRS

Infectious keratitis after laser vision correction (LVC) is a rare but serious complication. Studies have reported an incidence between 0.02% and 0.8% after photorefractive keratectomy (PRK)[1–4] and from 0% to 1.5% after laser in situ keratomileusis (LASIK).[5] Several risk factors have been reported; these include employment in a healthcare setting,[6,7] contact lens manipulation,[5,7] dry eye,[2,8] exposure,[2] trauma,[8] lack of perioperative antibiotics,[5,8] enhancements and previous radial keratotomy surgery,[5,8] lack of aseptic technique,[5,8] use of tobramycin monotherapy for postoperative prophylaxis,[9] and systemic herpes simplex virus (HSV) infection.[5] A high incidence of atypical infectious organisms, in particular after LASIK, has been reported.[5,8,10]

Although critical in shaping our current guidelines for treatment of infectious keratitis after refractive surgery,[11,12] these previous studies did not use a reference population of patients who did not contract infectious keratitis to rigorously analyze the risk factors associated with developing microbial keratitis. Careful analysis of the risk factors associated with developing microbial keratitis after LVC is necessary to further our understanding of this significant complication and perhaps to lead to improved clinical practice.

This study evaluated the incidence of and risk factors for microbial keratitis in a very large population of patients having LVC. We believe that this is the first study to use a case-control method to analyze contributing factors to developing infectious keratitis.

PATIENTS AND METHODS

This study was reviewed and approved by the Committee on Human Research (which is the university-specific name for the Institutional Review Board) at the University of California, San Francisco. This work is compliant with the United States Health Insurance Portability and Accountability Act of 1996 and adhered to the tenets of the Declaration of Helsinki.

This retrospective case-control study comprised all cases of presumed microbial keratitis that occurred after primary or enhancement PRK or LASIK between January 1, 2008, and April 1, 2015,

Submitted: May 23, 2016 | Final revision submitted: January 11, 2017 | Accepted: January 15, 2017

From the University of California San Francisco (J.M. Schallhorn), San Francisco, the Roski Eye Institute (S.C. Schallhorn), University of Southern California Los Angeles, Los Angeles, California, USA; Optical Express (S.C. Schallhorn, Hettinger, Hannan), Glasgow, United Kingdom.

Presented at the ASCRS Symposium on Cataract, IOL and Refractive Surgery, San Diego, California, USA, April 2015.

Supported by an unrestricted grant from Research to Prevent Blindness, New York, New York, USA (University of California San Francisco Department of Ophthalmology and the University of Southern California Roski Eye Institute).

The managing surgeons at Optical Express treated the cases of microbial keratitis.

Corresponding author: Julie M. Schallhorn, MD, MS, University of California, San Francisco, 10 Koret Way, San Francisco, California 94043, USA. E-mail: jschallhorn@gmail.com.

0886-3350/$ - see frontmatter
http://dx.doi.org/10.1016/j.jcrs.2017.01.017

at Optical Express centers, Glasgow, United Kingdom. Optical Express uses an extensive medical records system that records all aspects of patient care, including complications arising from surgery, facilitating a comprehensive retrospective review. The records of all laser vision treatments performed by Optical Express during this inclusive time period were searched for cases that had been identified as having a corneal infiltrate at any postoperative visit or had been identified as having definite or possible microbial keratitis. The remainder of cases having primary LASIK or PRK without microbial keratitis during this period were used as controls.

The records of the suspected cases were reviewed by 2 independent reviewers (J.M.S., S.C.S.) and were classified as having culture-proved microbial keratitis, probable culture-negative or culture-unknown microbial keratitis, marginal keratitis, diffuse lamellar keratitis (DLK), other noninfectious keratitis, or delayed microbial keratitis that presented more than 6 months after surgery. The other noninfectious keratitis group included patients with noninfectious corneal erosions, delayed epithelial healing, or toxic keratitis. Patients were classified as having marginal keratitis if they had peripheral corneal infiltrates in the classic locations that responded to treatment with topical steroids and did not require intensive antibiotics for resolution.

The determination of a diagnosis of definite or probable infectious keratitis was based on symptoms, slitlamp findings, and microbiology/culture results. Clinical diagnostic criteria included the presence of corneal infiltrates compatible with infectious keratitis and exclusion of other causes of noninfectious keratitis. Any case that was clinically determined at the time of evaluation to require a culture was treated as a probable microbial keratitis case regardless of culture results; cases that had positive cultures were classified as definite microbial keratitis. Because of the U.K. heath privacy laws, not all culture results were reported to Optical Express and thus were not available for review. Cases were additionally categorized as other or noninfectious keratitis, DLK, or marginal keratitis. Cases that had onset of infectious keratitis 3 months or more after surgery were classified as delayed infectious keratitis; these were not treated as secondary to the LVC procedure.

All PRK and LASIK procedures were performed by experienced surgeons using standard techniques described elsewhere.[13–15] All patients had a formal informed consent process for their surgical procedure before surgery. For LASIK patients having the procedure with a mechanical microkeratome, a disposable microkeratome was used for each eye; there was no reuse of equipment between eyes. For all procedures, a complete set of disposable instruments was used. All patients received ofloxacin or levofloxacin eyedrops 4 times a day for 1 week after surgery or until healing of the epithelial defect after PRK. Laser in situ keratomileusis patients received prednisolone acetate 1.0% eyedrops 4 times a day for 1 week and PRK patients received fluorometholone 1.0% eyedrops 4 times a day for the first week after surgery with a 3-week taper. Patients having PRK had a bandage contact lens placed at the time of surgery that was removed when the epithelium had healed.

All patients desired improved vision without optical aids and met the indications for LVC as specified by the excimer laser user manual (Visx Star S4, Abbott Medical Optics, Inc.) with the exception that patients with autoimmune disease could have surgery if their condition was stable and well controlled. Patients were only considered for refractive surgery if they had a minimum central corneal thickness (CCT) of 450 μm for PRK and 480 μm for LASIK. Patient and surgeon preference was the primary driver of the procedure choice; however, patients with the following criteria were only offered PRK: a CCT less than 480 μm, a residual stromal bed less than 250 μm with LASIK, epithelial basement membrane disease, and corneal shape anomalies assessed by Scheimpflug-based tomography.

An Intralase iFS femtosecond laser (Abbott Medical Optics, Inc.) with a flap thickness of 100 to 120 μm was used for laser-cut flaps, and a Moria M2 mechanical microkeratome (Moria, Inc.) was used for the mechanical flaps with an estimated flap thickness of 130 μm. All femtosecond flaps were created with the hinge positioned superiorly, while the mechanical microkeratome flaps had nasal hinges. For PRK procedures, the epithelium was removed using an alcohol-based solution. The epithelium was discarded or repositioned depending on the preference of the surgeon. All PRK patients had a bandage contact lens placed at the end of the surgery. For wavefront-guided myopic corrections, a 6.0 mm optical zone with a total ablation zone of 8.0 mm was used; for standard myopic corrections, an optical zone of 6.5 mm with a total ablation zone of 8.0 mm was used. For both standard and wavefront-guided hyperopic ablations, an optical zone of 6.0 mm and total ablation zone of 9.0 mm were used.

Descriptive statistics were performed to determine the incidence of microbial keratitis and to describe the study population. For nonparametric data, the mean and interquartile range (IQR) (IQR, 25th to 75th percentiles) are reported. Analysis was performed using Stata software (Stata Corp.). A Cox proportional-hazards model was fit to the data to derive the hazard ratio associated with preoperative and intraoperative characteristics. The analysis was clustered by patient to account for the interrelatedness between the 2 eyes and for patients who had enhancement treatment. A univariate model was first run, and factors with a *P* value of 0.1 or less in the univariate model were used to construct a multivariate model.

RESULTS

Eighty-two patients (101 eyes) were identified in the database as having corneal infiltrates after LVC between January 1, 2008, and April 1, 2015. The records for each of the cases were reviewed and classified (Table 1). After review, 9 eyes were classified as having definite culture-proven microbial keratitis and 23 eyes were identified as having probable microbial keratitis after primary LVC. Five eyes were classified as having probable microbial keratitis after enhancement. During the study period, 645 920 refractive procedures in 317 583 patients met the inclusion criteria for controls. Of these, 543 811 were primary LASIK procedures, 57 574 primary PRK procedures, 20 328 enhancement LASIK procedures with flap lifting, and 24 207 enhancement PRK procedures, of which 20 818 (86%) were above a previous LASIK flap.

Microbial Keratitis

During the study period, 37 eyes of 35 patients had probable or culture-confirmed microbial keratitis after LVC; 2 patients had bilateral microbial keratitis after LASIK. For all LVC procedures, the overall incidence of suspected or confirmed infectious keratitis after LVC surgery was 0.0057% per procedure.

Table 1. Classification of cases of corneal infiltrates resulting from proven or probable microbial keratitis or other causes after chart review.

Classification	PRK	LASIK	Total (%)
Culture-proven microbial keratitis	2	7	9 (9)
Probable microbial keratitis	9	19	28 (28)
Other/noninfectious keratitis	6	9	15 (15)
Marginal keratitis	12	20	32 (32)
Diffuse lamellar keratitis	—	7	7 (7)
Delayed Infectious keratitis	6	4	10 (10)

PRK = photorefractive keratectomy; LASIK = laser in situ keratomileusis

Eleven eyes of 11 patients developed probable or culture-confirmed microbial keratitis after having PRK and 26 eyes of 24 patients developed it after having LASIK, for an incidence of 0.013% per procedure after PRK and 0.0046% per procedure after LASIK. One eye of 1 patient developed presumed infectious keratitis after sustaining a free flap during LASIK performed with a mechanical microkeratome; the procedure was aborted and the patient did not have excimer ablation. This patient was analyzed in the LASIK group. Five cases of suspected microbial keratitis in 5 patients occurred after an enhancement procedure during the same time period; all occurred after a PRK enhancement over a previous LASIK flap. The overall incidence of post-enhancement microbial keratitis was 0.011% per procedure.

Cases of microbial keratitis presented a mean of 8.7 days after LASIK (IQR 9; range 1 to 38) and 5.8 days after PRK (IQR 2; range 3 to 19) (Figure 1). Laser in situ keratomileusis cases tended to present later than PRK cases; however, this difference was not statistically different ($P = .4$). Of 36 cases, 34 had classic presentation of microbial keratitis with white corneal infiltrate. Two cases presented after LASIK with focal white cells in the flap interface and were initially diagnosed as DLK, which worsened with topical steroids and after which the eyes were diagnosed as microbial keratitis and treated accordingly.

Cultures were performed in 31 of 37 cases. Of the 6 cases that were not cultured, 3 were after LASIK and 3 were after PRK. All presented with a small peripheral infiltrate and responded rapidly to hourly treatment with moxifloxacin or gatifloxacin. All cases of microbial keratitis after LASIK that had cultures taken had flap lift for culturing. Cultures were positive, and the authors had access to the data in 9 cases; cultures were negative in 13 cases. Because of privacy laws in the U.K., culture data were not available in 9 cases. Of the culture-positive cases, 4 were typical corneal ulcer pathogens (*Staphylococcus epidermidis, Pseudomonas aeruginosa*, and *Staphylococcus aureus* [2 cases]). Five cases were atypical organisms, including 2 cases of *Mycobacterium chelonae*, 1 each of *Nocardia* and *Aspergillus*, and 1 unidentified fungal organism. One of the cases of *S aureus* was methicillin-resistant.

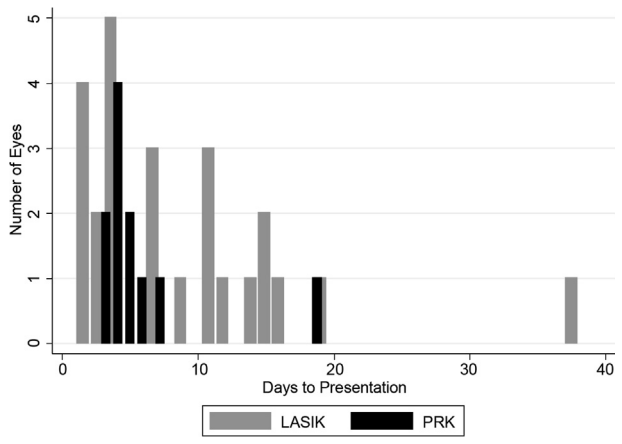

Figure 1. Days to presentation of cases of microbial keratitis (LASIK = laser in situ keratomileusis; PRK = photorefractive keratectomy).

Risk Factors for Microbial Keratitis

Analysis of factors in the development of microbial keratitis in the microbial keratitis and control groups showed no association between age, eye, myopia or hyperopia, sex, preoperative intraocular pressure, pachymetry, keratometry, operative temperature or humidity, preoperative corrected visual acuity (CDVA), ablation profile (wavefront-guided versus standard), flap type (mechanical microkeratome versus femtosecond laser), preoperative average keratometry, and risk for developing probable or culture-proven microbial keratitis (Table 2). A multivariate analysis including factors with borderline significance from the univariate model revealed similar findings (Table 3). There was a significant association with procedure type and the development of microbial keratitis, with a hazard ratio of 2.92 (95% confidence interval, 1.42-6.00; $P = .004$).

Table 4 shows the incidence of microbial keratitis in the different preoperative scenarios that are routinely encountered, calculated using the raw data from the study. The lowest incidence in this population was after femtosecond LASIK, at 1 case of microbial keratitis for every 22 536 procedures. The highest was after PRK, at 1 case per every 7434 procedures.

Outcomes

Data were available for a follow-up of 1 month or longer in 34 of 37 eyes. The remaining 3 cases were referred for management immediately after diagnosis and did not return thereafter. Table 5 shows the clinical outcomes of patients with microbial keratitis. All penetrating keratoplasties (PKPs) were performed for visual rehabilitation; none was performed during the acute phase of infectious keratitis. Other procedures and complications were flap amputation performed for flap melt; further LVC, including astigmatic keratotomy (n = 2), for visual rehabilitation; and central scarring, which occurred in eyes that did not have PKP. The remainder of eyes had paracentral or peripheral scaring. Three eyes that did not have PKP developed late flap complications; 2 cases had visually significant striae requiring flap lift and 1 case, epithelial ingrowth that did not require intervention.

Follow-up data on the postoperative CDVA were available for 24 of the 37 microbial keratitis cases up to at least 1 month (range 1 to 52 months). Eighteen eyes (75%) achieved a CDVA of 20/40 or better. Data on uncorrected acuity were available for 26 of 37 eyes with at least 1 month of follow-up. The uncorrected acuity was 20/40 or better in 16 eyes (62%).

Other Causes of Keratitis

Of the 101 eyes of 82 patients identified as having corneal infiltrates, 64 eyes of 47 patients were classified as noninfectious (Table 1). Thirty-two eyes of 19 patients with marginal keratitis manifested with the classic triad of peripheral infiltrates, blepharitis, and response to treatment with topical steroids.

Table 2. Characteristics in microbial keratitis group and control group.

Characteristic	Consecutive Treatments	Microbial Keratitis	HR	95% CI	*P* Value*
Age (y)					
Mean	37.3	40.7	1.00	0.99, 1.00	.1
IQR	28, 47	29.2, 50.1			
Range	18 to 76	20 to 63			
Eye, n (%)			0.96	0.52, 1.77	.9
Right	325 909 (50.5)	19 (51.3)			
Left	320 011 (49.5)	18 (48.7)			
Sex, n (%)			1.65	0.83, 3.03	.2
Female	166 671 (52.6)	13 (37.1)			
Male	150 256 (47.4)	22 (62.8)			
Follow up (d)					
Mean	268	314	1.00	0.99, 1.00	.6
IQR	39, 322	20, 387			
Range	1 to 3804	1 to 2682			
Preop CDVA (logMAR)					
Mean	−0.08	−0.07	0.99	0.01, 93.39	.9
IQR	−0.08, −0.08	−0.08, −0.04			
Range	−0.18 to 0.1	−0.18 to 0.1			
Preop MSE (D)					
Myopes			—	—	—
Mean	−3.17	−2.84			
IQR	−4.25, −1.75	−3.438, −0.875			
Range	−26.125 to −0.01	−8.25 to −0.875			
Hyperopes					
Mean	+1.92	+2.02			
IQR	1.25, 2.375	1.5, 2.5			
Range	(0 to +23.125)	+1.125 to +2.625	—	—	—
Group			1.91	0.89, 4.11	.09
Myopes, n (%)*	493 378 (85.6)	28 (75.7)			
Hyperopes, n (%)*	81 357 (14.4)	9 (24.3)			
Preop IOP (mm Hg)					
Mean	15.1	14.5	0.92	0.82, 1.02	.13
IQR	13, 17	12.3, 16			
Range	5 to 35	10.7 to 20.3			
Preop pachymetry (μm)					
Mean	547	541	0.99	0.98, 1.00	.4
IQR	524, 568	520, 570			
Range	350 to 700	458 to 621			
Preop keratometry (D)					
Mean	43.6	43.2	0.85	0.65, 1.14	.3
IQR	42.63, 44.63	42.69, 44.25			
Range	30 to 56	33.63 to 46.38			
Temperature (°C)					
Mean	21.0	21.3	1.14	0.98, 1.34	.09
IQR	20.0, 22.0	20.7, 22.0			
Range	10.0 to 30.0	18.6 to 24.2			
Humidity (%)					
Mean	39.6	39.8	1.00	0.97, 1.04	.8
IQR	35, 44	37.5, 43			
Range	20 to 80	29 to 53			
Ablation type, n (%)			1.16	0.50, 2.69	.7
Standard	141 490 (21.9)	7 (19.4)			
WFG	543 428 (78.1)	29 (80.6)			
Flap creation, n (%)†			1.27	0.55, 2.94	.6
Microkeratome	159 891 (29.4)	9 (34.6)			
Femto laser	383 111 (70.6)	17 (65.4)			
Enhancement, n (%)			2.17	0.83, 5.65	.1
Primary	601 416 (93.1)	32 (86.5)			
Enhancement	44 540 (6.9)	5 (13.5)			
Procedure, n (%)			2.92	1.42, 6.00	.004
PRK	81 781 (12.7)	11 (29.7)			
LASIK	564 139 (87.3)	26 (70.3)			

CDVA = corrected distance visual acuity; CI = confidence interval; femto = femtosecond; n = number of eyes, HR = hazards ratio; IOP = intraocular pressure; IQR = interquartile range; LASIK = laser in situ keratomileusis; logMAR = logarithm of minimum angle of resolution; PRK = photorefractive keratectomy; WFG = wavefront guided

*Primary procedures only

†Primary LASIK procedures only

Table 3. Multivariate model for risk of development of culture-proven or probable microbial keratitis including factors that had a *P* value of 0.1 or less from the univariate analysis.

Characteristic	HR	95% CI	*P* Value
Age	1.00	0.99, 1.00	.6
Temperature	1.16	0.99, 1.36	.06
Hyperopic vs myopic	1.39	0.50, 3.90	.5
Enhancement vs primary	1.37	0.54, 3.49	.5
PRK vs LASIK	2.62	1.26, 5.47	.01

CI = confidence interval; HR = hazard ratio; LASIK = laser in situ keratomileusis; PRK = photorefractive keratectomy

Fourteen eyes of 11 patients were classified as having other types of noninfectious keratitis. This included 6 cases of persistent or recurrent epithelial defects in the early postoperative period. Three eyes (2 patients) developed suspected eyedrop-related toxic epitheliopathy, a bilateral case of medication toxicity from the prescribed postoperative drops, and a unilateral case of accidental application of skin cream to the eye. The 1 case of a mild bilateral flap melt was in a patient with rheumatoid arthritis in whom the disease had been quiescent for 15 years before surgery. There was 1 case of a corneal foreign body seen 14 days postoperatively; flap lift and retrieval were performed. Seven eyes were classified as having significant DLK because they responded to aggressive treatment with topical steroids without additional antibiotics.

There were 10 eyes of 10 patients that had delayed infectious keratitis from 4 months to 5 years after surgery; these were not treated as secondary to the LVC procedure. Of these, 2 eyes developed recurrent corneal erosions that were treated with a bandage contact lens and developed bacterial keratitis that was presumed secondary to the extended contact lens wear. One eye developed presumed HSV epitheliitis 6 months after treatment. Seven eyes had abrasions from accidental trauma and subsequently developed infectious keratitis. Overall, 10 of 645 957 eyes (0.0015%) developed delayed infectious keratitis. With a mean follow-up of 268 days for the entire cohort, this amounts to an incidence of 2.2×10^{-5} cases per eye-year, or 0.22 cases per 10 000 eyes per year.

DISCUSSION

Infectious keratitis is a feared complication of laser refractive surgery that can result in significant loss of CDVA in eyes with excellent visual potential. Despite this, there is very little in the literature analyzing risk factors for infectious keratitis in a controlled fashion. In this study, we examined the rate of infectious keratitis after LASIK and after PRK and analyzed a number of patient and procedure specifics to try to elucidate the factors related to postoperative microbial keratitis. To our knowledge, this is the largest study published to date on the topic and the first study to use a case-control method to evaluate the risk for microbial keratitis after refractive surgery.

We found an extremely low overall rate of infectious keratitis after primary LVC in this case series—0.0046% per eye (1 of 21 697 procedures) after LASIK and 0.017% (1 of 7434 procedures) per eye after PRK. The largest previous series of infectious keratitis after surface ablation[1] reported a rate of 0.019% (5 cases in 25 337 eyes), which is on par with that reported in this study. Leccisotti et al.[4] reported a similar rate of 0.02% (2 cases in 10 452 eyes) in patients having PRK. Several studies have reported higher rates, including a rate of 0.21% (39 cases in 18 651 eyes),[2] 0.1%,[16] and 0.3% (13 cases in 4492 eyes).[3]

The largest previous series of infectious keratitis after LASIK reported rates of 0.031% and 0.035% in more than 200 000 eyes.[17,18] This rate was reduced to 0.011% (10 cases in 91 340 eyes) after the introduction of moxifloxacin in addition to tobramycin in the postoperative protocol.[9] A survey of the American Society of Cataract and Refractive Surgeons (ASCRS) membership in 2003 reported a rate of 0.034%.[10] Moshirfar et al.[19] reported a rate of nonviral infectious keratitis of 0.095% (10 cases in 10 477 eyes) in a university-based practice.

In this study, the rate of infectious keratitis after LASIK and after PRK was approximately a factor of 10 smaller than the majority of previously reported rates, with the exception of those reported by Wroblewski et al.[1] and Leccisotti et al.[4] after PRK. The reason is unclear. The most notable difference between this study and the previous studies is the later dates at which ours was performed (2008 to 2015); all previous studies were performed before 2006 with the exception of 1, which covered a period from 2003 to 2013.[9] The later time resulted in the inclusion of and strict adherence to techniques that had been recommended by the previous studies as well as published guidelines[11,12] from which the previous studies would not have benefited.

Table 4. Incidence of microbial keratitis in different patient populations. Sex data are presented as per patient; the rest of the data are presented as per eye.

Population	Control Group	Microbial Keratitis (n)	Incidence (%)	Incidence (1:xxx)
Men	150 829	22	0.014	1:6856
Women	166 830	13	0.0077	1:12 833
Myopes	503 573	28	0.0055	1:17 985
Hyperopes	128 720	9	0.0069	1:14 302
PRK	81 781	11	0.013	1:7434
LASIK	564 140	26	0.0046	1:2 697
Mechanical microkeratome	159 891	9	0.0056	1:17 765
Femtosecond laser	383 111	17	0.0044	1:22 536
Enhancement	44 536	5	0.011	1:8907

LASIK = laser in situ keratomileusis; PRK = photorefractive keratectomy

Table 5. Clinical outcomes of patients with microbial keratitis in the 34 eyes for which follow-up data were available.

Outcome	Eyes, n (%)
Penetrating keratoplasty	8 (22)
Further LVC*	2 (5)
RGP contact lens	2 (5)
Flap complications	3 (8)
Central scar	8 (22)
Paracentral scar	5 (16)
Peripheral scar	9 (24)
Unknown*	3 (8)

LVC = laser vision correction; RGP = rigid gas-permeable
*Patients referred for treatment; follow-up data not available

In this study, the PRK procedure had a higher rate of postoperative microbial keratitis with a hazard ratio of 2.92. No other factor we analyzed, including age, preoperative refractive error, and sex, was associated with the development of postoperative microbial keratitis. This supports the results in previous studies. De Rojas et al.[2] reported the rate of infectious keratitis was 5.7 times higher after PRK than after LASIK (0.2% versus 0.035%), and a later study[9] found that the rate of infection after PRK remained 6 times higher than after LASIK (0.066% versus 0.011%) at the same centers after the addition of moxifloxacin to the postoperative regimen. De Oliveira et al.[3] reported that the rate of infectious keratitis after PRK was twice the rate after LASIK (0.2% versus 0.1%) at a Brazilian clinic. The association between PRK and the increased risk for microbial keratitis is unsurprising given the large epithelial defect that surface ablation procedures create. Theoretically, the open epithelium provides an area for infectious microbes to adhere and replicate, which the intact epithelium after LASIK does not.

Infectious keratitis after LASIK is generally classified as early (within 2 weeks of surgery) or late (from 2 weeks to 3 months after surgery).[5] Some previous studies[2,3] have suggested that infectious keratitis appears sooner after surface ablation than after LASIK. In our series, 74% of LASIK cases and 90% of PRK cases presented within 2 weeks of surgery. Although LASIK cases had a later mean date of presentation than PRK cases (8.7 days versus 5.8 days), there was no statistical significance in time to presentation between these 2 groups. A higher proportion of our cases presented earlier than has been reported in the literature.[5,9]

The number of culture results available to examine for this study was unfortunately low because of a lack of results available to review; however, the cultures that were available had a preponderance of atypical organisms. The mixture of organisms is similar to what has been reported in other studies after LASIK[8,10,17,20] and after PRK.[1,2,7] Nontuberculous mycobacteria have been implicated as a pernicious cause of post-LVC keratitis and have been linked to outbreaks of infectious keratitis at refractive surgery centers.[21,22] The diversity of organisms encountered in this study support the standing recommendation from the American Academy of Ophthalmology,[11] ASCRS,[12] and many authors[5,8,10,23] to culture every case with flap lift in LASIK rather than simply treating with empiric antibiotics.

A number of causes of keratitis in this study were not caused by infections. The majority of cases of noninfectious keratitis were caused by marginal keratitis, which is in contrast to results in the study by Moshirfar et al.,[19] in which the majority of cases of keratitis were caused by DLK and a minority caused by marginal keratitis. The discrepancy in the results between this study and the previous study likely results from case selection. This study specifically looked at eyes classified as having corneal infiltrates after LVC. As a result, only very severe cases of DLK were included, whereas the study by Moshirfar et al. looked at all cases of keratitis after LASIK and as such included a higher number of DLK cases. Aside from DLK and marginal keratitis, a smattering of other causes of keratitis were seen in this study.

A small number of eyes in this series (10 of 101) had delayed infectious keratitis with presentation between 4 months and 5 years after surgery. Overall, the incidence of delayed infectious keratitis was 2.2×10^{-5} cases per eye-year, or 0.22 infections per 10 000 eyes per year. This is significantly lower than what has been reported in contact lens wearers in a similar population in Scotland (2.44 cases per 10 000 eyes per year) and similar to noncontact lens wearers in the same population (0.36 cases per 10 000 eyes per year).[24]

This study had limitations. Chiefly, it was retrospective in nature and no set of stringent guidelines was applied for the detection of microbial keratitis at the time of diagnosis. To lessen this effect, all cases with corneal infiltrates were reviewed using standard criteria. Optical Express has an extensive electronic medical record system designed to capture any complication after refractive surgery for analysis; thus, it is unlikely that any cases of postoperative infiltrates would have been missed. Another limitation of this retrospective study is that it also relied on patients returning for follow-up because patients who did not return for follow-up but developed microbial keratitis would have not been included in this analysis. However, most patients who develop a complication will return to their treatment center rather than seeking care from a new source. The numerous (>200) locations and wide geographic location of Optical Express clinics in the U.K. make accessing care for patients with any difficulty after LVC convenient and easily available. In addition, data were not collected for a variety of other factors that might contribute to the development or profile of microbial keratitis, including overall health status, recent hospitalizations, or a history of ocular infections. A prospective study would be ideal to address these concerns; however, given the rarity of microbial keratitis, such a study would be a wieldy undertaking.

The data provided in this study can be used to counsel patients who often want to know the real risks they are assuming. Overall, the very low risk for postoperative

microbial keratitis in this study should be reassuring to patients and practitioners alike.

WHAT WAS KNOWN

- The rates of infectious keratitis after LVC surgery are low.
- There is a higher reported incidence of infectious keratitis after PRK than after LASIK.

WHAT THIS PAPER ADDS

- The rate of infectious keratitis after PRK was higher than after LASIK.
- Other patient and procedure-specific factors were not risk factors for infectious keratitis.

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Disclosures: *Mr. Hettinger and Dr. Hannan are employees of Optical Express. Dr. S.C. Schallhorn receives consulting fees from Abbott Medical Optics, Inc., and Optical Express. Dr. J.M. Schallhorn has no financial or proprietary interest in any material or method mentioned.*