Infectious keratitis in 18 651 laser surface ablation procedures

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PURPOSE: To evaluate the incidence, culture results, risk factors, treatment strategies, and visual outcomes of infectious keratitis after surface ablation.

SETTING: Multicenter study in Spain.

DESIGN: Case series.

METHODS: The medical records of patients who had surface ablation between January 2003 and December 2009 were reviewed to identify cases of infectious keratitis. The incidence, risk factors, clinical course, days to diagnosis, medical and surgical treatment, and visual outcome were recorded. Main outcome measures were incidence of infectious keratitis after surface ablation, culture results, response to treatment, and visual outcomes.

RESULTS: The study reviewed the records of 9794 patients (18 651 eyes). Infectious keratitis after surface ablation was diagnosed in 39 eyes of 38 patients. The onset of infection was early (within 7 days after surgery) in 28 cases (71.79%). Cultures were positive in 13 of 27 cases in which samples were taken. The most frequently isolated microorganism was *Staphylococcus* species (9 cases). The final corrected distance visual acuity (CDVA) was 20/20 or better in 23 cases (58.97%), 20/40 or better in 36 cases (92.30%), and worse than 20/40 in 3 cases (7.69%).

CONCLUSIONS: The incidence of infectious keratitis after surface ablation was 0.20%. Infectious keratitis is a potentially vision-threatening complication. Prompt and aggressive management with an intensive regimen of fortified antibiotic agents is strongly recommended. Proper management can preserve useful vision in most cases.

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Surface ablation procedures are increasingly popular. The main techniques are photorefractive keratectomy (PRK), laser-assisted subepithelial keratectomy (LASEK), and epithelial laser in situ keratomileusis (epi-LASIK). These techniques are less susceptible to initial or secondary flap complications (including ectasia) than other approaches, and their efficacy and safety are well documented.[1–6] However, recovery time is longer and concern remains about the development of infectious keratitis, which, although rare, is a potentially sight-threatening complication.

There are few reports of the incidence, clinical presentation, management, and visual prognosis of infectious keratitis after surface ablation procedures. In addition, the incidence of keratitis after surface ablation is difficult to estimate and varies widely depending on the source of the data.

Wroblewski et al.[7] and Leccisotti et al.[8] found an incidence of 5 cases (0.019%) in 25 337 PRK procedures and 2 cases (0.02%) in 10 452 PRK procedures, respectively, while Machat[9] and de Oliveira et al.[10] calculated a post-PRK incidence of 1 (0.1%) in 1000 cases and 9 (0.2%) in 4492 cases, respectively. The small number of cases makes it difficult to perform an integrated data analysis and draw conclusions on diagnosis and management. The largest series reported to date analyzed 13 cases[11] and 16 cases[12] of infectious keratitis after PRK. However, the authors do not specify the total number of procedures, making it difficult to draw conclusions about the incidence. A 2003 literature review by Donnenfeld et al.[11] identified

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26 reported cases of bacterial keratitis after PRK, although no statistical evaluation was performed. In a study by Leal et al.,[12] only results from cultures or scrapings were provided and there was no information about presentation characteristics, management, or visual outcomes.

Regarding LASEK and epi-LASIK, the only published case reports—5 cases after LASEK[13–16] and 2 cases after epi-LASIK[17]—have been anecdotal. The incidence of infection after these procedures could be similar to that after PRK because they all share the same risk factors for infection.

Because the incidence of infection after surface ablation is low, an analysis of a large series from a single center could provide additional data on several clinically relevant parameters and a better understanding of the presentation, etiology, and management of these infections. Single-center series report an incidence in a controlled setting; that is, patients and surgeons follow uniform protocols before, during, and after surgery. However, it is difficult to draw conclusions because of the small number of patients in this type of series.

We report the largest series to date of infectious keratitis after surface ablation and after LASEK, with all procedures performed at the same institution. Cases were retrospectively reviewed to examine the onset, etiology, clinical course, risk factors, and treatment of infections with the aim of providing a better understanding of the prevention, diagnosis, and management of this entity.

PATIENTS AND METHODS

This retrospective case-series review comprised eyes that had primary surface ablation or enhancement surgery consecutively at Clinica Baviera between January 2003 and December 2009. More than 40 000 refractive procedures are performed each year at the clinic, a private ophthalmology institution with 23 centers and 91 surgeons throughout Spain.

Patients with a diagnosis of infectious keratitis within 6 months after surface ablation were identified by an electronic search of medical histories using the key words *surface ablation* and *infectious* or *surface ablation* and *keratitis*. The clinical data files of the clinic's patients are computerized and contain a field called "indication," which includes the type of surgery each patient had. In laser corneal refractive surgery, 2 options are available: laser in situ keratomileusis (LASIK) or surface ablation, the latter of which includes PRK and LASEK. Epi-LASIK is not performed at the institution.

The diagnosis of infectious keratitis was based on symptoms, slitlamp findings, microbiology results, or a combination. Clinical diagnostic criteria included the presence of corneal infiltrates compatible with infectious keratitis, excluding other causes of noninfectious keratitis (peripheral sterile infiltrates) (Figure 1).[18–21]

Patient charts were analyzed to collect the following data: age, sex, involved eye, procedure type (PRK versus LASEK; primary versus enhancement), time from surgery to presentation, preoperative and postoperative corrected distance visual acuity (CDVA), postoperative uncorrected distance visual acuity, risk factors, culture results, medical and surgical treatment, and complications. Data collection fulfilled Spanish legal requirements, and institutional review board approval was obtained. Given the retrospective nature of the research design, no informed consent was required.

Patients had a complete ophthalmologic examination before surgery following a standard protocol to determine whether they were suitable candidates for the procedure. Written informed consent was obtained in each case.

Surgical Technique

All procedures were performed according to standard protocols. The surgical suite met the criteria for ophthalmologic laser procedures, and all instruments were autoclaved before surgery. Patients were instructed to perform lid hygiene during the 3 days before surgery. Surface ablation procedures were performed by PRK or LASEK.

Figure 1. Slitlamp photograph of a typical sterile infiltrate. The peripheral infiltrate was without overlying epithelial defect and appeared 2 days after PRK outside the area of the surgically induced epithelial defect. There was no anterior chamber reaction. Cases with these features were not included in the study because they are consistent with sterile NSAID-related infiltrates. An experienced surgeon can easily differentiate between sterile infiltrates and cases of suspected infectious keratitis (see Figure 2).

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Table 1. Patient demographics.

Parameter	Result
Age (years)	
Mean ± SD	38.10 ± 9.02
Range	25, 64
Sex	
Female	16 (41.02)
Male	22 (56.41)
Type of surgery	
LASEK	25 (64.10)
PRK	14 (35.89)
Primary	37 (94.87)
Reoperation	2 (5.12)

LASEK = laser-assisted subepithelial keratectomy; PRK = photorefractive keratectomy

Debridement of epithelium for PRK was performed mechanically using a hockey knife or assisted with exposure to 20% alcohol for 20 seconds, depending on the surgeon's preference. Laser ablation was performed in the right eye first and then in the left eye using a Technolas 217C or 217-Z-100 excimer laser (Bausch & Lomb) or the Mel 80 excimer laser (Carl Zeiss Meditec AG). A bandage soft contact lens was fitted after surgery, and the patient was prescribed a topical combination of tobramycin 3 mg/mL–dexamethasone 1 mg/mL (Tobradex) 4 times a day until the contact lens was removed and diclofenac sodium 0.1% 4 times a day for 2 days together with preservative-free artificial tears. Once the contact lens was removed, the patient received a tapering regimen of fluorometholone 0.1% and preservative-free artificial tears for 1.5 months.

Postoperative Assessment

Postoperatively, all patients were examined at 12 hours, 4 days (for contact lens removal), 1 month, and 3 months unless complications required more frequent visits. The outcome measures were the incidence of infectious keratitis after surface ablation, culture results, response to treatment, and visual acuity.

RESULTS

During the study period, 18 651 surface ablation procedures (primary or enhancement) were performed in 9794 patients. Infectious keratitis after surface ablation was diagnosed in 39 eyes of 38 patients (overall rate 0.2%). Table 1 shows the patients' demographics. Twenty-three infections (58.97%) involved the right eye and 16 (41.02%) involved the left. Infection was bilateral in 1 patient. Twenty-five eyes were treated with LASEK, and 14 eyes were treated with PRK. Of the eyes treated with PRK, 6 had mechanical debridement of the epithelium and 8 had an alcohol-assisted procedure. Two infections appeared after an enhancement procedure (Table 1). The mean follow-up was 7.6 months ± 7.24 (SD) (range 1 to 29 months) and was longer than 6 months in 14 cases. In 7 cases (all early onset and rapid resolution), the patients did not complete the scheduled routine visit at 3 months.

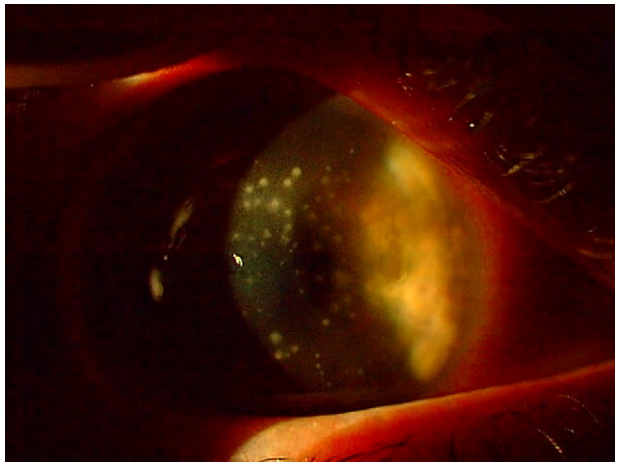

Figure 2. A slitlamp view of case 7 with suspected infectious keratitis shows multiple infiltrates within the area of surgical treatment that appeared 2 days after LASEK in a painful eye. Although culture was negative, treatment with an intense regimen of topical vancomycin and ciprofloxacin was started.

The mean time from surgery to the appearance of initial symptoms was 12.36 days ± 26.07 (SD) (range 1 to 160 days); onset was early (within 7 days postoperatively; mean 5 ± 1.68 days; range 1 to 7 days) in 28 eyes (71.79%) and late (more than 7 days postoperatively; mean 32 ± 44.43 days; range 8 to 160 days) in 11 eyes (28.20%). Most infections (89.74%) presented within 1 month. No clusters were detected. The following were identified as risk factors: blepharitis, dry eye, ocular trauma, spouse with conjunctivitis, health professional, and VII nerve palsy.

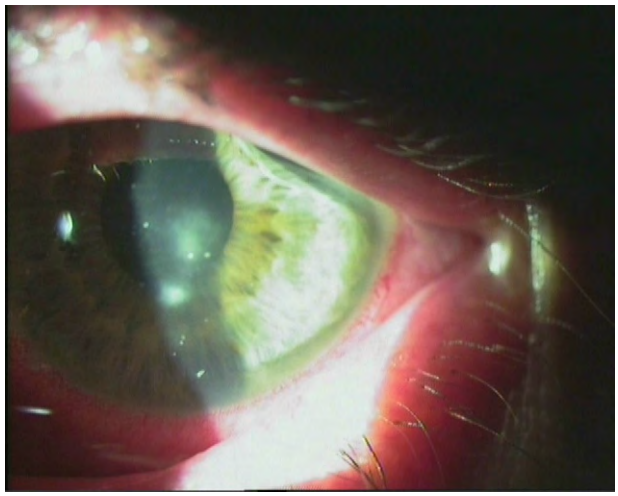

Figure 3. Slitlamp photograph of a proven case of infectious keratitis (case 34) after PRK. Two paracentral infiltrates were observed 5 days after PRK, and *S aureus* was isolated from cultures.

Table 2. Summary of cases of infectious keratitis after surface ablation procedures between January 2003 and December 2009, including risk factors, onset after surgery, microorganisms, treatment, and clinical outcome.

Case	Age (Y)/Sex	Eye	Surgery	Risk Factors	Present (D)	Culture Sample?	Organism
1	36/M	R	LASEK	Blepharitis	6	N	—
2	33/F	L	LASEK	—	3	Y	CP *Staph*
3	25/M	L	LASEK	—	7	Y	*Staphy* sp
4	51/M	R	PRK-M	—	6	Y	—
5	34/M	R	PRK-M	—	5	N	—
6	29/F	R	LASEK	—	4	Y	CN *Staph*
7	29/M	L	LASEK	—	2	Y	—
8	36/M	L	LASEK	—	5	Y	*Candida parapsilosis* (contact lens)
9	45/M	L	LASEK	—	7	N	—
10	57/M	L	LASEK	—	3	Y	*S aureus*
11	32/M	R	LASEK	—	7	Y	*S aureus*
12	41/F	R	PRK-A	—	18	Y	—
13	40/M	R	LASEK	—	7	Y	—
14	35/F	R	LASEK	VII nerve palsy	4	N	—
15	33/M	L	LASEK	—	5	Y	—
16	35/M	L	LASEK	—	5	Y	*S aureus*
17	31/M	R	PRK-M	Dry eye	4	N	—
18	52/M	L	LASEK	—	11	N	—
19	32/M	R	LASEK	—	8	Y	—
20	30/F	R	LASEK	—	5	N	—
21	64/M	L	LASEK	—	3	N	—
22	35/M	R	PRK-A	Trauma	38	Y	—
23	30/M	R	RE PRK-M	—	5	Y	—
24	40/F	R	PRK-A	Dry eye	160	Y	*S pneumoniae*
25	47/F	L	PRK-A	—	2	Y	*S pneumoniae*
26	39/M	L	PRK-A	—	11	Y	CN *Staph*
27	38/F	R	PRK-A	Dry eye; conjunctivitis husband	4	Y	—
28	45/F	L	PRK-M	Dry eye	45	Y	—
29	56/F	R	RE LASEK	—	7	N	—
30	29/M	R	LASEK	—	34	Y	—
31	38/F	R	PRK-A	HCW	8	Y	—
32	33/F	R	LASEK	—	11	Y	—
33	32/F	R	PRK-A	—	1	N	—
34	39/M	L	PRK-M	Blepharitis	5	Y	*S aureus*
35	29/M	R	LASEK	—	4	Y	*S epidermidis*
36	35/F	R	LASEK	—	5	N	—
		L	LASEK	—	2	N	—
37	33/F	R	LASEK	—	5	Y	—
38	53/F	L	LASEK	HCW	10	Y	*Pseudomonas*

Amik = amikacin 35 mg/mL; Amph = amphotericin; BCL = bandage contact lens; CDVA = corrected distance visual acuity (with spectacles); Ceftaz = ceftazidime 50 mg/mL; Ciprofl = ciprofloxacin 3.5 mg/mL (Oftacilox); CN = coagulase negative; CP = coagulase positive; Doxy = doxycycline; FU = follow-up; Gati = gatifloxacin 3 mg/mL (Zymar); Genta = gentamicin 16 mg/mL; HCW = health care worker; LASEK = Laser subepithelial keratectomy; Moxi = moxifloxacin 5 mg/mL (Vigamox); Neo+Pol+Gram = neomycin 1700 IU, polymyxin B 5000 IU, and gramicidin 25 IU per mL (Oftalmowell); Oflox = ofloxacin 3 mg/mL (Exocin); Pol+Trimet = polymyxin B 10000 IU and trimethoprim 1 mg per mL (Oftalmotrim); Present = presentation; PRK–A = photorefractive keratectomy, alcohol assisted removal of epithelium; PRK–M = photorefractive keratectomy, mechanical debridement of epithelium; RE = enhancement; sp = species; *S pneumoniae* = *Streptococcus pneumoniae*; *Staph* = *Staphylococcus*; Tobra = tobramycin 16 mg/mL; Tx = treatmentUDVA = uncorrected distance visual acuity; Vanc = vancomycin 50 mg/mL

*After penetrating keratoplasty

Regarding clinical symptoms, pain was present in 19 eyes (48.71%), decreased vision in 27 (69.23%), and red eye in 18 (46.15%). Seven patients (17.94%) reported photophobia, 10 (25.64%) reported tearing, and 22 (56.41%) reported discomfort.

Table 2. (Cont.)

Medical Tx	FU (Mo)	Preop CDVA	Postop UDVA	Postop CDVA
Oflox	4	20/20	20/20	20/20
Vanc + Ceftaz + Ciprofl	3	20/25	20/25	20/25
Oflox + Tobra	2	20/20	20/20	20/20
Oflox + Tobra + Ciprofl	18	20/20	20/25	20/20
Oflox + Ciprofl + Tobra	7	20/20	20/20	20/20
Moxi	3	20/40	20/63	20/50
Vanc + Ciprofl + Tobra	2	20/20	20/30	20/20
Oflox + Vanc	16	20/20	20/40	20/40
Oflox + Pol + Trimet	3	20/20	20/20	20/20
Vanc + Tobra + Ciprofl + oral minocycline	14	20/20	20/200	20/70
Genta + Moxi	11	20/20	20/20	20/20
Vanc + Ciprofl	25	20/25	20/100	20/32
Vanc + Ceftaz + Tobra	14	20/32	20/40	20/25
Oflox + Tobra	5	20/20	20/20	20/20
Vanc + Amik	27	20/20	20/20	20/20
Vanc + Amik	7	20/20	20/40	20/40
Vanc + Amik	5	20/25	20/30	20/30
Vanc + Oflox	9	20/25	20/32	20/30
Vanc + Tobra	4,5	20/20	20/20	20/20
Vanc + Tobra + Oflox	5	20/25	20/32	20/25
Oflox + Tobra	2	20/20	20/32	20/25
Vanc + Amik + Ciprofl	5	20/20	20/20	20/20
Vanc + Amik + Oflox	3	20/20	20/32	20/20
Vanc + Oflox + Gati	29	20/25	20/125	20/50*
Vanc + Oflox + Ciprofl	16	20/20	20/70	20/25
Vanc + Amik + Neo + Pol + Gram + Moxi	5	20/25	20/20	20/20
Vanc + Tobra + Amik	6	20/20	20/25	20/25
Vanc + Oflox	5	20/20	20/30	20/20
Oflox	1	20/20	20/20	20/20
Vanc + Oflox	11	20/20	20/20	20/20
Vanc + Ceftaz + Amph	2	20/20	20/20	20/20
Oral Doxy + Moxi + Fluconazole				
Tobra + Oflox + Ciprofl	3	20/20	20/20	20/20
Tobra + Oflox	3	20/20	20/20	20/20
Vanc + Tobra + oral minocycline	3	20/20	20/25	20/25
Vanc + Tobra + Oflox	2	20/20	20/25	20/20
Vanc + Ceftaz + Oflox	3	20/20	20/20	20/20
Vanc + Ceftaz + Oflox	3	20/20	20/20	20/20
Vanc + Oflox	1	20/25	20/20	20/20
Tobra + Amik	9	20/25	20/40	20/40

Corneal infiltrates were detected in all cases (1 infiltrate in 23 eyes, 2 in 11 eyes, 3 in 2 eyes, and more than 5 in the remaining cases) (Figures 2 and 3).

Samples were taken for microbiologic analysis in 27 cases before treatment. Fourteen of the samples were negative and 13 were positive. The microorganisms

identified were *Staphylococcus* species (*Staphylococcus epidermidis*, *Staphylococcus aureus*, and unidentified *Staphylococcus* species), *Pseudomonas* species, and *Streptococcus pneumoniae*. *Candida parapsilosis* was isolated from a contact lens but not from the corneal scraping in case 8 (Table 2). No opportunistic bacteria, fungi, or amoebas were cultured from corneal scrapings in these patients. Apart from 3 cases, the onset of symptoms was early in all cases with a positive culture. Seven *Staphylococci* isolates and the *Pseudomonas* isolate were sensitive to tobramycin, while 2 *Staphylococci* and the *S Pneumoniae* isolates were resistant to tobramycin. No methicillin-resistant *Staphylococcus* species were detected.

Treatment was started empirically with an intensive regimen of topical fortified antibiotics or a fluoroquinolone. Table 2 shows the antibiotic treatment regimens. A broad-spectrum combination consisting of fortified vancomycin with an aminoglycoside (tobramycin or amikacin) or a fluoroquinolone was the most common regimen. A fourth-generation fluoroquinolone was used in 3 cases (moxifloxacin [3 cases] and gatifloxacin [1 case]). Oral minocycline was added in 2 cases and oral doxycycline in 1 case. Despite a negative culture result, case 31 received topical amphotericin B and oral fluconazole because of the appearance of the infiltrate. All patients responded to medical therapy.

Table 2 also shows the visual results. The mean final CDVA was 0.08 $\pm$ 0.13 logMAR (Snellen range 20/63 to 20/20). Twenty-six cases maintained CDVA. The final CDVA was 20/20 or better in 23 cases (58.97%), 20/40 or better in 36 cases (92.30%), and worse than 20/40 in 3 cases (7.69 %). Residual corneal scars were recorded in 23 eyes (Figure 4). Rehabilitation procedures after resolution of infection included glasses (3 cases), contact lenses (3 cases), arcuate keratotomy (1 case), LASEK enhancement (1 case), and penetrating keratoplasty (PKP) (1 case). The latter (case 24) was performed 12 months after the onset of infection (Table 2).

Figure 4. Slitlamp view of residual corneal leucoma after resolution of infectious keratitis after PRK (case 24). The patient had PKP.

DISCUSSION

Surface ablation procedures are increasingly popular. New excimer delivery systems and prophylactic mitomycin-C have led to better PRK results with a minimal risk for stromal haze. Surface ablation procedures eliminate the risk for flap-related complications, and the risk for ectasia in particular is significantly diminished.[1] Recent evidence shows that the LASIK flap creates topographic changes that affect the accuracy of wavefront ablations with greater higher-order aberrations and lower contrast sensitivity in LASIK eyes than in eyes treated with surface ablation.[5,6] However, there is little information in the literature on the incidence of infectious keratitis after LASIK compared with the incidence after surface ablation procedures. This is important because infectious keratitis is a potentially sight-threatening complication of corneal laser refractive surgery.

The actual incidence of infectious keratitis after surface ablation varies widely depending on the source of the data. In our study, we found 39 cases in 18 651 procedures (ie, an incidence of 0.2% or 1 case in 500 procedures). To our knowledge, this is the largest series of infectious keratitis after surface ablation reported to date and the first large series of infectious keratitis after LASEK. The true incidence depends on our completeness of follow-up of the 18 651 eyes that had surface ablation. If patients do not complete the follow-up, the possibility exists that cases of infectious keratitis would be missed. Nevertheless, it is our experience that most patients attend all scheduled visits. Moreover, these visits are included in the cost of the procedure, so they are free of charge. Ours is a private ophthalmology institution with 19 centers throughout Spain; therefore, any patient could reasonably be expected to attend the scheduled follow-up appointment if they experienced any change from his or her last visit. We believe, then, that the calculated incidence is reasonably accurate. The incidence of infectious keratitis we observed is similar to that reported by Machat[9] and de Oliveira et al.[10] but it is 10-fold higher than the 0.019% estimated by Wroblewski et al.[7] and Leccisotti et al.[8] The reason for a lower rate of infection in the latter series is unclear. Both are retrospective studies in which cases of infection could have been missed. All the series mentioned above include patients treated with PRK, while our series consisted of patients treated with

PRK or LASEK. Few cases of infectious keratitis after LASEK[13–16] have been published. Nevertheless, we assumed that the incidence of infection would be similar to that of PRK; therefore, we considered the incidence and presentation characteristics of both procedures as a whole.

It appears as though the incidence of infection after surface ablation procedures could be higher than that of post-LASIK infectious keratitis. We previously reported a rate of infection of 0.035% after LASIK at our institution (72 cases of infection in 204 586 procedures),[22] which is 5.7 times lower than the incidence of 0.2% after surface ablation ($P < .001$, χ^2 test). The institution, the protocols, the operating room, and the surgeons were the same; thus, in the absence of other unknown variables, the only factor that could account for the difference in infection rate is the type of procedure itself. This finding is consistent with the results in a previous study[10] in which the incidence of infection after LASIK was 0.1% (0.2% in PRK). Certainly, one would expect an increased risk in surface ablation procedures because the cornea is open to infection for 3 reasons. First, the epithelial defect (approximately 6.0 to 8.0 mm) leading to a breakdown of the barrier function of the corneal epithelium takes approximately 4 days to heal. Second, the use of a bandage contact lens on an extended-wear basis[23,24] increases the risk for microbial keratitis. Third, the use of topical corticosteroids to control wound healing may suppress the ability of the immune system to fight infection. Continued analysis of the relative safety and efficacy of these procedures is highly relevant with regard to informed consent and evidence-based clinical practice.

Infectious keratitis after LASIK is classified as early onset (occurring within 1 to 2 weeks after surgery) and late onset (occurring after 1 or 2 weeks to 3 months after surgery).[25] Similarly, we analyzed the percentage of early and late infectious keratitis after PRK in our series and the results were consistent with those of other authors.[7,8,10,11] Most infections appeared within 1 week of surgery, and the percentage of early infections was higher than the estimated 62.5% of infections classified as early onset after LASIK in our previous study.[22]

Apart from 1 case, the microorganisms detected in the current series were gram positive and all except 3 cases presented before 7 days. In case 8, *C parapsilosis* was isolated from the contact lens but not from corneal scrapings; this was probably the result of sample contamination. No cases of mycobacterial infection were detected. These etiologies cannot be ruled out by negative culture results, although this seems unlikely because all infections responded quickly to medical therapy. In a previous literature review,[11] anecdotal cases of infectious keratitis after PRK caused by mycobacteria and fungi were identified; however, in the 2 largest series of keratitis after PRK, gram-positive microorganisms were responsible for all cases [11] or for all cases except 1 (caused by fungus).[12] Donnenfeld et al.[11] registered a single case caused by a gram-negative microorganism, *Pseudomonas aeruginosa*. A high incidence of bacterial keratitis caused by *P aeruginosa* has been reported in studies of contact lens–related keratitis.[26] In the current study, only 1 case was caused by *Pseudomonas* species. The patient was a health professional. A higher risk for infection by methicillin-resistant *S aureus* (MRSA) has been found to be associated with the health care environment,[11,27] although we are not aware of such a risk factor for gram-negative microorganisms. It has been suggested that, after PRK, gram-positive organisms pose the greatest risk for infectious keratitis,[11] which probably originates in the eyelid and conjunctival flora.

Several sources of infection have been reported, including surgical instruments, surgeons' hands, environmental factors, and periocular flora. Feizi et al.[28] found the rate of corneal interface contamination during LASIK to be 24.5%. Other studies of contamination during intraocular surgery[29–31] also found *S epidermidis* to be one of the most commonly retrieved organisms. *Staphylococcus epidermidis* is a normal inhabitant of the eyelids, eyelashes, and conjunctiva, and it is believed that the bacteria that cause postoperative complications originate from the eyelids and conjunctiva. However, in the study by Feizi et al.,[28] in 38.8% of contaminated cases, cultures of the eyelid margins, conjunctiva, and instruments were negative; therefore, the sources of contamination could not be determined. A recent study by Chung et al.[32] analyzed the antibiotic susceptibility of conjunctival bacterial isolates from patients who had refractive surgery. The microorganisms isolated were as follows: coagulase-negative staphylococci (85%), *S aureus* (2.3%), *S pneumoniae* (1.2%), and gram-negative bacilli (4.8%). The most effective antibiotic agents against these bacteria were moxifloxacin, gemifloxacin, and gatifloxacin.

The current study is limited by the high rate of negative cultures, which could be due to technical reasons such as scant samples, sample alteration during transport to the reference microbiology laboratory, and previous growth-inhibiting antibiotic therapy. Also, 12 of the 39 cases of infection were not cultured before treatment. We are aware that proper management of infectious keratitis includes scraping and culturing, and this step is recorded in our protocols. However, our clinics are outpatient (not part of a hospital environment); therefore, culture plates are not always available when the emergency treatment is started. The risk caused by the delay in obtaining the plates in some circumstances (eg, holidays) outweighs the

benefits of obtaining the sample. Therefore, empiric treatment is started even if plates are not available.

The potential risk factors for keratitis after surface ablation reported in the literature include blepharitis, contact lens manipulation, and health care environment.[7,11,27] We identified blepharitis, dry eye, previous trauma, conjunctivitis in the husband, and healthcare environment to be possible risk factors. These findings stress the importance of proper preoperative examination and treatment of the lids and dry-eye disease.[33] Eyelid hygiene, which is included in our preoperative protocol, decreases bacterial load on the corneal surface; therefore, it is reasonable to believe that this measure could be associated with a decreased risk for infection, although this has not been shown in this study or elsewhere. We usually initiate hygiene measures no more than 3 days before surgery because longer periods could alter the distribution pattern of the saprophytic ocular flora.[34]

In a review of cases of post-LASIK infectious keratitis caused by MRSA, Solomon et al.[27] found that 8 of 11 patients were exposed in a health care setting. Two of our patients were health professionals, although we did not isolate MRSA. One culture grew *Pseudomonas* and the other was negative.

One of our patients presented with bilateral involvement. Some clinicians recommend performing monocular surgery or using separate instruments when performing bilateral surgery[35]; however, this is not the practice of the members of the American Society of Cataract and Refractive Surgery Cornea Clinical Committee.[33]

The rate of symptom presentation was similar to that reported elsewhere for post-LASIK infectious keratitis.[22,25] Given that 71.79% of the cases appeared within 1 week and 89.74% within 1 month, we strongly recommend the postoperative follow-up visit schedule followed in our clinics (see above).

The mean follow-up in this study was 7.07 months (range 1 to 29 months). Seven cases did not complete the 3-month scheduled routine visit. All of them were cases with early onset and rapid resolution. Patients would have been expected to attend the scheduled follow-up appointment if they had experienced any change from their last visit.

Infectious keratitis is easily detected by the presence of focal infiltrates. Slitlamp biomicroscopy most commonly shows corneal infiltrates, which were present in all our cases. This finding is consistent with those in post-LASIK infectious keratitis.[22,25] Sterile infiltrates, which are related to contact lens–induced hypoxia or topical nonsteroidal antiinflammatory drugs (NSAIDs), may be present during the first week after surgery. These infiltrates must be differentiated from infectious keratitis. In fact, infiltrates that were considered sterile were not included in the study; they were peripheral or midperipheral and small (1.0 to 3.0 mm) with no anterior chamber reaction. In most cases, the epithelium overlying the infiltrate was intact or with minimal localized superficial keratopathy and the infiltrates are outside the area of the surgically induced epithelial defect. These infiltrates are treated by an intensive regimen of topical antibiotic agents accompanied by gram-positive coverage and removal of the soft contact lens. The incidence of NSAID-related infiltrates decreases significantly with concomitant use of topical corticosteroids (included in our protocol after surface ablation).[9,20] Although sterile infiltrates have a typical appearance and patients are followed by the surgeon who performed the procedure, it is possible that some of the 14 cases with a negative culture result or in which culture was not performed could have been sterile infiltrates. If that were the case, our results would overestimate the real incidence of infectious keratitis after surface ablation, although the possibility seems highly unlikely. The occurrence of proven infections (cases with positive culture) in the current series would be 0.06%. This incidence would still be significantly higher than the occurrence of infections after LASIK ($P < .05$, chi-square test).[22]

Management of post-PRK infectious keratitis with aggressive antibiotic agents and the addition of gram-positive coverage and removal of the soft contact lens have been recommended.[7,10,11] Unlike post-LASIK infections, the scraping procedure is easier, bacteria are not sequestered at the interface, and the flap does not prevent penetration of antibiotic agents. Even with early and aggressive treatment, flap amputation is necessary in some cases of post-LASIK keratitis.[22,25,36] All eyes in our series responded to medical therapy, as did those in other post-PRK series.[7,10,11]

Visual acuity results in the current series are reasonably satisfactory and similar to those published by other authors. Wroblewski et al.[7] reported a final CDVA of 20/30, 20/25, 20/16, 20/20, and 20/20 in 5 patients with infectious keratitis after PRK. In the series of 13 cases from Donnenfeld et al.,[11] final visual acuity ranged from 20/20 to 20/100. The CDVA was 20/20 in 5 cases, 20/40 or better in 11 cases, and worse than 20/40 in 2 cases, with 1 patient awaiting PKP. In a study by de Oliveira,[10] the final CDVA was 20/20 or better in 7 of 9 cases of culture-proven infectious keratitis after PRK and 20/40 or better in the remaining 2 cases. Quick resolution and excellent visual acuity were also reported after infections caused by gram-positive organisms in previous series of post-LASIK keratitis.[25] In our previous study of post-LASIK infectious keratitis,[22] the CDVA was 20/20 or

better in 52.7% of eyes, 20/40 or better in 93.05%, and 20/40 or worse in 6.94%. The mean final CDVA was 0.08 ± 0.15 logMAR. Although management of post-LASIK infectious keratitis is more challenging than treatment of infectious keratitis after surface ablation, there were no statistically significant differences in final visual acuity outcomes after management of infectious keratitis between surface ablation and LASIK ($P = .901$, Mann-Whitney test).

In summary, infectious keratitis after surface ablation was recorded in 0.2% of cases, which is higher than after LASIK. Although management of post-LASIK infectious keratitis is more challenging than treatment of infectious keratitis after surface ablation, the visual results are the same. Infectious keratitis after surface ablation is a potentially vision-threatening complication. Antibiotic prophylaxis and treatment should be broad spectrum and include gram-positive coverage. Prompt and aggressive management of this complication (eg, early scraping, culture, and intense topical antibiotic therapy) can preserve useful vision in most cases.

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