Int Ophthalmol (2014) 34:1107–1114
DOI 10.1007/s10792-014-9919-7

ORIGINAL PAPER

Intraoperative and early postoperative flap-related complications of laser in situ keratomileusis using two types of Moria microkeratomes

Yunus Karabela · Orkun Muftuoglu · Ibrahim Gokhan Gulkilik · Mehmet Selim Kocabora · Mustafa Ozsutcu

Received: 2 September 2013 / Accepted: 3 February 2014 / Published online: 17 February 2014

Abstract The purpose of this study is to describe the incidence, management, and visual outcomes of intraoperative and early postoperative flap-related complications of laser in situ keratomileusis (LASIK) surgery using two types of Moria M2 microkeratomes. This retrospective analysis was performed on 806 primary LASIK cases. The intraoperative and early postoperative flap-related complications were identified and categorized according to type of Moria microkeratome. There were 52 intraoperative and early postoperative complications—one case of partial flap (0.124 %), one case of free flap (0.124 %), one case of small flap (0.124 %), 13 cases of epithelial defect (1.61 %), 12 cases of flap striae (1.49 %), 10 cases of diffuse lamellar keratitis (1.24 %), 10 cases of interface debris (1.24 %), three cases of epithelial ingrowth (0.37 %), and one case of microbial infection (0.124 %). The overall incidence of flap complications was 6.45 %. There were 27 right eye (6.73 %) and 25 left eye (6.17 %) complications. The incidence of complications with the Moria automated metallic head 130 microkeratome was 4.22 % and with the Moria single-use head 90 microkeratome was 2.23 %. We observed one culture-negative interface abscess which was cured with surgical cleaning and intensive medical treatment. The most common complication encountered was epithelial defects, followed by flap striae. Our study showed that LASIK with a microkeratome has a relatively low incidence of intraoperative and early postoperative flap complications. The authors have no financial interest in any of the issues contained in this article and have no proprietary interest in the development of marketing of or materials used in this study.

Keywords Early postoperative flap complication · Intraoperative flap complication · Laser in situ keratomileusis · LASIK · Microkeratome

Y. Karabela (✉) · O. Muftuoglu · I. G. Gulkilik · M. S. Kocabora · M. Ozsutcu
Department of Ophthalmology, Medipol Mega Universite Hastanesi, Goz Hastaliklari, Istanbul Medipol University, TEM Otoyolu No: 1, Bagcilar, 34214 Istanbul, Turkey
e-mail: mrsbela@yahoo.com

Introduction

Laser in situ keratomileusis (LASIK) is the most popular method for the surgical correction of refractive errors worldwide. The creation of the lamellar flap is one of the most critical steps for succesful LASIK [1–4]. In LASIK surgery, as with any other surgical procedure, complications can occur [5]. Common intraoperative flap-related complications include button hole flaps, thin flaps, decentralized flaps, free flaps, incomplete flaps, and lacerated flaps. The common early postoperative flap-related complications also include flap displacement, flap striae, central toxic keratopathy, diffuse lameller keratitis (DLK), epithelial ingrowth, and

microbial keratitis. The incidence of flap-related complications in previous LASIK series is reported to be between 0.3 and 14 % and usually depends on the type of the microkeratome used and the surgeon involved [6–21].

In this retrospective study, we analyzed the incidence, management, and results of intraoperative and early postoperative flap-related complications in primary LASIK surgery.

Patients and methods

This retrospective study included a consecutive series of 806 eyes of 408 patients (228/55.9 % male; 180/44.1 % female) who underwent LASIK between January 2005 and April 2009 for treatment refractive errors at the Excimer Laser Center, Department of Opthalmology, Nisa Hospital, Istanbul, Turkey. All LASIK procedures were performed by the one author (YK) using the VISX STAR S4 Excimer Laser Platform (Abbott Medical Optics Inc.). Written and informed consent was provided by all patients regarding surgical intervention and inclusion in the study. The study was performed as per the tenets on the Declaration of Helsinki.

All patients underwent a complete preoperative opthalmological examination including measurement of uncorrected visual acuity (UCVA), and best spectacle-corrected visual acuity (BSCVA), measurement of refraction (manifest, dilated, and/or wavefront refractions) and keratometry, slit-lamp examination with fundus evaluation, measurement of corneal topography (Orbscan II; Bausch & Lomb, Rochester, USA) and/or ultrasonic pachymetry (US-1800 Echoscan; Nidek, Achi, Japan), and measurement of intraocular pressure. Inclusion criteria were myopia between −1.0 D and −13.0 D, <−5.50 of corneal astigmatism, hyperopia between +1.50 and +6.0 D, age ≥18 years with stable refraction for at least one year, and central corneal thickness >480 μm. Patients with a history of corneal dystrophy or herpetic eye disease, topographic or clinic evidence of keratoconus or degenerative corneal disorder or warpage from contact lenses, severe dry eye, corneal scarring, any ocular disease such as glaucoma, uveitis, collagen vascular diseases, and the use of systemic corticosteroids or antimetabolities were excluded.

The standard LASIK technique was performed in all patients. Two drops of proparacaine 0.5 % (Alcaine; Alcon) was instilled in each eye 5 min and just before the procedure. The perioculer area was cleaned with povidone-iodine preparation (Betadine). Eyelashes were isolated by sterilized plastic adhesive drapes and a speculum. The cornea was marked with a corneal marker using Gentian violet staining. A vacuum ring was placed into the operative eye and adequate vacuum obtained. The microkeratome settings (suction ring, flap stop) were chosen according to the steepest K (nomogram), aiming for the optimal flap diameter. The flaps were prepared using either the Moria M2 automated metallic head 130 or the M2 single-use head 90 microkeratome (Moria, Anthony, France); the hinges were positioned superiorly in all cases. The standard speed of pass was used in all patients. The blade was changed for each patient and the generally the right eye was treated first in bilateral cases. The stromal bed was dried with a surgical sponge and ablation was performed. After ablation, the stromal bed was irrigated with balance salt solution to wash out any debris or epithelial cells. Flap position and centration were checked and a striae test was performed to ensure proper flap adherence. Antibiotic and steroid drops were instilled, and the speculum and drape were then removed. All patients were examined 30–60 min after surgery to check flaps. Postoperatively, patients were given prednisolone acetate 1 %, and ofloxacin 0.3 % drops four times a day for 2 weeks and artificial tears solution (single use, preservative-free) six or eight times a day for 1 month. Bandage contact lenses were used on selected cases.

Data collected from the charts included patient's age, gender, preoperative refraction, spherical equivalent (SE), preoperative corneal thickness, keratometric values, and details of intraoperative and early postoperative flap complications. Statistical analysis of the results was performed using SPSS V21 program for Windows. Correlations, descriptive statistics, frequencies, Student *t* test and nonparametric tests (Chi squared, Mann–Whitney *U* tests) were analyzed.

Results

Between January 2005 and April 2009, 806 eyes of 408 patients (401 right eyes, 405 left eyes) underwent primary LASIK surgery. The Moria M2 single-use head 90 microkeratome was used in 183 (22.7 %) eyes and the Moria M2 automated metallic head 130

Table 1 Demographic and refractive data, and the incidence of intraoperative and early postoperative flap-related complications

Complications	Gender	Eye	Keratome	Mean age (years)	Mean spherical equivalent (D)	Mean step K(D)	Mean flat K(D)	Mean preoperative thickness (μm)	Group incidence (%)	Overall incidence (%)
Incomplete flap	1F	1 L	1 Met	21 ± 0.00	−1.750 ± 0.00	45.00 ± 0.00	44.75 ± 0.00	534 ± 0.00	1.923	0.124
Free flap	1F	1 R	1 Sing	20 ± 0.00	−4.125 ± 0.00	43.25 ± 0.00	42.50 ± 0.00	543 ± 0.00	1.923	0.124
Small flap	1M	1 R	1 Met	24 ± 0.00	−2.750 ± 0.00	43.43 ± 0.00	43.26 ± 0.00	566 ± 0.00	1.923	0.124
Epithelial defects	5F + 7M	10 R + 3 L	11 Met + 2 Sing	36.76 ± 12.0 (18 − 59)	−1.68 ± 3.35 (2.88 to −7.00)	43.33 ± 1.50 (41.75 − 47.25)	42.37 ± 1.70 (40.12 − 46.25)	567.92 ± 44.45 (504 − 631)	25.0	1.61
Flap striae	5F + 5M	3 R + 9 L	7 Met + 5 Sing	26.83 ± 6.36 (20 − 44)	−3.91 ± 2.0 (−1.75 to −8,750)	44.79 ± 1.39 (43.25 − 47.37)	43.20 ± 1.33 (41.00 − 45.25)	562.0 ± 31.39 (514 − 610)	23.07	1.49
Diffuse lamellar keratitis	4F + 4M	5 R + 5 L	4 Met + 6 Sing	29.10 ± 5.66 (20 − 41)	−3.25 ± 2.67 (0.63 to −8.75)	43.67 ± 1.79 (41.25 − 46.00)	42.64 ± 1.81 (39.12 − 44.75)	541.5 ± 24.50 (494 − 569)	19.23	1.24
Microbial keratitis/ infection	1M	1 R	1 Sing	19 ± 0.00	−2.250 ± 0.00	42.25 ± 0.00	41.75 ± 0.00	598 ± 0.00	1.923	0.124
Interface debris	7F + 3M	5 R + 5 L	7 Met + 3 Sing	27.70 ± 7.9 (19 − 46)	−3.54 ± 2.71 (1.50 to −8.75)	43.94 ± 1.76 (41.50 − 47.25)	42.81 ± 1.80 (40.75 − 46.75)	551 ± 22.02 (523 − 598)	19.23	1.24
Epithelial ingrowth	2M	1 R + 2 L	3 Met	23.66 ± 1.15 (23 − 25)	−6.33 ± 2.40 (−3.75 to −8.50)	43.29 ± 0.56 (42.75 ± 43.87)	42.25 ± 1.52 (40.50 − 43.25)	568 ± 13.52 (554 − 581)	5.77	0.37

D diopters, *R* right eye, *L* left eye, *F* female, *M* male, *Met* metallic head, *Sing* single-use head

microkeratome in 623 (77.3 %) eyes. Of these, intraoperative and early postoperative flap-related complications were identified in 52 (6.45 %) eyes of 36 (8.83 %) patients (20/55.55 % females; 16/44.45 % males). Complications occurred in 27/401 (6.73 %) right eyes and 25/405 (6.17 %) left eyes. Of these 52 eyes, 34 (4.22 %) were treated with the Moria metallic head and 18 (2.23 %) with the Moria M2 single-use head 90 microkeratome. No statistical difference was found for microkeratome-related flap complications between the Moria M2 single-use 90 and the metallic head microkeratome (11eyes vs 30 eyes; $t = 0.645$, $p > 0.05$). All eyes studied had refractive myopia, hyperopia and astigmatisma. The mean age of all patients was 29.01 ± 7.78 years (range 18–59 years). The mean age for patients with flap complications was 29.29 ± 9.12 years (range 18–52 years), the mean preoperative SE was 3.20 ± 2.78 D (range +2.875 to −8.750 D), the mean preoperative steep K power was 44.06 ± 1.62 D (range 41.50–47.37 D), the mean preoperative flat K power was 42.74 ± 1.58 D (range 39.12–42.74 D), and the mean preoperative corneal thickness was 557.80 ± 31.93 μm (range 494 to −631 μm). Demographic, refractive data, and the incidence of flap-related complications are shown in Table 1.

Keratectomy was incomplete in the second eye of a 21-year-old female patient when the microkeratome stopped before completing the cut. This case was treated succesfully by re-cutting the cornea 6 weeks after the initially surgery. Final UCVA was 1.2, and manifest refraction was 0.00. Additionally, poor keratectomy also occurred in another patient. A slightly smaller flap was formed, but the ablation was not postponed. Preoperative refraction of the eye was –2.75. Postoperative final refracion was +0.50 × 30°, UCVA was 1.0, and the patient was satisfied 2 weeks after surgery. Preoperative measurements, especially K powers, were normal for the two above cases. The overall incidence of both complications was 0.124 % seperatedly (Table 1).

Free complete flap occurred in only one eye (0.124 %). The patient had a mild myopia (−4.0 D) and minimal astigmatism (−0.25 D). BCSVA of this patient was 1.0 preoperatively. Preoperative data of this patient were normal, and patient did not have a flat cornea. The Moria M2 single-use head was used in this procedure. Free flap occurred in the right eye during the first operation and the procedure was aborted, and ablation was not applied. The flap was then placed, and sutured at the hinge at 6 o'clock with a 10-0 nylon suture (Alcon). A bandage contact lens was used. The sutures were removed on the second postoperative day. No loss of line in BSCVA or irregular astigmatism were observed. Postoperative refraction for this eye was −4.0 (−0.50 × 160°) which was similar to preoperative refraction.

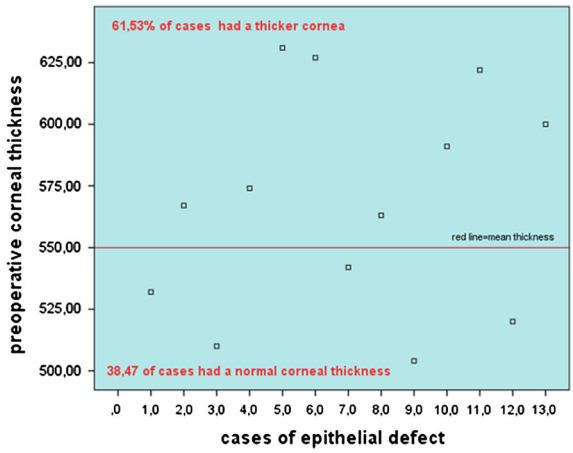

Fig. 1 Distribution of epithelial defects and preoperative Orbscan corneal thickness

Flaps folds were detected in 12 eyes postoperatively. The overall incidence of flap folds was 1.49 %; most of them were fine lines (microstriae) on the first day after the surgery. Flap repositioning procedures were performed in both eyes of one patient on the first day after surgery where a metallic head microkeratome had been used in both eyes. The Moria automated metallic head microkeratome was used in five of the remaining ten eyes and the Moria M2 single-use head was used in the other five remaining eyes. A statistically significant relationship was found between flap striae and age ($r = 0.676$; $p = 0.22$).

Epithelial defects or abrasions were detected in 13 eyes (1.61 %) (Fig. 1). Epithelial defects occurred in 11 eyes in which the Moria metallic head microkeratome had been used. Although most of the patients had a thick cornea >550 μm (61.53 %), this result was statistically insignificant ($r = 0.37$; $p = 0.655$) because the mean preoperative corneal thickness in all cases was 557.80 ± 31.93 μm. There were two facts to consider regarding epithelial defects. First, epithelial defects occurred more commonly in the first eye to undergo surgery, i.e., the right eye, and second,

the use of the Moria metallic head microkeratome. No relationship was found between age or gender or preoperative SE or steep/flat K power ($p > 0.05$).

We detected interface debris in ten eyes (overall incidence 1.24 %). Seven (70 %) of the ten eyes were treated with the Moria metallic head microkeratome, and three (30 %) with the Moria M2 single-use head. In five cases, the flaps were lifted and interfaces were irrigated. DLK occurred simultaneously in two eyes with interface debris. One of the patients had epithelial defects simultaneously.

DLK occurred in ten eyes of eight (4 females, 4 males) patients (1.24 %). The other features of DLK are shown in Table 1. Two eyes of one patients had both DLK and striae. All cases had stage I or II, and were treated with topical corticosteroids. One of them occurred after the repositioning procedure for flap striae.

Infectious keratitis occurred in one eye of one patient. On the first postoperative day the cornea and interface were clear. Minimal debris was noted in the interface of the fellow eye. The patient came back with blurred vision, photophobia, conjunctival hyperemia on the fifth postoperative day. A 1–1.5 mm round gray-white abscess with stromal infiltration was located in the interface. The interface was opened and irrigated with antibiotic/antifungal solution after taking a culture. Gram staining and culture were negative. The progression of infiltration was rapid, and satellite infiltration appeared despite systemic, subconjontival and topical antibiotic treatment. Systemic and topical antifungal treatment was then added. The progression was controlled with intensive treatment and visual complications were prevented. The patient lost three lines of BSCVA, final refractive data was $+0.25$ ($+2.50 \times 122°$), and a slight inactive infiltration was observed on the third postoperative month.

Epithelial ingrowth was detected in two patients—both eyes of one patient and the left eye of the other patient. Epithelial ingrowth was detected in both eyes of the first patient, a 23-year-old male, during the first month after surgery. In the right eye, preoperative SE was -8.50 D, preoperative corneal thickness was 569 μm, and preoperative K reading for flat, and steep powers was 43.25. In the left eye, these values were -6.75 D, 581 μm, and 43.0 D and 43.87 D, respectively. The patient had grade I epithelial ingrowth in the right eye and grade II in the left eye. The left eye was treated by reopening the flap. The stromal bed and the back of the flap were scraped and the interface was irrigated. Six months after this procedure, no progression was detected in both eyes. He had lost no lines of BSCVA in the left eye. On the first postoperative month, refraction of the right and left eye was -0.50 ($-0.50 \times 100°$) and 0.00 ($-1.0 \times 65°$), respectively. Final refraction of the left eye after re-operation was $+0.25$ on the sixth postoperative month. Epithelial ingrowth appeared in the left eye of the second patient, a 25-year-old male, two months postoperatively. There was grade I–II ingrowth. The patient was followed up for 6 months. No progression occurred; however, the patient lost two lines of BSCVA in the affected eye. His preoperative refraction was -2.0 ($-1.75 \times 15°$) and his final refraction was $+0.25$ ($+0.75 \times 135$) at 6 months postoperatively. His preoperative SE was -3.75 (sphere -2.75, cylinder -2.0), preoperative thickness was 554 μm,and preoperative K reading was 42.75 D for the steep K, and 40.50 D for flat K power.

Statistically, there was no significant relationship between microkeratome-related complications (free, incomplete and small flaps, epithelial defects, and flap striae; together) and preoperative K readings ($p > 0.05$). In this study, no statistically significant correlation was found between the laterality of the eye and the incidence of flap complications (Chi squared $p = 0.199$). No button hole or decentralized or displaced flap was identified.

Discussion

Although LASIK has some advantages over surface ablation, its primary disadvantage is flap-related complications [21]. In this study, we reviewed the incidence of flap-related complications using the Moria M2 automated metallic head 130 and the Moria M2 single-use head 90 microkeratomes. In our study, the incidence of intraoperative flap-related complications was 1.99 %, and early postoperative flap-related complications was 4.46 %; the overall incidence was 6.45 %. The Moria M2 single-use head 90 microkeratome was used in 18 of the 52 eyes and the Moria M2 metallic head 130 microkeratome was used in 34 of the 52 eyes (34.61 vs 65.39 %). Microkeratome-related complications (incomplete flap, free flap, small flap, epithelial defect, flap stria, interface debris, and epithelial ingrowth) were found in 11 eyes with the

Moria M2 single-use 90 head and in 30 eyes with the Moria M2 metallic head; however, no statistical difference was found between the Moria M2 single-use 90 head and M2 metallic head ($p > 0.05$). The etiology of poor keratectomy and risk factors for flap-related complications have been postulated to be multifactorial [21]. Our complication rates were either lower or comparable to previous reports [6–21].

A free cap is a free corneal flap without a hinge. Failure to the stop the mechanism of the microkeratome, inadequate or loss of suction, and a flat cornea (keratometry readings ≤41 D) may lead to the formation of a free flap. The reported incidence of free flap with different microkeratomes ranges from 0.1 to 5.9 % [5–16]. In our study, the incidence of free flap was 0.124 %, and no association was found with keratometric readings (flat K, 42.50 D; steep K, 43.25 D). We had only one case of a complete free flap that was repositioned and sutured. In this case the stromal bed was seen to be adequate in size, but the laser ablation was not applied. Sutures were removed on the second postoperative day. The flap reposition was good and the patient did not have any loss of BSCVA; re-cutting was not performed because the patient refused re-operation.

Incomplete or partial flaps are the result of a premature stop of the microkeratome during its course, and have been reported in up to 5 % of cases [10, 13]. In this study, an incomplete flap occurred in one eye (0.124 %). The surgery was aborted, and the partial flap was replaced. Re-cutting and ablation procedures were performed successfully after six postoperative weeks.

A small diameter flap occurred in one eye (0.124 %). In this case, the flap lifted and ablation was applied because the surgeon decided that the stromal bed was smooth and adequate in size. Preoperative K readings of this case were 43.43 D for steep K and 43.26 for flat K power. In a large study by Albelda-Valles et al. [22], the incidence of free and incomplete flaps was found to be higher in flatter corneas, whereas the incidence of epithelial abrasions and thin/irregular flaps was found to be higher in steeper corneas. In our study, no relationship was found between preoperative K readings and free, small or incomplete flaps or epithelial defects.

In our study, epithelial defects were the most common intraoperative complication of LASIK, similar to other studies. The overall incidence of epithelial defects during LASIK is thought to be between 2.6 and 14 %. Different microkeratomes have different rates of associated epithelial defects [14–21]. The incidence of epithelial defects in our series was 1.61 %, and occurred mostly in eyes that had undergone surgery with the Moria M2 metallic head (84.61 %). Use of the Moria metallic head seemed to play a role in epithelial defects. Khachikian et al. [20] evaluated 4,000 LASIK procedures and noted epithelial defects in 326 (8.2 %). They also reported that microkeratome design and head type played a role in the formation of epithelial defects. Corneal epithelial defects during LASIK result from overuse of topical anesthetic drops, trauma by the corneal markers, the suction ring, passage of the microkeratome over the surface, dehydration and drying of the flap, or minor trauma by forceps or spatula. The risk factors are epithelial basement membrane dystrophy, age >40 years, hyperopia, thicker preoperative corneal thickness, and surface drying during keratome pass. An epithelial defect can also increase the patient's risk of developing DLK, flap striae, and epithelial ingrowth [14, 15, 23, 24]. Shah et al. [25] reported that the presence of an epithelial defect increases the risk of developing DLK 24 times. On the contrary, Yıldırım et al. [14] did not find any association. In this study, DLK did not occur in any case of epithelial defect. In our study, there was no evidence of a relationship between epithelial defects and age, gender or hyperopia. However, there was a relationship between epithelial defects and the first eye to undergo surgery; 76.92 % of 13 eyes with epithelial defects were the first eyes to undergo surgery. Chen et al. [24] also reported a correlation between epithelial defect and age, but no correlation with gender, corneal curvature, preoperative thickness, microkeratome, or preoperative/postoperative refraction. In the overhelming majority of patients, epithelial defects healed within 24–48 h. A bandage contact lens was applied at the end of the procedure and left in place until the epithelial defect healed. A recurrent corneal erosion occurred in one eye after three postoperative months. Pressure patching and a bandage contact lens was applied. In this study, the epithelial defects may be associated with blade quality or head type or preoperative thicker cornea. Overuse of medication or surgical trauma may also have contributed.

The incidence of flap striae or folds after LASIK reported in various studies ranges from 1.1 to 10 %

[6–10, 12–15]. In our study, the incidence of flap striae or fold was 1.62 %. We determined a significant correlation between flap striae and age ($r = 0.679$; $p = 0.22$), i.e., increasing flap striae with increasing age. Flap striae are classified into two types—macrostriae and microstriae. Central striae or any striae that affect visual acuity, quality of vision or cause irregular astigmatism, should be treated early, especially on the first postoperative day [14, 15]. We lifted, hydrated, and placed back into position or 'ironed out' the flap with a wet Merocel sponge in both eyes of one patient. This patient's preoperative refractions were -4.25 ($-2.50 \times 10°$) for the right eye and -4.50 ($-2.50 \times 172°$) for the left eye. Postoperative refractions after repositioning procedures were -0.25 ($-0.50 \times 20°$) in the right eye and $+0.25$ ($-0.75 \times 10°$) in the left eye. Two patients who had flap striae refused the repositioning procedure despite recommendation; one of them lost two lines and the other lost one line of BSCVA. While preoperative refraction of the first patient's left eye was -2.0 ($-2.50 \times 180°$), final postoperative refraction was $+1.25$ ($-1.50 \times 115°$) at the sixth postoperative month. The other patient's refraction was -2.0 ($-1.75 \times 15°$) in the affected eye, and postoperative refraction was $+0.25$ ($+0.75 \times 135°$) after the first postoperative year.

Epithelial proliferation and the advancement of epithelial cells into the space between the stromal bed and flap is known as epithelial ingrowth [5]. Poor or improper adhesion of the flap will encourage migration of the epithelial cells into the interface. The risk factors for epithelial ingrowth include anterior basement membrane dystrophy, postoperative epithelial defects, postoperative inflammation, postoperative flap slippage, previous corneal surgery, and history of ingrowth in the fellow eye [15]. Epithelial ingrowth was observed in three (0.37 %) eyes of two patients. In various studies, the incidence of epithelial ingrowth after LASIK was reported to be 0–8.8 % [5–18, 26]. We performed re-lifting and scraping procedure in one eye, and no line of BSCVA was lost. No progression occurred in the other patient's eye, but two lines of BSCVA were lost within 1 year after LASIK. Our patients did not have any risk factors.

DLK is a non-infectious condition and is also called 'Sands of Sahara Syndrome'. The first published report appeared in 1998 by Smith and Maloney [27]. The etiology of this syndrome is still unknown. An allergic or toxic reaction in the most commonly invoked hypothesis. The inflammation typically responds rapidly to topical corticosteroid treatment [5, 14, 15]. Lin and Maloney [8] reported an incidence of 1.8 %. We observed DLK in ten eyes with mild interface inflammation but no other ocular inflammation (grade II–I). The incidence of DLK was 1.24 % in our study. One case of DLK had interface debris simultaneously. In another case, DLK occurred following repositioning of flap striae. All patients with DLK were treated with topical corticosteroids. None of the eyes with DLK lost any lines of BSCVA.

Interface debris may result from metal fragments of blade, oil material from the microkeratome, powder from gloves, sponge fibers, meibomian secretions or lint fibers [5, 9, 12]. In this study, we frequently observed iron particles and sponge fibers in the interface. These particles rarely provoke inflammation or affect vision [5, 9, 12, 14]. However, we performed washing out of the interface in six (60 %) of ten eyes.

Microbial infection is a rare but potentially vision-threatening complication following LASIK [5, 12, 14]. Perez-Santonja et al. [28] reported the first case, and various authors then reported cases of bacterial and fungal infections after LASIK [5, 7, 29, 30]. The incidence of infection ranges from 0 to 1.5 % [5, 7, 9, 29, 30]. Microbial infection occurred in one eye in our series. It was controlled by surgical cleaning of copious material and intensive medical treatment. The abscess in the interface in our patient healed with minimal stromal scarring and a final BSCVA of 0.7 using a Snellen Chart at 6 months after LASIK surgery.

It should be noted that our study had inherent limitations of a retrospective study.

In conclusion, our study showed that epithelial defects were the most common type of flap-related complications, followed by flap striae, interface debris, and DLK. Free flap, and incomplete flap rates were small. The overall incidence of complications in both eyes were similar. Although no statistical difference was found for microkeratome-related flap complications between the Moria M2 single-use 90 and the Moria M2 automated metallic head microkeratome, the Moria M2 single-use 90 seems to have a lower complication rate of epithelial defects compared to the M2 automated metallic head. Further prospective and controlled studies are needed to evaluate the rate of flap-related complications with LASIK using microkeratomes as well as femtosecond lasers.

References

1. Pallikaris IG, Papatzanaki ME, Stathi EZ, Frenschock O, Georgiadis A (1990) Laser in situ keratomileusis. Lasers Surg Med 10:463–468
2. Duffey RJ, Leaming D (2003) US trends in refractive surgery: 2002 ISRS Survey. J Refract Surg 19:357–363
3. Duffey RJ, Leaming D (2005) US trends in refractive surgery: 2003 ISRS/AAO survey. J Refract Surg 21:87–91
4. Solomon KD, Fernández de Castro LE, Sandoval HP et al (2009) LASIK world literature review: quality of life and patient satisfaction. Ophthalmology 116(4):691–701
5. Bromley JG, Albright TD, Kharod-Dholakia B, Kim JK (2012) Intraoperative and postoperative complications of laser in situ keratomileusis. Expert Rev Opthalmol 7(1):25–31
6. Gimbel HV, Basti S, Kaye GB, Ferensowicz M (1996) Experience during the learning curve of laser in situ keratomileusis. J Cataract Refact Surg 22:542–550
7. Gimbel HV, Anderson Penno EE, van Westenbrugge JA et al (1998) Incidence and management of intraoperative and early postoperative complications in 1000 consecutive laser in situ keratomileusis cases. Ophthalmology 105:1847–1848
8. Lin RT, Maloney RK (1999) Flap complications associated with lamellar refractive surgery. Am J Ophthalmol 127:129–136
9. Stulting RD, Carr JD, Thompson KP et al (1999) Complications of laser in situ keratomileusis for the correction of myopia. Ophthalmology 106:13–20
10. Tham VM, Maloney RK (2000) Microkeratome complications of laser in keratomileusis. Ophthalmology 107:920–924
11. Holland SP, Srivannaboon S, Reinstein DZ (2000) Avoiding serious corneal complications of laser assisted in situ keratomileusis and photorefractive keratectomy. Ophthalmology 107:640–652
12. Melki SA, Azar DT (2001) LASIK complications: etiology, management and prevention. Surv Ophthalmol 46:95–116
13. Jacobs JM, Taravella MJ (2002) Incidence of intraoperative flap complications in laser in situ keratomileusis. J Cataract Refract Surg 28:23–28
14. Yıldırım R, Devraoğlu K, Ozdamar A, Aras C, Ozkırıs A, Ozkan S (2001) Flap complications in our learning curve of laser in situ keratomileusis using the Hansatome microkeratome. Eur J Opthalmol 11(4):328–332
15. Sridhar MS, Rao SK, Vajpayee RB, Aasuri MK, Sinha HR (2002) Complications of laser in situ keratomileusis. Indian J Opthalmol 50(4):265–282
16. Walker MB, Wilson SE (2000) Lower intraoperative flap complications rate with the Hansatome microkeratome compared to the Automated Corneal Shaper. J Refract Surg 16:79–82
17. Pallikaris IG, Katsanevaki VJ, Panagopoulou SI (2002) Laser in situ keratomileusis intraoperative complications using one type of microkeratome. Ophthalmology 109:57–63
18. Nakano K, Nakano E, Olivera M, Portellinha W, Alvarenga L (2004) Intraoperative microkeratome complications in 47,094 laser in situ keratomileusis surgeries. J Refract Surg 20:723–726
19. Carrillo C, Chayet AS, Dougherty PJ, Montes M, Magallanes R et al (2005) Incidence of complications during flap creation in LASIK using the NIDEK MK-2000 microkeratome in 26,600 cases. J Refract Surg 21: 655–657
20. Khachikian SS, Moruson RT, Belin MW, Mishra G (2006) Thin head a single use microkeratome reduce epithelial defects during LASIK. J Refract Surg 22(5):482–485
21. Al-Mezaine HS, Al-Amro SA, Al-Obeidan S (2011) Intraoperative flap complications in laser in situ keratomileusis with two types of microkeratomes. Saudi J Opthalmol 25:239–243
22. Albelda-Vallés C, Martín-Reyes C, Ramos F, Beltran J, Llovet F, Baviera J (2007) Effect of preoperative keratometric power on intraoperative complications in LASIK in 34,099 eyes. J Refract Surg 23:592–597
23. Randleman JB, Lynn MJ, Banning CS, Stulting RD (2007) Risk factors for epithelial defect formation during laser in situ keratomileusis. J Cataract Refract Surg 33:1738–1743
24. Chen YT, Tseng SH, Ma MC, Huang FC, Tsai YY (2007) Corneal epithelial damage during LASIK: a review of eyes 1873. J Refract Surg 23(9):916–923
25. Shah MN, Misra M, Wihelmus KR, Koch DD (2006) Diffuse lamellar keratitis associated with epithelial defects after laser in situ keratomileusis. J Cataract Refract Surg 26:1312–1318
26. Walker MB, Wilson SE (2000) Incidence and prevention of epithelial ingrowth within the interface after laser in situ keratomileusis. Cornea 19:170–173
27. Smith RJ, Maloney RK (1998) Diffuse lamellar keratitis: a new syndrome in lamellar refractive surgery. Opthalmology 105:1721–1726
28. Perez-Santonja JJ, Sakla HF, Abad JL, Zorraquino A, Esteban J, Alio JL (1997) Nocardial keratitis after laser in situ keratomileusis. J Refract Surg 13:314–317
29. Chang MA, Jain S, Azar DT (2004) Infections following laser in situ keratomileusis: an integration of the published literature. Surv Opthalmol 49(3):269–280
30. Solomon R, Donnenfeld ED, Azar DT et al (2003) Infectious keratitis after laser in situ keratomileusis: results of an ASCRS survey. J Cataract Refract Surg 29:2001–2006