Full-Thickness Macular Hole after LASIK for the Correction of Myopia

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Purpose: To describe 19 patients (20 eyes) who developed a macular hole (MH) after undergoing bilateral LASIK for the correction of myopia.

Design: Noncomparative, interventional, retrospective, multicenter case series.

Participants: Nineteen patients (20 eyes) who developed an MH after bilateral LASIK for the correction of myopia at 10 institutions in Venezuela, Colombia, Puerto Rico, Spain, and the United States.

Methods: Chart review.

Main Outcome Measure: Macular hole development.

Results: The MH formed between 1 to 83 months after LASIK (mean, 12.1). In 60% of cases, the MH developed ≤6 months after LASIK, and in 30% of cases it developed ≥1 year after LASIK. Eighteen of 19 (94.7%) patients were female. Mean age was 46 years (range, 25–65). All eyes were myopic (range, −0.50 to −19.75 diopters [mean, −8.9]). Posterior vitreous detachment was not present before and was documented after LASIK in 55% of eyes. A vitrectomy closed the MH on the 14 eyes that underwent surgical management, with an improvement of final best-corrected visual acuity in 13 of 14 (92.8%) patients. Our 20 eyes with a full-thickness MH after LASIK reflect an incidence of approximately 0.02% (20/83 938).

Conclusion: An MH may infrequently develop after LASIK for the correction of myopia. Our study shows that vitreoretinal surgery can be successful in restoring vision for most myopic eyes with an MH after LASIK. Vitreoretinal interface changes may play a role in MH formation after LASIK for the correction of myopia. *Ophthalmology 2005;112:1207–1212*

Although most macular holes (MHs) are idiopathic and age related, they also may be associated with myopia, trauma, scleral buckling, pneumatic retinopexy, and vitrectomy.[1,2] Tangential foveal traction by the posterior vitreous cortex is regarded as the main cause of full-thickness MHs.[3] Recently, the prefoveal Müller cell cone has been implicated to play an important role in this process.[4]

LASIK has become one of the most popular options for the correction of low to moderate myopia worldwide.[5,6] However, vitreoretinal complications including endophthalmitis, retinal tearing and detachment (RD), retinal hemorrhaging, and choroidal neovascular membrane have been reported.[7–17]

Chan and Lawrence[18] have reported 3 eyes of 3 myopic patients who developed an MH in one eye after bilateral LASIK or photorefractive keratectomy. Ruiz-Moreno et al[19,20] recently reported a case of an MH in a myopic eye after LASIK. We previously reported 10 eyes (10 patients) with full-thickness MH development after bilateral LASIK for the correction of ammetropia.[21]

This article reports a larger series of 20 cases of full-thickness MH development after bilateral LASIK for the correction of myopia, including 9 from our previously reported series and a more detailed description. To our knowledge, this is the largest series of this type reported to date.

Originally received: October 13, 2004.
Accepted: January 20, 2005. Manuscript no. 2004-184.

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Presented in part at: American Academy of Ophthalmology Annual Meeting, November, 2003; Anaheim, California.

Supported in part by the Fundacion Arevalo-Coutinho para la Investigacion en Oftalmologia, Caracas, Venezuela.

The authors have no proprietary or financial interest in any products or techniques described in the article.

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ISSN 0161-6420/05/$–see front matter
doi:10.1016/j.ophtha.2005.01.046

Patients and Methods

Institutional review board/ethics committee approval and patients' informed consent were obtained for this study. We reviewed the medical records of and obtained follow-up information on all consecutive patients in our files referred to us with a full-thickness MH after LASIK between March 1996 and March 2003 at 10 institutions in Venezuela, Colombia, Puerto Rico, Spain, and the United States. The refractive surgeons who performed LASIK on the patients who later on developed a full-thickness MH were asked to provide the total number of LASIK procedures performed during the study period. A total of 83 938 LASIK procedures (eyes) were performed during the study period (7 years) (Table 1). A preoperative examination, including dilated funduscopy with indirect ophthalmoscopy, and slit-lamp biomicroscopy were performed by a retina specialist and/or a refractive surgeon. Patients had a mean of 41 years of age (range, 18–65) and were female in 60.7% of cases. Patients underwent surgical correction of myopia ranging from −0.75 to −29.00 diopters (D) (mean, −6.19). Patients were scheduled to be seen during the first postoperative day, at 3 months, at 12 months, and yearly thereafter. Patients were observed for a mean of 65 months after LASIK (range, 6–84). Patients with an MH were included in the study independent of the length of follow-up.

A chart review of cases that developed a full-thickness MH after LASIK included recording data on gender, laterality, age, preoperative correction (before LASIK), time between LASIK and MH formation (onset of symptoms), fellow-eye status, stage of the MH, presence or absence of yellow deposits on the retinal pigment epithelium (RPE), presence or absence of epiretinal membrane, diameter of the MH, location of the MH (centric vs. eccentric), presence or absence of subretinal fluid (SRF), presence or absence of posterior vitreous detachment (PVD) before LASIK and after LASIK, vitreoretinal procedure performed to close the MH (if performed), visual acuity (VA) before and after vitreoretinal surgery (if performed), length of follow-up after vitreoretinal surgery (if performed) or MH formation, and type of excimer laser and microkeratome used to perform LASIK.

Before LASIK, a retina specialist and/or a refractive surgeon performed contact or noncontact biomicroscopic evaluation of the fundus to determine posterior vitreous status. After LASIK, a retina specialist performed contact or noncontact biomicroscopic evaluation of the fundus to determine posterior vitreous status and MH characteristics. The presence of a Weiss ring was an important index for diagnosing PVD. The data were collected from the clinical record and/or operative report. Optical coherence tomography was used after LASIK by the retina specialist to confirm the MH and its characteristics.

Table 1. Cases (Eyes) Contributed by Each Participating Center

Center	Eyes That Had LASIK*	Eyes with MHs
Clinica Oftalmologica Centro Caracas, Caracas, Venezuela	5720	5
Retina Associates, San Juan, Puerto Rico	1221	1
Fundacion Oftalmologica Nacional, Bogota, Colombia	440	1
Unidad de Cirugia Vitreo-Retina La Colina, San Cristobal, Venezuela	240	3
Clinica de Ojos de Maracaibo, Maracaibo, Venezuela	960	1
Centro Medico Docente la Trinidad, Caracas, Venezuela	37 905	1
Retinal Diagnostic Center, Campbell, California	14 400	4
Southern California Desert Retina Consultants, Palm Springs, California	2880	1
VitreoRetinal Surgery, P.A., Minneapolis, Minnesota	11 200	2
Vitreo-Retinal Unit, Instituto Oftalmológico Alicante, Alicante, Spain	8972	1
Total	83 938	20

MH = macular hole.
*Total number of LASIK procedures performed during the study period by the refractive surgeons who performed LASIK on patients who later developed a full-thickness MH.

Selected Case Reports

Case 1

A 42-year-old man complained of poor vision in his left eye. His ocular history included bilateral LASIK for the correction of myopia of −1.25 D in the right eye and −0.50 D in the left eye on November 1998. Eight months after refractive surgery, he presented with a stage 4 MH in the left eye, associated with a best-corrected VA (BCVA) of 20/50. A hyperfluorescent spot corresponding to the hole was seen on the early frames of the fluorescein angiogram (Fig 1A). During vitrectomy to repair the MH, an optical distortion that originated at the interface of the corneal cap interfered with intraocular visibility and the surgeon's binocular depth perception. An iatrogenic retinal tear occurred temporal to the fovea, and an endolaser was applied. Unfortunately, severe retinal pigment epithelial hyperplasia developed at the laser site, with mild traction exerted on the fovea (Fig 1B). Nevertheless, BCVA recovered to 20/25, with MH closure 9 months after successful vitrectomy, internal limiting membrane peeling, and fluid–gas exchange.

Case 4

A 30-year-old woman, with −13.00 D of myopia in the right eye and −10.00 D in the left eye, underwent bilateral LASIK in June 2001. Six months after surgery, she noted the onset of blurred vision involving her left eye. Retinal examination revealed a stage 4 MH in the left eye (Fig 2A), associated with an RD localized to the posterior fundus, and a BCVA of counting fingers. An optical coherence tomography image showed features of both RD and retinoschisis (Fig 2B). Best-corrected VA recovered to 20/150, with MH closure 4 months after successful vitrectomy and fluid–gas exchange.

Case 7

A 57-year-old woman with myopia of −16.50 D in the right eye and −9.00 D in the left eye underwent bilateral LASIK in August 2001. Six months after surgery, she noted the onset of blurred vision involving her left eye. Fundus examination revealed a stage 4 MH in her left eye, associated with a BCVA of 20/200. A hyperfluorescent spot corresponding to the MH was seen on the fluorescein angiogram. Optical coherence tomography showed a full-thickness MH with significant surrounding retinal edema and cystic changes. The diameter of the hole measured directly from

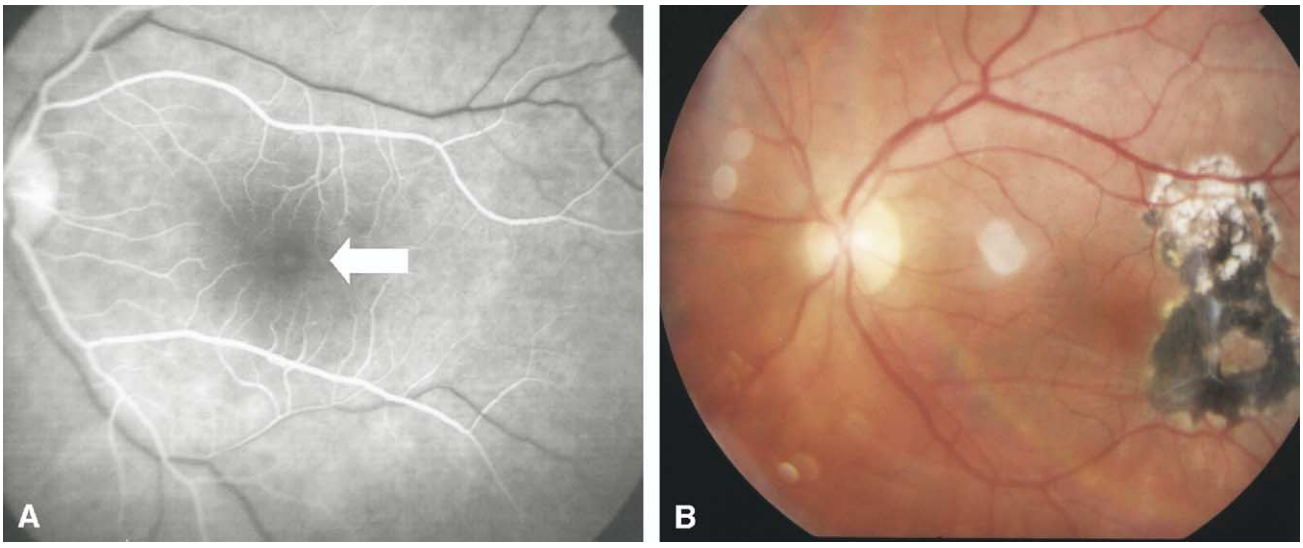

Figure 1. **A**, A hyperfluorescent spot (arrow) corresponding to the hole was seen in the early arteriovenous phase of the fluorescein angiogram. **B**, During vitrectomy, an optical distortion originating at the interface of the corneal cap interfered with intraocular visibility and the surgeon's depth perception. An iatrogenic retinal tear was created temporal to the fovea, and endolaser was applied. Unfortunately, severe retinal pigment epithelial hyperplasia developed at the laser site, with mild traction exerted on the fovea. The white reflections superotemporal to the fovea and superonasal to the optic disc are artifacts.

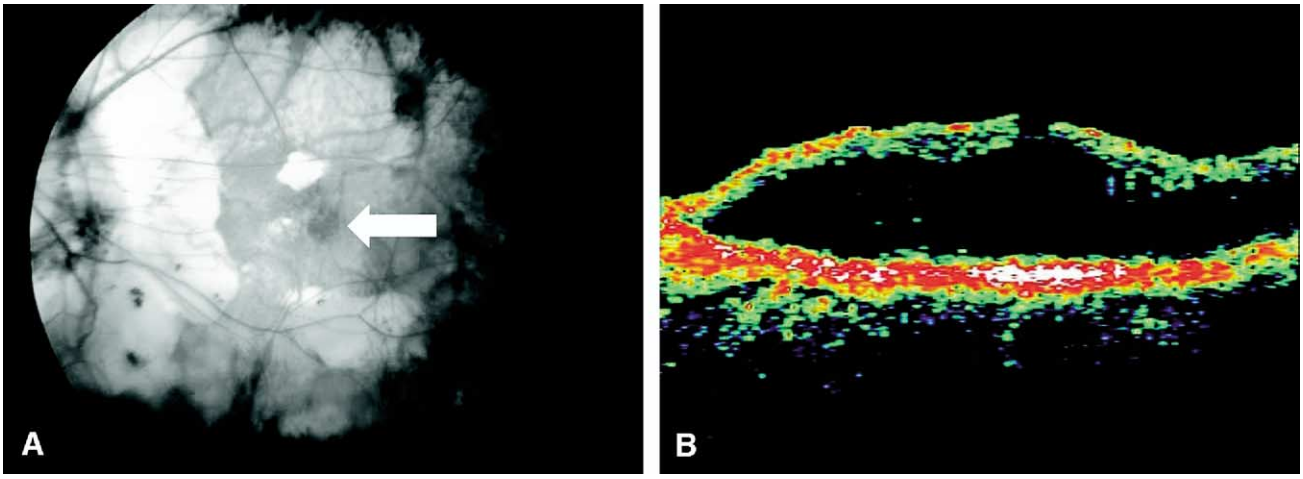

Figure 2. **A**, Retinal examination revealed a stage 4 macular hole (arrow) in the left eye associated with a retinal detachment (RD) localized to the posterior fundus and a best-corrected visual acuity of counting fingers. Posterior staphyloma and myopic chorioretinal and retinal pigment epithelium (RPE) atrophy are seen. **B**, An optical coherence tomography image showing features of both RD and retinoschisis. The RPE–choriocapilaris complex high reflectivity is due to atrophy and choroidal backscatter.

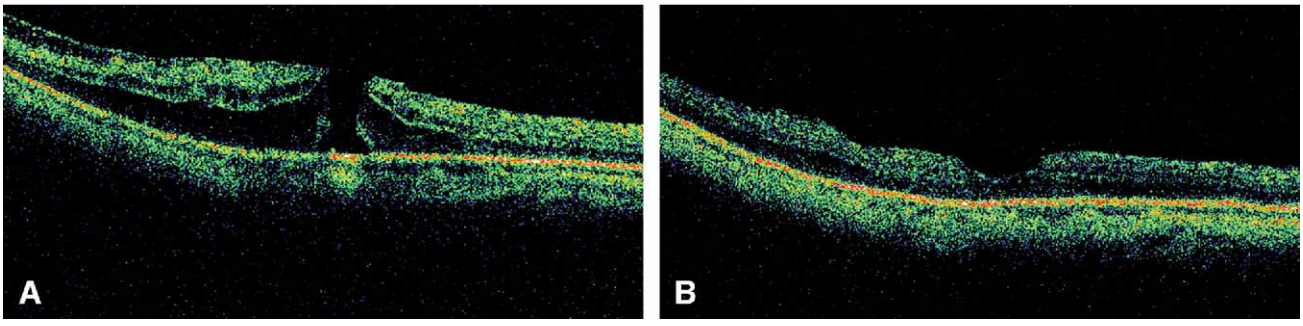

Figure 3. **A**, Optical coherence tomography (OCT) showed a full-thickness hole with significant surrounding retinal edema and cystic changes. The diameter of the hole measured directly from the OCT was 390 μm. **B**, Optical coherence tomography after a vitrectomy performed 1 week after examination closed the macular hole. The fovea regained its normal configuration.

Table 2. Clinical Findings of Patients with Macular Holes (MHs) after LASIK (20 Eyes)

Patient	Gender	Laterality	Age (yrs)	Preoperative Refraction (SE)	Time after LASIK (mos)	Fellow Eye	Stage of MH	Yellow Deposits	ERM	Diameter of MH (μm)	Location	Cuff of SRF	PVD before LASIK	PVD after LASIK
1	M	L	42	(−) 0.50	8	Stage 1 MH	4	No	Yes	400	Eccentric	No	No	Yes
2	F	L	50	(−) 3.25	1		2	No	No	100	Centric	No	No	No/ VMTS
3	F	R	32	(−) 10.00	2	OK	4	No	No	100	Eccentric	Yes	No	Yes
4	F	L	30	(−) 10.00	6	OK	4	No	No	380	Centric	PPRD	No	Yes
5	F	L	25	(−) 4.50	1	OK	4	Yes	No	400	Centric	Yes	No	Yes
6	F	R	58	(−) 10.00	17	OK	4	No	No	600	Centric	PPRD	No	Yes
7	F	L	57	(−) 9.00	6	OK	4	No	No	390	Centric	Yes	No	Yes
8	F	R	45	(−) 15.25	30	OK	4	No	No	390	Centric	Yes	No	Yes
9	F	L	34	(−) 9.00	5	OK	4	No	No	500	Centric	RRD	Yes	Yes
10	F	R	48	(−) 8.25	5	Lattice	2	No	No	200	Centric	Yes	No	No
11	F	R	54	(−) 3.50	6	Lattice	2	No	No	200	Centric	Yes	No	No
12	F	L	35	(−) 7.75	14	OK	2	No	No	200	Centric	Yes	No	No
13	F	L	52	(−) 14.50	2	OK	4	No	Yes	550	Centric	PPRD	No	Yes
14	F	L	45	(−) 7.75	6	15	3	No	No	500	Centric	Yes	No	No
15	F	R	45	(−) 8.75	11	14	3	No	No	400	Centric	Yes	No	No
16	F	R	51	(−) 8.00	1	OK	4	No	No	400	Centric	Yes	No	Yes
17	F	R	47	(−) 15.00	8	OK	4	Yes	No	524	Centric	No	No	Yes
18	F	R	52	(−) 7.75	18	VMTS	2	No	No	200	Centric	Yes	No	No
19	F	L	53	(−) 6.75	12	OK	3	Yes	No	325	Centric	No	No	Yes
20	M	R	65	(−) 19.75	83	OK	4	No	No	750	Centric	PPRD	Yes	Yes

ERM = epiretinal membrane; F = female; L = left eye; M = male; OK = no vitreoretinal pathology/no MH; PPRD = posterior pole retinal detachment; PVD = posterior vitreous detachment; R = right eye; RRD = rhegmatogenous retinal detachment; SE = spherical equivalent; SRF = subretinal fluid; VMTS = vitreomacular traction syndrome.

the optical coherence tomography was 390 μm (Fig 3A). A vitrectomy performed 1 week after examination closed the MH (Fig 3B), with a BCVA of 20/80 5 months later.

Results

We found 20 eyes (19 patients) with a full-thickness MH after LASIK (20/83 938), for an incidence of 0.02%. The MH formed between 1 to 83 months after LASIK (mean, 12.1). Eighteen (94.7%) patients were female. Mean age was 46 years (range, 25–65). All eyes were myopic (range, −0.50 to −19.75 D [mean, −8.9]). Posterior vitreous detachment was not present before and was documented after LASIK in 55% of eyes (Table 2). The vitrectomy closed the MH in all 14 eyes that underwent surgical management, with an improvement of final BCVA in 13 of 14 (92.8%) patients (Table 3).

Table 2 outlines detailed characteristics of MHs in our case series. The mean diameter of the MH was 375.4 μm, and the range was from 100 to 750 μm. The MH was centrally located in 19 eyes (95%). The MH was unilateral in 18 of 19 patients (although one of those patients had an impending MH [stage 1] in the fellow eye). A stage 4 MH was found in 12 eyes (60%). There was absence of yellow deposits on the RPE of the MH in 17 eyes (85%). Eighteen eyes (90%) lacked a surrounding epiretinal membrane. Sixteen eyes (80%) had SRF surrounding the MH; 5 of those eyes (all with ≥−10.00 D of myopia) had extensive SRF in the posterior fundus (Table 2).

Discussion

In our study, 20 eyes (19 patients) developed an MH after bilateral LASIK for the correction of myopia. The MH formed at a mean of 12.1 months after LASIK. The MH developed within 6 months after LASIK in 60% of cases, and in 30% of cases, the MH developed ≥1 year after refractive surgery. The MHs in our series also developed primarily in young myopic women with a mean myopia of −8.9 D. Typical characteristics of MHs in our series also include the following: the majority were unilateral, 60% were stage 4, 85% lacked yellow deposits on the base of the hole, and 90% also lacked an associated epiretinal membrane. In addition, most were centric holes, with a mean diameter of 375.4 μm. Sixteen eyes (80%) had SRF surrounding the hole, including 5 eyes (all with ≥−10.00 D of myopia) that had extensive SRF in the posterior fundus. Our findings support previous studies that showed the characteristics and demographics of myopic MHs to differ from those of idiopathic MHs. Myopic MHs tend to develop in young subjects and may be associated with a rhegmatogenous RD surrounding the MH.[22,23]

In the present series, PVD was not present before and was documented after LASIK in 55% of eyes. Luna et al[24] have used kinetic ultrasonography to demonstrate vitreoretinal alterations after LASIK, including partial or total PVD in 24% (12 eyes) of high myopes. In addition, Kakehashi et al[25] have determined that some highly myopic eyes have a complete PVD with collapse (29.6%) in which the vitreous gel exhibits liquefaction and, therefore, a large retrocortical space and smooth movement of the detached vitreous with ocular movements. Diffuse chorioretinal atrophy in high myopia might induce vitreous liquefaction and somehow reduce vitreoretinal adhesion. Their findings are consistent with similar results in more than half of myopic eyes with MH formation after LASIK in our series. It is possible that

Table 3. Management and Visual Acuity of Patients with Macular Holes (MHs) after LASIK (20 Eyes)

Patient	Treatment	VA with before MH Surgery	Final VA	Follow-up (mos)	Excimer Laser	Microkeratome
1	Vitrectomy + gas	20/50	20/25	9	Chiron Technolas Keracor 217*	Chiron automated corneal shaper*
2	None	20/50	20/50	1	Ladar Vision 4000†	Camazo-Barraquer‡
3	None	20/200	20/200	2	Nidek EC-5000§	Hansatome*
4	Vitrectomy + gas	CF	20/150	4	Nidek EC-5000§	Nidek MK-2000§
5	Vitrectomy + gas	20/200	20/30	7	Nidek EC-5000§	Nidek MK-2000§
6	None	CF	CF	17	Nidek EC-5000§	Nidek MK-2000§
7	Vitrectomy + gas	20/200	20/80	4	Chiron Technolas Keracor 217*	Chiron automated corneal shaper*
8	None	20/200	20/200	5	Coherent Schwind Keratom II‖	Moria One‡
9	Vitrectomy + gas + laser	LP	20/200	70	VISX 20/20¶	Chiron automated corneal shaper*
10	Vitrectomy + gas	20/200	20/60	10	Nidek EC-5000§	Hansatome*
11	Vitrectomy + gas	20/200	20/40	6	Nidek EC-5000§	Chiron automated corneal shaper*
12	Vitrectomy + gas	20/200	20/100	12	Nidek EC-5000§	Chiron automated corneal shaper*
13	Vitrectomy + gas	CF	20/400	28	VISX 20/20¶	Chiron automated corneal shaper*
14	Vitrectomy + ILM + gas	20/80	20/40	24	VISX 20/20¶	Moria One‡
15	Vitrectomy + ILM + gas	20/80	20/25	20	VISX 20/20¶	Moria One‡
16	None	CF	CF	12	Nidek EC-5000§	Moria One‡
17	None	5/400	5/400	60	Coherent Schwind Keratom II‖	Moria One‡
18	Vitrectomy + Silicone oil	20/80	20/200	11	Nidek EC-5000§	Chiron automated corneal shaper*
19	Vitrectomy + ILM + gas	20/100	20/50	41	Chiron Technolas Keracor 217*	Chiron automated corneal shaper*
20	Vitrectomy + ILM + Silicone oil	HM	20/200	3	VISX 20/20¶	Chiron automated corneal shaper*

CF = counting fingers; HM = hand movements; ILM = internal limiting membrane peeling; LP = light perception; VA = visual acuity.
*Baush & Lomb Surgical, Inc., San Dimas, CA.
†Alcon Laboratories, Inc., Fort Worth, TX.
‡MORIA USA, Doylestown, PA.
§NIDEK Co., Ltd., Gamagori, Japan.
‖Coherent, Santa Clara, CA.
¶VISX USA, Inc., Santa Clara, CA.

in our group of myopic patients with MHs the prevalence of PVD was enhanced by LASIK surgery, and that PVD may play a role in the formation of MHs. However, due to the retrospective nature of our study, the 55% incidence of PVD after LASIK should be interpreted with caution. Macular hole surgery (MHS) can achieve substantial VA improvement for myopic eyes, but the results do not seem to be as favorable as those reported for typical idiopathic MHs in recent series.[26,27] A vitrectomy closed the MH in all 14 eyes that underwent surgical management, with an improvement in final BCVA in 13 of 14 (92.8%) patients. However, 6 (42.8%) of 14 eyes that underwent vitreous surgery had a VA of ≤20/100, and 5 (35.7%) of 14 eyes had a VA outcome of ≥20/40. Reasons for poor VA included the development of cataract and the presence of chorioretinal atrophy. In addition, 4 of our 5 cases of MH and associated posterior pole RD underwent MHS. All of them ended up with a VA of 20/150 or worse. Case 18 was our only case of loss of VA after vitrectomy. However, silicone oil removal and cataract extraction are still pending, and could improve final VA. Our results should be interpreted with caution, because multiple surgeons with different surgical techniques and training participated in this study. Two of our patients had to be treated with silicone oil due to their impossibility of tolerating prolonged facedown positioning. In addition, internal limiting membrane peeling was performed in only 4 of our cases, with trypan blue (Membrane-Blue, DORC International b.v., Zuidland, The Netherlands) or indocyanine green (IC-Green, AKORN Inc., Decatur, IL) staining.

The pathogenesis of MHs (especially idiopathic MHs) remains controversial. Certainly, vitreofoveal traction is felt to be the predominant force, together with preexisting degenerative changes in the fovea. Chan and Lawrence[18] have stated that LASIK surgery has certain features that may induce postoperative vitreoretinal interface changes. For instance, the acute intraocular pressure rise associated with the mechanical stretching of the vitreous base induced by the suction ring as well as the shock waves generated by the excimer laser may lead to vitreoretinal traction.[10,11,22,23] In addition, Ruiz-Moreno et al[19,20] recently reported a case of MH formation in a myopic eye after LASIK. Their report stated an incidence of 0.01% (1/8972) of an MH after LASIK. We previously reported 10 eyes with unilateral full-thickness MH development after bilateral LASIK for

the correction of ammetropia.[21] Retinal breaks and RD also have been reported to occur after LASIK.[10–15]

An important limitation of our study is that, due to its retrospective nature, follow-up was not consistent, and it is possible that patients who developed an MH were seen by other ophthalmologists. Thus, it is possible that the 0.02% rate reported in this study is an underestimation of the true incidence of MH formation after LASIK. However, in the participating centers patients with MHs are referred to a very limited group of retina and vitreous specialists, with the exception of the 3 participating centers in the U.S. To the best of our knowledge, no additional cases of MH after LASIK have occurred in patients from our study group.

Our findings are not generalizable to all myopic eyes that undergo LASIK. However, myopia is a risk factor for MH formation.[2] It is possible that vitreomacular interface changes occurring after LASIK may predispose certain myopic eyes to form an MH. Nevertheless, there are not enough hard data in the literature to determine if these are just myopic holes that would have developed anyway, regardless of LASIK.

In summary, we report 20 eyes of 19 patients with no presurgical sign of an MH that developed a full-thickness MH after LASIK. Consistent with previous series, 94.7% of the patients developing an MH were women. Our study shows that vitreoretinal surgery can be successful in restoring vision for most myopic eyes with an MH after LASIK. However, final VA may be limited by myopic degeneration, amblyopia, or cataract formation. LASIK should be added to the list of conditions or surgical procedures that may be associated with formation of an MH, although its incidence is very low (0.02%). Our results need to be confirmed by prospective studies to determine a more accurate incidence of MHs after LASIK. Future prospective investigation involving a large number of myopic eyes and with ultrasonic findings may be valuable for determining vitreoretinal interface changes before and after LASIK.

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