Characteristics and Surgical Outcomes of Rhegmatogenous Retinal Detachment Following Myopic LASIK

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Purpose: To describe the clinical features and surgical outcomes of rhegmatogenous retinal detachment (RRD) following myopic laser in situ keratomileusis (LASIK).
Methods: In a retrospective, non-comparative case series, 46 eyes that had undergone vitreoretinal surgery for management of RRD following myopic LASIK were identified. Data was reviewed with emphasis on characteristics of the RRD, employed surgical techniques, and anatomic and visual outcomes.
Results: Mean pre-LASIK myopia was -9.7±3.9 (range -4.00 to -18.00) diopters (D). Mean interval between LASIK and development of RRD was 11.6±11.2 months. Posterior vitreous detachment was present in 44 eyes (95.6%). The retinal breaks included flap tears in 36 (78.3%) eyes, giant tears in 8 (17.4%) eyes and atrophic holes in 2 (4.3%) eyes. In eyes with flap tears, the breaks were multiple, large or posterior to the equator in 24 (66.7%) eyes. Retinal breaks were related to lattice degeneration in 20 (43.5%) eyes of which, three had history of prophylactic barrier laser photocoagulation. Scleral buckling was performed as the initial procedure in 32 (69.6%) eyes and primary vitrectomy was undertaken in 14 (30.4%) eyes. The initial surgical procedure failed in 14 (30.4%) eyes due to proliferative vitreoretinopathy (PVR). Retinal reattachment was finally achieved in 43 (93.4%) eyes. Postoperative visual acuity ≥20/40 and ≥20/200 was achieved in 16 (34.8%) and 25 (54.3%) eyes, respectively.
Conclusion: Post-LASIK retinal detachment has a complex nature in eyes with moderate to high myopia. The retinal detachment is complex in terms of size, number and location of retinal breaks, is associated with a high rate of PVR and entails unfavorable visual outcomes.

Key words: Keratomileusis, Laser in Situ; Retinal Detachment; Myopia

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INTRODUCTION

The number of patients undergoing laser in situ keratomileusis (LASIK) has been rapidly growing worldwide over the past decade.[1] Anterior segment complications of LASIK have been well documented in the literature.[1,2] There have been growing reports of posterior segment complications after LASIK,[3-14] which have inspired investigations in this regard.[15] Retinal tears and detachments are the most important types of posterior segment complications; however, the cause and effect relationship remains controversial. The present study was planned to determine the clinical features and surgical outcomes of rhegmatogenous retinal detachment (RRD) following myopic LASIK. To the best of our knowledge, this is one of the largest case series of post-LASIK RRD in the literature.

METHODS

All vitreoretinal surgeons practicing in university affiliated and private referral centers were asked to fill an information sheet for cases of post-LASIK RRD which had been managed during the past 3 years with at least 6 months' follow-up. LASIK procedures had been performed in a routine manner. The most common types of microkeratomes were the Chiron Automated Corneal Shaper (Chiron Vision, Irvine, USA) with a superior or inferior hinge or the Hansatome microkeratome (Chiron Vision, Irvine, USA) with a nasal hinge. Laser ablation was performed using the Summit (OmniMed Technology, Waltham, USA), Nidek EC-5000 (Nidek Co. Ltd, Gamagori, Japan), and Chiron Technolas Keracor 217C (Bausch & Lomb Surgical, Claremont, USA) excimer machines.

Characteristics of retinal breaks and grade of PVR were recorded. Retinal flap tears were considered "large" if greater than one clock hour, "posterior" when completely or partially located posterior to the equator, and giant when extending >90 degrees. The updated PVR classification was used.[16] Surgical procedures included scleral buckling or pars plana vitrectomy (with or without lensectomy) with endolaser and internal tamponade or a combination of both techniques. The scleral buckling procedure consisted of placement of a segmental sponge (meridional or circumferential) without drainage of subretinal fluid, or an encircling buckle with drainage of subretinal fluid.

RESULTS

Forty-six eyes of 43 patients including 28 (65.1%) male subjects with mean age of 32.8± 10.2 (range 19-62) years underwent vitreoretinal surgery for post-LASIK RRD from January 1999 to June 2002. Minimum follow-up period after retinal detachment surgery was 6 months. Operated eyes included the right eye in 20 patients, the left eye in 20 patients and both eyes in 3 patients. Mean pre-LASIK spherical equivalent refractive error was -9.7±3.9 (range -4.00 to -18.00) diopters (D). Interval between LASIK and RRD was 11.6±11.2 months on average, less than 6 months in 22 (47.8%) eyes and less than one year in 33 (71.7%) eyes.

Symptoms or signs of acute posterior vitreous detachment (PVD) were present in 44 (95.6%) eyes at the time of the diagnosis of RRD which was associated with fresh vitreous hemorrhage in 11 (23.9%) eyes. The RRD was macula-on in 6 (13.0%) eyes, involved 2 or 3 quadrants and the macula in 20 (43.5%) eyes, and was total in the other 20 (43.5%) eyes. Retinal breaks were located in the temporal quadrants in 84.8%; there were only 7 eyes with retinal breaks in the nasal quadrants. Retinal breaks included flap tears in 36 (78.3%) eyes, giant tears in 8 (17.4%) eyes and atrophic holes associated with lattice degeneration in 2 (4.3%) eyes of one patient. The latter patient developed a giant retinal tear in the left eye following scleral buckling surgery (Table 1, case #30). Of 8 eyes with giant retinal tears, the breaks were associated with lattice degeneration in 3 cases. All eyes with giant retinal tears were highly myopic with refractive errors exceeding -8.00 D. The interval between LASIK and diagnosis of RRD in eyes with giant retinal tears was 12 months or less in all 8 eyes and less than 6 months in 6 eyes. Of 36 eyes with flap retinal tears, the breaks were multiple, large or posterior in 24 (66.6%) eyes. Pre-LASIK myopia in eyes with flap retinal tears ranged from -4.00 D to -18.00 D with mean and mode of -9.00 D.

Table 1 Patient characteristics (Part 1)

No.	Sex/Age (years)	Eye	Myopia (Diopter)	BCVA before LASIK	Lattice	Prophylactic barrier laser	Relation of breaks with lattice	Interval between LASIK and RD (months)	Acute PVD	Vitreous hemorrhage	Type of retinal breaks
1	M/31	OD	-10.00	20/25	+	+	+/-	4	+	+	Multiple, large flap tears
		OS	-10.00	20/25	+	-	+/-	10	+	+	Multiple, large flap tears
2	F/27	OD	-9.00	20/30	-	-	-	15	+	-	Large flap tear
3	M/37	OD	-9.00	20/25	-	-	-	36	+	+	Multiple, large, posterior flap tears
4	M/48	OS	-9.00	20/50	-	-	-	22	+	-	Large, posterior flap tear
5	M/42	OS	-10.00	20/50	+	-	+	9	+	-	Multiple flap tears
6	M/43	OD	-6.00	20/25	+	-	+	2	+	-	Multiple flap tears
7	M/22	OD	-11.50	20/25	+	-	+	2	+	+	GRT, Multiple flap tears
8	M/I9	OD	-14.00	20/120	+	+	+	1.5	+	-	Multiple flap tears
9	M/35	OD	-10.00	20/30	+	+	-	36	+	-	Flap tear
10	M/38	OD	-10.50	20/30	-	-	-	5.5	+	+	Large, posterior flap tear
11	M/20	OS	-4.00	20/15	-	-	-	12	+	-	Multiple Flap tears
12	M/39	OS	-11.00	20/60	+	-	-	2	+	+	GRT
13	F/21	OD	-11.00	20/50	+	-	+	24	+	-	Flap tear
14	F/38	OS	-12.00	20/40	-	-	-	9	+	-	Flap tear
15	F/30	OS	-14.00	20/50	+	-	+	2	+	-	Multiple Flap tears
16	F/36	OS	-10.00	20/20	-	-	-	2	+	-	Flap tear
17	M/26	OD	-6.00	20/20	+	-	+	4	+	+	Multiple Flap tears
18	M/18	OD	- 9.00	20/25	-	-	-	1	+	-	Flap tear
19	M/23	OS	-18.00	20/40	-	-	-	2.5	+	+	GRT
20	F/40	OD	-11.00	20/30	-	-	-	12	+	+	Large, posterior flap tear
21	M/62	OD	-12.00	20/30	-	-	-	1.5	+	-	Multiple Flap tears
22	M/21	OS	-12.00	20/30	-	-	-	12	+	-	GRT
23	F/31	OD	-7.00	20/30	+	-	+	4	+	-	Multiple Flap tears
24	F/25	OS	-8.00	20/25	-	-	-	3	+	-	Flap tear
25	F/54	OS	-6.00	20/25	-	-	-	8	+	-	Large, posterior flap tear
26	M/56	OD	-4.00	20/20	+	-	+	24	+	-	Flap tear
		OS	-6.00	20/20	+	-	+	20	+	-	Flap tear
27	M/45	OS	-5.00	20/20	-	-	-	36	+	+	Multiple, posterior Flap tears
28	F/35	OS	-8.00	20/160	-	-	-	36	+	-	Multiple flap tears
29	M/35	OS	-9.00	20/160	-	-	-	4.5	+	+	Multiple flap tears
30	M/30	OD	-9.00	20/20	+	-	+	24	-	-	Atrophic holes
		OS	-9.00	20/20	+	-	+	24	-	-	Atrophic holes
31	M/38	OS	-10.00	20/40	+	-	+	1.5	+	-	Flap tear
32	F/26	OD	-18.00	20/40	-	-	-	36	+	-	Multiple flap tears
33	M/20	OD	-15.00	20/30	-	-	-	12	+	-	Flap tear
34	M/42	OD	-8.00	20/20	+	-	+	5	+	-	Multiple flap tears
35	F/31	OS	-11.00	20/25	-	-	-	9	+	-	Large flap tear
36	M/25	OD	-8.00	20/25	+	-	+	3	+	-	Flap tear
37	M/30	OS	-9.00	20/25	+	-	+	8	+	-	Flap tear
38	F/28	OS	-11.00	10/10	+	-	+	2	+	-	Flap tear
39	M/25	OD	-8.00	20/25	-	-	-	3	+	-	GRT
40	M/30	OS	-9.00	20/25	-	-	-	24	+	-	Large flap tear
41	M/35	OD	-13.00	20/30	-	-	-	4.5	+	-	GRT
42	F/25	OD	-8.00	20/25	-	-	-	12	+	-	GRT
43	F/30	OS	-9.00	20/25	+	-	+	5	+	-	GRT

BCVA, best-corrected visual acuity; LASIK, Laser in situ keratomileusis; RD, retinal detachment; PVD, posterior vitreous detachment; M, male; F, female; OD, right eye; OS, left eye; GRT, giant retinal tear.

Table 1 Patient characteristics (Part 2)

No.	Status of macula	PVR	Primary treatment	Result of primary treatment	Second treatment	Third treatment	Fourth treatment	Final VA	Final anatomic result
1	Off	B	SB & Laser	Successful	New SB (localized RD)	-	-	20/25	Reattached
	Off	B	SB & Gas	Successful	Barrier laser (new break)	-	-	20/30	Reattached
2	On	A	SB, Sponge 507	Unsuccessful (PVR)	Intraocular gas	Lensx, Vitx, ELP, SO, band	SO removal	20/200	Reattached
3	Off	B	Primary vitrectomy, band, ELP	Successful	-	-	-	20/200	Reattached
4	Off	B	SB	Unsuccessful (Posterior break)	Vitx, FGX	-	-	20/50	Reattached
5	Off	B	SB	Unsuccessful (PVR)	PE, Vitx, ELP, SO	Repeat Vitx, relaxing retinotomy	Repeat Vitx, repeat retinotomy, SO	5/200	Reattached
6	Off	C	Lensx, Vitx ELP, SO, band	Successful	SO removal	-	-	10/200	Reattached
7	Off	C	Lensx, Vitx ELP, SO, band	Unsuccessful (PVR)	Reoperation: repeat vitx & SO (failed)	Patient refusal	-	5/200	Partially reattached
8	Off	B	SB	Unsuccessful (PVR)	Lensx, vitx, ELP, SO	SO removal (leading to redetachment)	Repeat vitx, SO	10/200	Reattached
9	On	A	SB (Meridional sponge 507)	Successful	-	-	-	20/30	Reattached
10	Off	A	SB (Meridional sponge 507)	Unsuccessful (Open break)	Intraocular gas (leading to new inferior break)	Inferior buckle: sponge 505	-	20/40	Reattached
11	On	B	SB	Successful	Barrier laser	-	-	20/20	Reattached
12	Off	C	Vitx, ELP, SO, band	Successful	SO removal	-	-	20/200	Reattached
13	Off	B	SB	Successful	-	-	-	20/100	Reattached
14	Off	B	SB	Successful	-	-	-	20/100	Reattached
15	Off	C	SB	Unsuccessful (PVR)	Vitx, FGX	Patient refusal	-	LP	Prephtisis bulbi
16	Off	B	SB	Unsuccessful (PVR)	Vitx, SO	-	-	10/200	Inf. redetachment
17	Off	A	SB & Gas	Successful	-	-	-	20/30	Reattached
18	Off	A	SB	Successful	-	-	-	20/40	Reattached
19	Off	B	Lensx, Vitx ELP, SO	Unsuccessful (New break)	Segmental sponge (inferior)	SO removal	-	5/200	Reattached
20	Off	B	SB (Meridional sponge 507)	Unsuccessful (PVR)	Repeat Vitx, FGX	Patient refusal	-	HM	Total redetachment
21	Off	B	SB	Successful	-	-	-	20/40	Reattached
22	Off	B	Lensx, vitx ELP, SO, band	Successful	SO removal	-	-	20/100	Reattached
23	Off	A	SB	Successful	-	-	-	20/50	Reattached
24	Off	B	SB	Successful	-	-	-	20/40	Reattached
25	Off	B	SB & Gas	Successful	-	-	-	20/100	Reattached
26	Off	B	SB	Unsuccessful (PVR)	Intraocular gas	Vitx, SO	SO removal	10/200	Reattached
	Off	B	SB	Successful	-	-	-	2040	Reattached
27	Off	A	Vitx, ELP, FGX, band	Unsuccessful (PVR)	Repeat intraocular gas	Repeat Vitx, SO	SO removal	16/200	Reattached
28	Off	A	SB	Successful	-	-	-	20/160	Reattached
29	Off	-	Primary vitx	Unsuccessful (PVR)	Repeat vitx	Repeat Vitx	-	LP	Reattached (OA)
30	On	-	SB	Successful	Vitx for pucker	-	-	20/30	Reattached
	On	-	SB	Successful	Vitx due to GRT & Vit. Hem.	PE & PCIOL	-	20/50	Reattached
31	Off	B	SB	Unsuccessful (PVR)	Vitx, MPC, ELP, SO	ECCE, PCIOL, SO removal	Repeat vitx, SO	20/200	Reattached
32	Off	A	SB	Successful	-	-	-	20/120	Reattached
33	Off	A	SB	Unsuccessful (PVR)	Vitx, FGX	Lensx, Vitx, MPC, SO	SO removal	5/200	Reattached
34	Off	A	SB	Successful	-	-	-	20/30	Reattached
35	Off	B	Primary vitx & band	Successful	-	-	-	20/200	Reattached
36	Off	B	SB	Successful	-	-	-	20/40	Reattached
37	Off	B	SB	Successful	-	-	-	20/40	Reattached
38	Off	A	SB	Successful	-	-	-	20/20	Reattached
39	Off	C	Vitx, ELP, SO, band	Unsuccessful (PVR)	Reoperation	SO removal	-	20/200	Reattached
40	Off	C	Vitx, ELP, SO, band	Unsuccessful (PVR)	Reoperation	SO removal	-	20/200	Reattached
41	Off	C	Vitx, ELP, SO, band	Successful	SO removal	-	-	5/200	Reattached
42	Off	C	Vitx, ELP, SO, band	Successful	SO removal	-	-	HM	Reattached (OA)
43	Off	C	Vitx, ELP, FGX, band	Successful	-	-	-	20/50	Reattached

PVR, proliferative vitreoretinopathy; SB, scleral buckling; RD, retinal detachment; Lensx, lensectomy; Vitx, vitrectomy; ELP, endolaser photocoagulation; SO, silicone oil; FGX, fluid/gas exchange; PE, phacoemulsification; PCIOL, posterior chamber intraocular lens; ECCE, extracapsular cataract extraction; MPC, membrane peeling cutting ; HM, hand motions; LP, light perception; Vit, vitreous; Hem, hemorrhage; inf., inferior; OA, optc atrophy.

Based on available data, lattice degeneration had been detected in 22 (47.8%) eyes prior to LASIK. Multiple areas of lattice degeneration were present circumferentially in multiple rows in most cases. Retinal breaks resulting in RRD were related to lattice degeneration in 20 (43.5%) eyes. Only 3 (13.6%) eyes had undergone prophylactic barrier laser photocoagulation before LASIK. In these eyes, new retinal breaks resulting in RRD were located at the margin of the treated lattice degeneration in 2 eyes (Table 1, right eyes of cases #1 and #5). In the remaining case, the flap tear was unrelated to the previously treated lattice degeneration (Table 1, case #9). An asymptomatic retinal tear was seen at the posterior margin of an area of lattice degeneration in one eye, (Table 1, case #9). Both eyes in another patient showed retinal breaks unrelated to lattice degeneration (Table 1, case #1).

Thirty-two eyes (69.6%) underwent scleral buckling as the initial procedure. A meridional sponge was placed in four eyes without drainage of subretinal fluid. Segmental circumferential solid silicone tire with an encircling band together with drainage of subretinal fluid was performed in the remaining cases. Retinopexy was induced either by intraoperative cryopexy or postoperative laser photocoagulation around the retinal breaks. Intravitreal gas injection was performed in 6 eyes as a supplemental procedure in the same session or in a second session because the retinal breaks remained open after scleral buckling. New retinal breaks and subsequent RDs were managed by additional scleral buckling and/or barrier laser photocoagulation in 3 eyes. New retinal break formation was a complication of intravitreal gas injection in one of these eyes (Table 1, case #10).

Of 32 eyes undergoing scleral buckling as primary treatment, 12 (37.5%) required reoperations including pars plana vitrectomy with endolaser photocoagulation and internal tamponade. Retinal reattachment could not be achieved despite placement of a buckle in one eye due to the presence of a large, posterior retinal break. Vitrectomy was indicated in one patient due to macular pucker in one eye and for management of a late-onset giant retinal tear in the fellow eye (Table 1, case #30). PVR was the cause of failure in 9 other eyes after scleral buckling. Removal of the lens (lensectomy or phacoemulsification) was combined with vitrectomy for management of anterior PVR in most such cases (Table 1).

Fourteen eyes (30.4%) underwent primary vitrectomy, endolaser photocoagulation and internal tamponade combined with an encircling band. Six of these eyes had multiple, large or posterior retinal breaks, with or without vitreous hemorrhage, including 3 eyes with PVR C; the remaining 8 eyes had giant retinal tears, 5 of which showed signs of PVR grade C before surgery. Of the 14 eyes undergoing pars plana vitrectomy as primary treatment, retinal reattachment was achieved in 8 cases but reoperations were required in the remaining 6 eyes which was due to PVR in five eyes.

Overall, PVR grade C was present in 8 of 46 (17.3%) eyes before surgery. Of these, only one eye with PVR grade CP1 underwent scleral buckling as the initial procedure while pars plana vitrectomy was performed in the remaining seven eyes. Multiple vitreoretinal procedures were necessary in these eyes.

Silicone oil (1000 cs or 5000 cs viscosity) was used for internal tamponade in 18 eyes during initial surgery or reoperations. Silicone oil was removed 3 to 6 months later in cases which the retina was reattached posterior to the buckle. Retinal redetachment, however, occurred in 2 eyes necessitating reoperations (Table 1).

Corneal flap dislocation occurred in 3 eyes; in two eyes (Table 1, right eye of case #1 and #27) this happened when the surgeon removed the corneal epithelium. The interval between LASIK and retinal detachment surgery was 36 and 4 months in these cases respectively. In one eye (Table 1, case #6), flap dislocation occurred despite no manipulation. This eye had undergone vitreoretinal surgery two months after LASIK. Flap dehiscence was managed at the end of surgery by irrigating the stromal bed and repositioning the flap followed by application of a light pressure patch. One day after the operation, the LASIK flap remained in position in the first two cases. Nevertheless in the third case, it seemed to be slightly displaced with some wrinkling requiring flap fixation with three separate 10/0 nylon sutures which were removed two weeks later; the flap remained stable and the cornea was clear thereafter.

Overall, 27 (58.7%) eyes required additional procedures. Complete retinal reattachment was finally achieved in 43 (93.4%) eyes. Three patients with retinal detachments complicated by PVR refused further operations. Before LASIK, all eyes had best-corrected visual acuity (BCVA) of 20/40 or better. Postoperative visual acuity of 20/40 or better and 20/200 or better was achieved in 16 (34.8%) and 25 (54.3%) eyes, respectively. Four eyes had final visual acuity of light perception (LP) to hand motions due to total retinal redetachment in 2 eyes (Table 1, cases #15 and #20) and optic atrophy in 2 other eyes (Table 1, cases #29 and #42). Optic atrophy was presumed to be due to perioperative intraocular pressure (IOP) elevation.

DISCUSSION

Axial myopia is one of the most important risk factors for RRD. Moderate and high myopia predispose the eye to retinal detachment because of an increased rate and severity of vitreous liquefaction and subsequent PVD which occur at a significantly younger age in myopic eyes. Moreover, myopic eyes are more likely to develop retinal tears following PVD. Lattice degeneration is also more common in myopic eyes which further increases the risk of retinal tears when PVD occurs.[17]

In a study performed to identify risk factors for idiopathic RRD, myopia emerged as the strongest one. Eyes with refractive error of -1.00 to -3.00 D had a four-fold risk as compared to emmetropic eyes; with refractive errors exceeding -3.00 D, the risk was nearly 10 times. The incidence of retinal detachment is about 30 per 100,000 per year in the general population vs 0.7% to 6% per year in myopic patients.[17] The authors concluded that RD is primarily dependent on the architecture of the eye.

The role of LASIK as a potential additive risk factor for RRD in myopic eyes has been an issue of debate.[5-14,18] It has been suggested that LASIK is a "closed eye injury" and can be considered as an additional precipitating factor.[18] Theoretically, shock waves generated by the excimer laser may increase the risk of PVD.[5] Arevalo et al[8,10-12] hypothesized that IOP rise to levels greater than 60 mmHg induced by the pneumatic suction ring may exert traction on the vitreous base by anteroposterior compression and equatorial expansion leading to retinal breaks. Flaxel et al[15] observed an actual increase in axial length after placement of the suction ring without any change in anterior chamber depth and concluded that changes in ocular dimensions may induce posterior vitreous detachment. This may also lead to anterior movement of the vitreous base resulting in traction on areas of lattice degeneration. In their clinical and experimental studies, Luna et al[3] reported the occurrence of PVD following LASIK. Qin et al[19] found PVD in 5 of 6 eyes with RRD among 18,342 post-LASIK eyes. In our study, PVD was observed in 44 of 46 eyes with post-LASIK RRD. Delayed retinal break formation following PVD has already been described[20] which may explain the long interval between LASIK and RRD in some cases.

Several forms of retinal detachment have been considered as "complex"; these include cases with large and/or multiple retinal tears, retinal detachments due to posterior or giant retinal tears, and those with PVR.[16] Giant retinal tears occur most frequently in association with myopia and ocular trauma. When both factors coexist, the risk of giant retinal tear is further increased. Farah and co-authors[9] reported two cases of giant retinal tears following LASIK for high myopia; the retinal detachments developed less than 3 months after surgery and final visual acuity was 20/400 and LP. Ozdamar et al[5] reported a case of simultaneous bilateral retinal detachment associated with giant retinal tears after LASIK in a highly myopic patient. Another case of bilateral retinal detachment associated with giant retinal tears has been reported in a highly myopic patient two months after LASIK.[14] A significant percentage of our cases (17.3%) had giant retinal tears; all eyes were highly myopic and the time interval between LASIK and RRD was short in most cases. In addition to giant retinal tears, more than half of our patients had multiple, large posterior retinal flap tears. Overall, 70% of our cases (8 with GRT and 22 with multiple, large and posterior retinal flap tears) had complexities related to the type and size of retinal breaks. This is a higher rate in comparison with previous reports in the literature.[6-14] Chan et al[21] also reported complexity in their post-LASIK RRD cases including two or more breaks in 53%, 3 or more breaks in 26.7%, bilateral involvement in 30%, PVR in 8.3%, GRT in 6.7%, and extensive retinal dialysis in 5.0%. The high incidence of PVR in our series may be due to presence of large and multiple retinal breaks[22-24] and the greater extent of RRD.[23,25-27] Moreover, many cases were referred by anterior segment surgeons, possibly prolonging the interval between onset of RRD to diagnosis.

LASIK procedures using commercially available excimer laser machines have been approved in the United States for up to 14 D of myopia.[28] In other countries higher degrees of myopia have been corrected using this technique. Nevertheless, the results have generally been worse in cases with more than 7D of myopia.[28,29] In addition to structural tissue alterations, highly myopic eyes may be prone to an increased risk of retinal detachment following LASIK because of greater total laser energy and longer duration of shock waves.[3] Luna et al[3] noticed that PVD was more prevalent in high as compared to low myopia. Diminished hyaluronic acid and loss of compartmentalization predispose highly myopic eyes to acute PVD and development of retinal tears including GRT.

In a study by Chan et al,[21] characteristics of post-LASIK retinal breaks and detachments were evaluated in 60 eyes with documented pre-LASIK retinal examinations. A large percentage of eyes had substantial myopia and complex vitreoretinal complications. Of the 60 eyes, 15% and 40% developed retinal lesions within 1 and 6 months after LASIK, respectively. Eyes that developed more extensive RD had significantly higher myopia than eyes with limited RD within 12 months after LASIK.

Our study was not designed to identify the incidence of RRD after LASIK; we were also unable to investigate the cause and effect relationship between LASIK and RRD. A large percentage of our patients were highly myopic and the occurrence of complicated RRD in such eyes is not unexpected. One may only hypothesize that LASIK might be a precipitating factor in such predisposed eyes. To prove such a relationship between LASIK and RRD, a prospective study needs to be conducted.

In our series, 43.5% of eyes with RD had one or multiple retinal breaks associated with lattice degeneration. Arevalo et al[8] and Aras et al[7] reported such an association in 22.5% and 40% of their patients respectively. Lattice degeneration is a significant risk factor for RRD and frequently observed on fundus examination of myopic eyes.[30] Lattice degeneration is usually extensive and may be present in multiple rows in these eyes. The efficacy of prophylactic treatment of lattice degeneration in reducing the risk of RRD remains unclear.[31] In a study by Folk et al[32] prophylactic laser treatment of lattice degenerations was ineffective in eyes with more than 6 diopters of myopia or with more than 6 clock hours of lattice. Three patients in our series and some cases in other series developed RD following LASIK despite prophylactic barrier laser treatment of lattice degeneration. Moreover, in the series reported by Farah et al[9] and also in our series, some retinal breaks were located in apparently normal areas. LASIK may aggravate pre-existing retinal pathologies including invisible vitreoretinal adhesions which may result in retinal tear formation in locations with no prior visible changes.[16] In a retrospective study investigating the correlation between pre- and post-LASIK retinal lesions; the authors noticed that prophylactic treatment of lattice degeneration and retinal breaks prior to LASIK did not guarantee the prevention of vitreoretinal complications in highly myopic eyes.[33]

Multiple vitreoretinal procedures were performed in most of our patients and final retinal reattachment was achieved in 93.4 % of eyes which favorably compares to figures reported by Arevalo et al[8,10-12] and Aras et al.[7] Most patients in our series showed a dramatic decrease in visual acuity after multiple vitreoretinal operations despite retinal reattachment. Aras et al[7] presented 10 cases of RD following LASIK, final BCVA was less than 20/40 in all cases and 20/200 or worse in 7 eyes. These observations show that functional results may not be as satisfactory as anatomic results in eyes with post-LASIK RRD.

Surgery in these eyes may be associated with intraoperative complications of rapid corneal haziness and LASIK flap dehiscence. A case of corneal flap dehiscence 7 months after LASIK has been reported during RD surgery.[34] A similar complication occurred in 3 eyes in our series. The interval between LASIK and RD surgery was less than 6 months in two eyes and 36 months in the other eye. These observations are in accordance with a study which showed absence of bridging collagen fibers and cells between the flap and the stromal bed, indicating lack of wound repair at the LASIK interface.[35]

In conclusion, post-LASIK RRD usually occurs in eyes with moderate to high myopia and may have a complex nature in terms of size, number, location and type of retinal breaks, as well as a high rate of PVR. Surgeons may face corneal flap complications in these eyes. Multiple procedures may be needed and final visual results are usually not favorable. Although the retrospective nature of our study precludes determining a cause and effect relationship between LASIK and vitreoretinal complications, our findings suggest that every LASIK candidate should undergo a meticulous vitreoretinal examination. High myopia and/or presence of extensive circumferential lattice degeneration may be a warning sign. The patient should be informed that prophylactic treatment of peripheral retinal lesions does not have a proven efficacy in preventing RD following LASIK.

REFERENCES

1. Sugar A, Rapuano CJ, Culbertson WW, Huang D, Varley GA, Agapitos PJ, et al. Laser in situ keratomileusis for myopia and astigmatism: safety and efficacy. A report by the American Academy of Ophthalmology. *Ophthalmology* 2002;109:175-187.
2. Stulting RD, Carr JD, Thompson KP, Waring GO 3rd, Wiley WM, Walker JG. Complications of laser in situ keratomileusis for the correction of myopia. *Ophthalmology* 1999;106:13-20.
3. Luna JD, Artal MN, Reviglio VE, Pelizzari M, Diaz H, Juarez P. Vitreoretinal alterations following laser in situ keratomileusis: clinical and experimental studies. *Graefe's Arch Clin Exp Ophthalmol* 2001;239:416-423.
4. Panozzo G, Parolini B. Relationship between vitreoretinal and refractive surgery. *Ophthalmology* 2001;108:1663-1670.
5. Ozdamar A, Aras C, Sener B, Oncel M, Karacorlu M. Bilateral retinal detachment associated with giant retinal tear after laser- assisted in situ keratomileusis. *Retina* 1998;18:176-177.
6. Ruiz- Moreno JM, Pe'rez-Santonja N, Alio' JL. Retinal detachment in myopic eyes after laser in situ keratomileusis. *Am J Ophthalmol* 1999;128:588-594.
7. Aras C, Ozdamar A, Karacorlu M, Sener B, Bahcecioglu H. Retinal detachment following laser in situ keratomileusis. *Ophthalmic Surg Lasers* 2000;31:121-125.
8. Arevalo JF, Ramirez E, Suarez E, Morales-Stopello J, Cortez R, Ramirez G, et al. Incidence ofvitreo-retinal pathologic conditions 24 months after laser in situ ketatomileusis. *Ophthalmology* 2000;107:258-262.
9. Farah ME, Hofting-Lima AI, Nascimento E. Early rhegmatogenous retinal detachment following laser in situ keratomileusis for high myopia. *J Refract Surg* 2000;16:739-743.
10. Arevalo JF, Ramires E, Suarez E, Antzoulatos G, Torres F, Cortez R, et al. Rhegmatogenous retinal detachment after laser- assisted in situ keratomileusis (LASIK) for the correction of myopia. *Retina* 2000;20:338 -341.
11. Arevalo JF, Ramirez E, Suarez E, Cortez R, Antzoulatos G, Morales-Stopello J, et al. Rhegmatogenous retinal detachment in myopic eyes after laser in situ keratomileusis. Frequency, characteristics, and mechanism. *J Cataract Refract Surg* 2001;27:674-680.
12. Arevalo JF, Ramirez E, Suarez E, Cortez R, Ramirez G, Yepez JB. Retinal detachment in myopic eyes after laser in situ keratomileusis. *J Refract Surg* 2002;18:708-714.
13. Ruiz-Moreno JM, Alio JL. Incidence of retinal disease following refractive surgery in 9239 eyes. *J Refract Surg* 2003;19:534-547.
14. Hernaez-Ortega MC, Soto-Pedre E. Bilateral retinal detachment associated with giant retinal tears following LASIK. *J Refract Surg* 2003;19:611.
15. Flaxel CJ, Choi YH, Sheety M, Oeinck SC, Lee JY, McDonnell PJ. Proposed mechanism for retinal tears after LASIK: an experimental model. *Ophthalmology* 2004;111:24-27.
16. Michels RG, Wilkinson CP, Rice TA. Retinal detachment. St. Louis: Mosby;1990.
17. The Eye Disease Case Control Study Group. Risk factors for idiopathic rhegmatogenous retinal detachment. *Am J Epidemiol* 1993;137:749-757.
18. Arevalo JF, Freeman WR, Gomez L. Retina and vitreous pathology after laser- assisted in situ keratomileusis: is there a cause- effect relationship? *Ophthalmology* 2001;108:839-840.
19. Qin B, Huang L, Zeng J, Hu J. Retinal detachment

after laser in situ keratomileusis in myopic eyes. *Am J Ophthalmol* 2007;144:921-923.
20. Novak MA, Welch RB. Complications of acute symptomatic posterior vitreous detachment. *Am J Ophthalmol* 1984;97:308-314.
21. Chan CK, Arevalo JF, Akbatur HH, Sengün A, Yoon YH, Lee GJ, et al. Characteristics of sixty myopic eyes with pre-laser in situ keratomileusis retinal examination and post-laser in situ keratomileusis retinal lesions. *Retina* 2004;24:706-713.
22. Yoshino Y, Ideta H, Nagasaki H, Demura A. Comparative study of clinical factors predisposing patients to proliferative vitreoretinopathy. *Retina* 1989;9:97-100.
23. Girard P, Mimoun G,Karpouzas I, Montefiore G. Clinical risk factors for proliferative vitreoretinopathy after retinal detachment surgery. *Retina* 1994;14:417-424.
24. Nagasaki H, Ideta H, Demura A, Morita H, Ttok, Yonemoto J. Comparative study of clinical factors that predispose patients to proliferative vitreoretinopathy in aphakia. *Retina* 1991;11:204-207.
25. Sharma T, Challa JK, Ravishankar KV, Murugesan R. Scleral buckling for retinal detachment. Predictors for anatomic failure. *Retina* 1994;14:338-343.
26. Greven CM, Sanders RJ, Brown GC, Annesley WH, Sarin LK, Tasman W, et al. Pseudophakic retinal detachments. Anatomic and visual results. *Ophthalmology* 1992;99:257-262.
27. Ahmadieh H, Entezari M, Soheilian M, Azarmina M, Dehghan MH, Mashayekhi A, et al. Factors influencing anatomic and visual results in primary scleral buckling. *Eur J Ophthalmol* 2000;10:153-159.
28. Sanders DR, Vukich JA. Comparison of implantable contact lens and laser assisted in situ keratomileusis for moderate to high myopia. *Cornea* 2003;22:324-331.
29. Randleman JB, Russell B, Ward MA, Thompson KP, Stulting RD. Risk factors and prognosis for corneal ectasia after LASIK. *Ophthalmology* 2003;110:267-275.
30. Celorio JM, Pruett RC. Prevalence of lattice degeneration and its relation to axial length in severe myopia. *Am J Ophthalmol* 1991;111:20-23.
31. Wilkinson CP. Evidence-based analysis of prophylactic treatment of asymptomatic retinal breaks and lattice degeneration. *Ophthalmology* 2000;107:12-18.
32. Folk JC. Arrindell EL. Klugman MR. The fellow eye of patients with phakic lattice retinal detachment. *Ophthalmology* 1989;96:72-79.
33. Chan CK, Tarasewicz DO, Lin SO. Relation of pre-LASIK and post- LASIK retinal lesions and retinal examination for LASIK eyes. *Br J Ophthalmol* 2005;89:299-301.
34. Sakurai E, Okuda M, Nazaki M, Ogura Y. Late-onset laser in situ keratomileusis (LASIK) flap dehiscence during retinal detachment surgery. *Am J Ophthalmol* 2002;134:265-266.
35. Rumelt S, Cohen I, Skandarani P, Delarea Y, Ben Shaul Y, Rehany U. Ultrastructure of the lamellar corneal wound after laser in situ keratomileusis. *J Cataract Refract Surg* 2001;27:1323-1327.