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MAJOR REVIEW

Posterior Segment Complications of Laser in situ Keratomileusis (LASIK)

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Abstract. Laser in situ keratomileusis (LASIK) is the most common surgical procedure for treatment of refractive errors worldwide. Most of its complications are related to the refractive outcome or to corneal and anterior segment injury and wound healing. We review published posterior segment complications of LASIK, current clinical and experimental hypotheses explaining the occurrence of these events, and their management and outcome. Vitreoretinal complications after LASIK are very rare, and a cause–effect relationship between LASIK and reported posterior segment complications has not been proven. (**Surv Ophthalmol 54**:433–440, 2009. © 2009 Elsevier Inc. All rights reserved.)

Key words. adverse event • complication • laser in situ keratomileusis • LASIK • macula • posterior segment • refractive surgery • retina

I. Introduction

Laser in situ keratomileusis (LASIK), a surgical procedure for correction of refractive errors, has a high level of safety and efficacy.[31,65] LASIK has become the most frequent refractive surgical procedure worldwide. Most reported LASIK complications are related to the refractive outcome or to corneal and anterior segment injury and wound healing. Posterior segment complications after LASIK are rarely reported.[37] Although several hypotheses have been proposed to explain the effect of LASIK on the posterior segment,[4] the rarity of these events makes it difficult to examine the exact incidence and risk factors of vitreoretinal complications. Recent studies have attempted to investigate the effect of LASIK on vitreoretinal structures.[24,43,44]

Most reports on the complications of LASIK are published by refractive surgeons. As vitreoretinal disorders are usually managed by retinal subspecialists, refractive surgeons may not be as aware of posterior segment complications and their outcome.

We provide a survey of the reported posterior segment complications associated with LASIK, possible pathogenetic mechanisms, risk factors, current management, and outcomes.

II. Pathogenetic Mechanisms and Hypotheses of Vitreoretinal Alterations

Only a few studies have been published on the pathogenesis of vitreoretinal alterations after LASIK.[3] These may be categorized as follow.

A. BIOMECHANICAL CHANGES OF THE OCULAR GLOBE BY APPLICATION OF THE MICROKERATOME

Excessive mechanical stress is often suggested as the etiology of vitreoretinal pathology during or after

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the LASIK procedure. It is assumed that the eye changes shape during the application of the suction ring to fixate the globe during the creation of the corneal flap by the microkeratome blade.[4] The power vectors are believed to be relayed to the vitreoretinal structure. The suction ring is positioned approximately 3 mm outside the limbus. Applying suction causes an increase of intraocular pressure (IOP) to approximately 60 mm Hg, obviously not a normal physiological state. During the cutting of the cornea by an oscillating blade, the IOP increases even more. One hypothesis is that the axial length of the eye changes during the microkeratome usage (lengthening or shortening), resulting in vitreoretinal traction at the vulnerable macula and vitreous base. This was not corroborated in a recent in vivo study.[43]

Mirshahi and co-workers performed ultrasonographic measurements of the axial length of the eye (A-scan) before and during the application of a conventional suction ring for LASIK and found no significant changes of the axial length. Lens thickness did decrease during the suction period. The authors suggest that a decrease in the lens thickness with no change in axial length in young patients, where the anterior hyaloid is adherent to the posterior capsule of the lens, would lead to an anterior power vector in the vitreous body. The induced traction could act in areas of high vitreoretinal adherence—the vitreous base and macula—to produce retinal tears or macular holes. In areas of low vitreoretinal adhesion, the vector could produce vitreous detachment, as has already been reported by others.[38,45,62] No study has yet addressed changes of shape during the cutting of the corneal flap when the applied power to the eye is even higher.

Another variable is the time needed for creating the flap. Cutting time depends on various factors, some fixed (e.g., the type of microkeratome) and others variable (e.g., the surgeon's experience). Longer suction times might be associated with a higher incidence of vitreoretinal pathologies, but this has not been systematically studied. Nevertheless, it is noteworthy that many posterior segment complications (including optic neuropathy) were reported in the early period of LASIK use, when suction times needed for flap creation were longer than they are now. In addition, the number of published vitreoretinal complications has not risen proportionately to the increase in the total number of LASIKs performed worldwide. In our opinion, this may be explained by improved microkeratomes that reduce suction times. Although ischemic events in the posterior segment could result from longer periods of increased IOP, sudden biomechanical changes produced by the application of the microkeratome itself may result in power vector-related pathologies.

B. FEMTOSECOND LASER FOR LASIK

Recently, an ultrafast laser (femtosecond) has been introduced that allows the non-mechanical creation of corneal flaps for LASIK.[42] Although the actual cutting is non-mechanical and potentially less harmful to the eye, a suction ring is still necessary for stabilization of the eye. Less vacuum is necessary for femtosecond laser cutting (about 30–40 mmHg) compared to conventional microkeratomes. The time needed to create the corneal flap, however, is longer than with the mechanical method. Even with state-of-the-art 60 kHz technology, approximately 18 seconds are needed for creation of the flap. A report by Principe and co-workers shows that macular pathology may also occur when using the femtosecond laser.[51] That observation corroborates the hypothesis that application of the suction ring may play a decisive role in the development of LASIK-associated vitreoretinal pathology. A recent study by Tan and co-authors addresses vision during LASIK with different types of microkeratomes.[67] During both vacuum suction and corneal flap fashioning, a higher proportion of eyes in the conventional microkeratome group lost light perception compared with the femtosecond laser group.

C. EXCIMER LASER SHOCK WAVE

Krueger et al demonstrated that the effect of excimer laser shock wave appears negligible.[33] The hypothesis that application of the microkeratome—and not the use of the excimer laser itself—is the main factor in development of posterior segment complications is supported by the observation that all such complications have been reported in primary LASIK (with use of a microkeratome) or LASIK enhancements with re-cutting a flap. To our knowledge, there is no report of vitreoretinal complications after a LASIK enhancement with flap re-lifting (without using a microkeratome). It is worth noting that there are reports on retinal tears and detachment after photorefractive keratectomy (PRK), where no suction ring is applied.[15,69] Thus, the pathogenetic role of the excimer laser shock wave cannot be ruled out with certainty.

III. Experimental and Clinical Ultrasonography Studies

Two studies on cadaver eyes and one in vivo study have been performed to examine the actual changes in axial length that occur when the microtome is applied. While Mostafavi et al observed shortening of the ocular globe length in six porcine eyes using ultrasonography,[47] Flaxel and co-workers reported an increase in the axial length in eight enucleated