The Birth of Refractive Surgery

Development of LASIK

Refractive surgery's historical timeline is marked by several milestones.

BY IOANNIS G. PALLIKARIS, MD

More than 50 years ago, Professor José I. Barraquer, MD, made initial strides in lamellar refractive surgery, and proposed the theory that adding or removing corneal tissue can modify the refractive power of the eye.[1] From the very start, Dr. Barraquer realized the importance of preserving each layer of the cornea, a milestone in the development of modern lamellar refractive procedures.

KERATOMILEUSIS IN SITU

Dr. Barraquer's original technique included the creation of a corneal lamellar disc followed by the removal of stroma, either from the bed (keratomileusis in situ) or the stromal surface of the corneal lamellar disc. The widely used term *keratomileusis* was derived from the Greek root words "keras" (hornlike = cornea) and "smileusis" (carving) to describe lamellar techniques.[2]

In 1949, Dr. Barraquer introduced myopic keratomileusis with a freehand lamellar dissection of the anterior half of the cornea using a Paufique knife.[1] Removing the stroma in this manner proved difficult and led Dr. Barraquer to focus his research on refining lamellar resection and carving the resected corneal disc.[3] He designed the first manual microkeratome, applanator lenses, and suction rings of various heights. Dr. Barraquer appreciated the importance of maintaining constant contact between the microkeratome and the suction ring during the cut in order to create a smooth, even keratotomy.[4] Numerous disadvantages of the initial myopic keratomileusis procedure included induced corneal irregular astigmatism, corneal scarring, and complex instrumentation,[4] and ultimately gave rise to the development of alternative techniques, including epikeratophakia,[5-7] incisional keratotomy,[8-10] and IOL implantation.[11]

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In the late 1980s, lamellar refractive surgery evolved in two directions: freezing and nonfreezing procedures. According to reports, freezing lamellar procedures were often associated with corneal haze and induced irregular

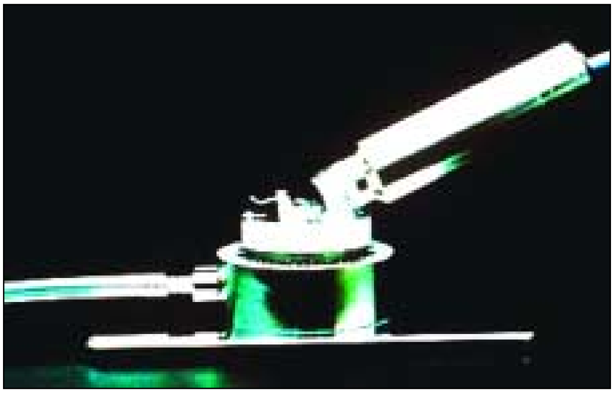

Figure 1. Early microkeratomes, like the Barraquer-Krumeich-Swinger, utilized a nonfreeze keratomileusis technique.

astigmatism.[12-16] In contrast, the nonfreezing techniques offered major advantages, including rapid patient recovery and fewer complications,[12,13,15] but these procedures were technically difficult to perform. They involved the use of a manual keratome (Figure 1) to perform a second cut on the stromal side of the resected lamellar disc.[12,13,15] Dr. Luis Ruiz of Bogota, Colombia, developed a nonfreeze procedure based on keratomileusis, known as *automated lamellar keratoplasty* (ALK). This procedure involved a primary keratectomy with an automated microkeratome to create a corneal disc, followed by a second keratectomy on the corneal bed that removed a small central piece of cornea in order to create a flatter central cornea when the corneal disc was replaced. The major complication associated with ALK, however, was induced corneal irregular astigmatism.

EVOLUTION OF CORNEAL REFRACTIVE PROCEDURES

Leo D. Bores, MD, of Fountain Hills, Arizona, was the first to perform keratomileusis in situ in the US.[8]

The manually driven microkeratomes had several apparent drawbacks, including a lack of precision and predictability and low levels of safety.[17] As a result, the introduction of ALK by Dr. Ruiz was well received in the 1980s. The obvious advantages of this procedure—rapid visual recovery, high levels of efficacy, and stability for the correction of high myopia—were balanced by induced irregular astigmatism and low predictability of the procedure.[18]

Early attempts by Gholam A. Peyman, MD, of New Orleans, Louisiana, to remove corneal tissue using a CO_2 laser failed due to major complications, including scarring and tissue coagulation.[19] Dr. Peyman reported the Er:YAG laser to be successful in modifying the corneal curvature, however.[20]

In 1983, Stephen L. Trokel, MD, and his group introduced photorefractive keratectomy (PRK).[21] When performed with a 193-nm excimer laser, PRK for high myopia often resulted in severe corneal haze, regression of myopia, and poor predictability.[22]

LASIK

The growing need for a safe and predictable corneal refractive procedure led our group (the Pallikaris group) to design and develop *laser in situ keratomileusis* (LASIK) in 1988 at the University of Crete, Greece. We combined lamellar refractive corneal surgery with excimer laser photoablation of the cornea under a hinged corneal flap.[23] The first animal studies, which were intended to determine the wound-healing response after LASIK, began in 1987 and involved a Lambda Physik excimer laser (Lambda Physik AG,

Figure 2. The Centurion SES microkeratome (CIBA Vision, Duluth, GA) offers surgeons an epikeratome with which to create an epithelial flap by means of mechanical subepithelial separation, also dubbed *Epi-LASIK* by the device's developer, Dr. Pallikaris.

Göttingen, Germany) and a microkeratome designed to produce a 150-mm corneal flap.[24] The original idea of manually creating a corneal cap and removing central tissue from the bed was first described by Nikolai P. Pureskin, Moscow, Russia, in 1967.[25]

We believed that a mechanically cut flap would ensure a better tissue alignment after the intrastromal photoablation. Furthermore, we expected that this type of flap would barely affect the anatomical relations of the corneal layers because it would preserve the Bowman's layer and preserve greater integrity of the superficial nerve plexus of the cornea through the base of the flap. In June 1989, the first LASIK on a blind human eye was performed at the University of Crete, as part of an unofficial blind eye protocol. Human studies began in 1990.[26,27] Three months after creating the flap, we observed that the cornea remained transparent and noted no significant irregular astigmatism on corneal topography. The safety of sutureless LASIK was also suggested by Dr. Ruiz and perhaps others at that time.[26]

Buratto et al introduced an excimer laser for intrastromal keratomileusis of the corneal button in 1992, and suggested the term *laser intrastromal keratomileusis*.[28] The next year, Stephen Slade, MD, of Houston, Texas, used the automated microkeratome to create a flap. He called the procedure *excimer ALK* (*E-ALK*) or *flap and zap*.[29] In 1994, our team reported the early experience of LASIK on sighted eyes as well as the first study comparing LASIK and PRK.[30,31] LASIK proved superior to PRK in terms of stability and predictability for the correction of myopia greater than 10.00 D. In 1999, the SVS Apex Plus Excimer Laser (Summit Technologies) was FDA approved for LASIK.[32]

THE FUTURE OF LASIK

We believe LASIK will remain the most popular corneal refractive procedure. Nevertheless, it is important to mention that current information about optical aberrations of the cornea induced by the creation of the flap[33] is giving rise to the evolution of surface ablation techniques. Our team at the University of Crete has recently introduced the Epi-LASIK procedure, a new surface-ablative technique that involves the creation of an epithelial flap that is repositioned on the cornea after the excimer laser ablation (Figure 2). The procedure combines the low rate of induced aberrations that are associated with PRK with LASIK's low incidence of pain and fast recovery.[34,35] We hope that these high expectations will be supported by long-term results of Epi-LASIK.

Until then, we can expect ongoing evolution in the field of microkeratomes, excimer lasers, and wavefront technology. These technologies should ensure high levels of patient satisfaction after LASIK. ■

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