ORIGINS

KERATOMES IN OPHTHALMIC SURGERY

A historical overview and discussion of modern keratomes.

BY KARL G. STONECIPHER, MD, AND J. JAMES ROWSEY, MD

First, we must define what a keratome does. This surgical instrument, sharp on one or both edges, is used to cut into a surface, such as the cornea for incisional or lamellar surgery. A microkeratome is a precision surgical instrument designed to create corneal flaps for in situ keratomileusis, automated lamellar keratoplasty, or LASIK. The thickness of a normal human cornea ranges from around 490 to 600 µm. A microkeratome creates flaps from 90 to 200 µm thick.

Keratomes have been used for eye surgery for thousands of years.

HISTORICAL BACKGROUND

The first documented use of keratomes in ophthalmology was in ancient Egypt. Nine pages of the Ebers Papyrus, a compilation of Egyptian medical texts dated about 1550 BC, are devoted to eye conditions.[1,2] In the early 5th century BC, Sushruta described using keratomes or blades for lamellar and incisional ophthalmic surgery including cataract and pterygium removal.[3] Centuries later, Galen described ophthalmic excisional and lamellar surgery using keratomes.[4]

José Ignacio Barraquer, MD, FACS, FRCOphth, was the first to describe the original device used for lamellar surgery, which is now known as *in situ keratomileusis*, in 1948.[5-8] The word *keratomileusis* literally means sculpting of the cornea. Barraquer's first procedures involved freezing a disc of anterior corneal tissue before removing stromal tissue frozen onto a lathe. Over the years, the procedure evolved, first through the Barraquer-Krumeich–Swinger nonfreeze technique in which tissue was removed from the underside of the disc by a second pass of the microkeratome.

In a later development, the microkeratome was passed a second time directly on the stromal bed. The procedure became known as *automated lamellar keratoplasty* after the invention of an automated microkeratome and was further refined. First, the disc was replaced with sutures. Later, the microkeratome was halted before the end of the pass to create a hinged flap, as first demonstrated in 1989.[9-15]

The advent of the excimer laser led to its combination with a flap, creating LASIK, as described by the Gholam A. Peyman, MD, patent.[16] A detailed history of LASIK was written by Reinstein et al.[17] Early mechanical microkeratomes had large standard deviations in flap thickness, but newer designs tightened those gaps. As the predictability and safety of microkeratomes improved, so did visual outcomes.

The development of femtosecond lasers for lamellar surgery made truly planar flaps possible. Complications associated with the mechanical microkeratome disappeared but were replaced with new issues related to the femtosecond laser.[18] Technical advances have minimized these issues, and modern LASIK is one of the safest procedures performed in any field of surgery.[19-22]

TYPES OF KERATOMES

Mechanical. Mechanical keratomes can be either translational or rotational.

- ***Translational.*** Translational mechanical microkeratomes use an oscillating blade that docks to a suction ring that induces high IOP. A lamellar corneal flap of 100 to 120 µm on average is created. These microkeratomes traditionally create nasal hinges. Single-use or disposable devices exist.
- ***Rotational.*** Rotational mechanical microkeratomes use a rotating or oscillating blade that docks to a suction ring that induces high IOP. A lamellar corneal flap of 100 to 120 µm is created. A nasal or superior hinge can be created, depending on the device. Disposable systems are also available for single use.

Femtosecond laser. This infrared laser operates at a wavelength of 1,053 nm. It uses photodisruption to create ultrashort pulses of 10^{-15} of a second, which create microcavitation bubbles of 2 to 3 µm. Thousands of these bubbles combine in a raster pattern to create a lamellar flap beneath the epithelium in the stromal bed. The sidecut is created at the end by stacking the bubbles. Femtosecond lasers are used for LASIK primarily but also for other corneal procedures, such as lamellar corneal surgery, corneal transplantation, and cataract surgery.

MODERN DEVELOPMENTS

The latest microkeratomes and femtosecond lasers can create flaps efficiently and with fewer complications. The increasing speed of lasers has reduced the time required to create flaps—a significant difference between this technology and microkeratomes. Further advances should produce better results and reduce the need for enhancements.[23-29] ■

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