What is so particular about using the femtosecond laser for corneal surgery? Compared with mechanical microkeratomes or trephines, the femtosecond laser can create extremely precise trans- and intracorneal dissections at a predetermined diameter, inclination, and depth. Be it the geometry of the lamellar cut or be it the predetermined depth of the cut, no manual dissection can compare to the precision of the femtosecond laser. This technology enables us to perform pre-designed profile cuts in the cornea, allowing faster visual recovery, stronger scar formation, and less induced astigmatism than previous mechanical devices or hand dissection.

Femtosecond laser cut architecture varies from anterior and posterior sidecuts to lamellar, full-thickness, and angled cuts (Figure 1). When used for penetrating keratoplasty (PKP), the laser can create profiled cut edges using the same tongue-and-groove principle commonly described in carpentry. All of the geometric cut profiles that we use today in femtosecond laser corneal surgery, such as the top hat, mushroom, zigzag, Christmas tree, zig square, and barrel, are simply variations of the tongue-and-groove principle.

**ADVANTAGES**

Cuts with tongue-and-groove profiles have two main advantages: (1) formation of a watertight seal with less suture tension and (2) provision of mechanical solidity in scar formation.

**Watertight seal.** In standard PKP, the watertight seal results from tightening the sutures enough for the wound margins to be pressed together seamlessly. However, the tongue-and-groove profiles created with the femtosecond laser more closely resemble the self-sealing incisions used for cataract surgery. The profile itself provides much of the watertightness, with the suture placed only to prevent the tissues from being pressed apart.

**Scar formation.** Compared with a straight vertical cut, the femtosecond-enabled cuts produce a much larger scarring (ie, healing) surface. No carpenter would glue two wooden boards together by their small sides; they create interdigitations to greatly enlarge the surface contact and therefore the bond between them. The same concept is true with PKP. Enlarging the wound surface builds a strong scar. We are making a stronger wound and a tighter fit by wound profile compared with classic trephine keratoplasty.

**PREFERRED PROFILES**

I was one of the first surgeons to perform femtosecond-assisted PKP more than 5 years ago. My first cases included patients with keratoconus, Fuchs dystrophy, corneal scars, and pseudophakic bullous keratopathy. My initial impression was that cut dimensions for recipient and donor and the suture technique were optimized. I have tried all of the geometric cut profiles previously mentioned, but with experience I have narrowed my choices mostly to the modified mushroom, barrel, anvil, and flask profiles. The profile I select depends on the characteristics of the eye that I am treating.

**Modified mushroom or anvil.** In this cut (Figure 2), the profile looks like a champagne cork or an anvil, with a wider outer lip like the head of a screw. The difference from the standard mushroom is that the angle is oblique through the inner portion, thus offering better adaptation of the inner margins in case of thickness disparity.

**Barrel.** I use this profile (Figure 3) often, especially for deep anterior lamellar keratoplasty (DALK) or secondary...
keratoplasty. Other surgeons prefer the zigzag configuration for DALK. Both profiles have the inner part of the profile slanting inward, facilitating the excision of the recipient with scissors. I perform femtosecond-assisted DALK any time the endothelium is intact, especially in patients with keratoconus, iatrogenic ectasia, scars, stromal opacities, surface irregularities, or hereditary degenerations. The depth of the widest part of the profile is at 50% of the average pachymetry, and the posterior sidecut starts approximately 80 µm into the stroma from the thinnest pachymetry measurement within the diameter of the inner cut.

Modified top hat or flask. This configuration (Figure 4), with a larger inner and a smaller outer diameter, is best suited for diseases of the inner cornea. It may be appropriate when newer lamellar techniques, such as Descemet’s stripping endothelial keratoplasty, are not indicated. This type of profile is good mechanically, but immunologically its relatively large inner diameter may cause a higher incidence of endothelial rejection. The modification of outward slanting of the inner part is, again, thought to improve inner adaptation with thickness disparities.

**DISCUSSION**

Currently, the IntraLase femtosecond laser (Abbott Medical Optics Inc., Santa Ana, California) is the only technology with software facilitating geometric cut profiles for PKP. The refined profiles available today are result of the work of a small yet active community of surgeons who are excited by femtosecond-assisted keratoplasty and its capabilities. Other lasers, such as the Femtec (Technolas Perfect Vision GmbH, Munich, Germany), produce a vertical cut only, similar to a trephine punch-out of the cornea.

With as many advantages as femtosecond-assisted keratoplasty has, why wouldn’t every corneal surgeon make keratoplasty cuts with the laser? The answer is simple: In most cases, this technology is affordable only for centers that also perform refractive surgery. Some corneal surgeons in the United States, and a smaller number in Europe, have found innovative ways to perform femtosecond-assisted keratoplasty, incising the profile so that the incision is not completely penetrated until the patient is transported to the corneal operating room. My practice is lucky because we had the opportunity to buy a used femtosecond laser for our corneal operating room.

Femtosecond-assisted keratoplasty opens fascinating new perspectives in corneal surgery. Its potential may not be realized in most corneal centers where refractive surgery is not offered, but it is applicable in clinical routine use where the technology is available. The femtosecond laser provides corneal surgeons with the most precise, versatile tool for keratoplasty cuts. Tissue dissection in the donor and recipient are flawless, the patient experiences quick visual recovery, and surgically induced astigmatism is minimized.

**TAKE-HOME MESSAGE**

- Predesigned profile cuts allow faster visual recovery, stronger scar formation, and less induced astigmatism after keratoplasty.
- The cut geometries available today are all profiles of the tongue-and-groove principle; the appropriate profile cut depends on the characteristics of the individual’s eye.

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