These devices interrupt the biomechanic progression of disease in keratoconus.

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Keratoconus, pellucid marginal degeneration, keratoglobus, and other noninflammatory corneal thinning disorders can cause the corneal surface to become irregular and ectatic. In its earliest stages, spectacles and contact lenses are preferable methods of treatment for ectasia; however, as the corneal disease progresses, penetrating keratoplasty (PKP) or various alternative treatments may be warranted. This article focuses on one alternative treatment, the implantation of intrastromal corneal ring segments (ICRSs), to flatten the cornea and achieve a refractive adjustment. These segments have been shown to be a safe surgical procedure to correct corneal ectasia, astigmatism, and keratoconus.1-11

There are currently three ICRS models on the market: the Ferrara Ring (Ferrara Ophthalmics), Intacs (Addition Technology, Inc.), and the Keraring (Mediphacos Inc.). Although each model is unique, their main function is to act as a tissue addition. When implanted inside a corneal pocket, the ICRS produces a flattening effect in the peripheral cornea. ICRSs are available in a variety of diameters, and the ring segment diameter is inversely proportional to the resulting flattening intensity.

One characteristic of ICRS implantation is that the ring segments generate both an immediate response as well as a time-dependent (biomechanic) response in the keratoconic eye. The immediate response of the implant is to interrupt biomechanic disease progression; the time-dependent response subsequently improves vision over the following 6 months after implantation. Because of their its flattening effects, ICRSs can also treat astigmatism and improve visual acuity.

SURGICAL PREPARATION AND TECHNIQUES

Indications and contraindications for ICRS implantation are listed in Table 1, and factors that should be assessed in preoperative evaluation are listed in Table 2. In the past several years, there has been a trend toward using the femtosecond laser for ICRS channel creation. However, a mechanical tunnel creation method is still acceptable and produces the same postoperative results as femtosecond-assisted ICRS implantation. The advantage of the femtosecond laser is that the incidence of intraoperative complications is likely minimized. Both the mechanical and femtosecond surgical approaches to ICRS implantation are described below. A combined surgical technique using both corneal collagen crosslinking (CXL) and ICRS is also mentioned.

Mechanical tunnel creation. After identifying the geometric center of the cornea using an 11-mm zone marker, the center of the cornea is marked using a Sinskey hook. Next, the incision mark of the procedure marker is aligned 1 mm from the limbus. For right and left eyes, respectively, this is at the 9- and 3-o’clock positions. A temporal, radial, 1-mm incision is then created to an approximate corneal thickness depth of 70% on the flattest axis of the topographic map.

At this point, a pocketing hook is introduced to initiate intrastromal tunnels and a glide blade is used to assess incision length and to verify a sound pocket structure. Once a vacuum-centering guide is placed along with the procedure marker on the corneal surface, the devices are aligned with the geometric center of the cornea.
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From here, the procedure can vary depending on the chosen ICRS model. With Intacs, for instance, the KV 2000 Vacuum System (Addition Technology, Inc.) is set on low and then advanced to the highest setting. Using dissectors (corneal separators), the intrastromal tunnels are created in the desired directions, and the Intacs inserts are implanted into the tunnels. After surgery, we prescribe antibiotic (tobramycin) and corticosteroid (dexamethasone) eye drops three times daily for 2 weeks.

Femtosecond laser-assisted tunnel creation. With aid of a disposable glass lens, the femtosecond laser canonizes the cornea, fixes the eye, and maintains a precise distance from the head of the laser to the focal point of the tunnel location. All laser models are different; the pulse duration of the Intralase (Abbott Medical Optics Inc.) is 600 femtoseconds. Using this device, the inner-to-outert diameter of the Intacs tunnel is set from 6.7 to 8.2 mm, the spot size is set to 1 µm, and the energy is set at 6 mJ.

In the next maneuver, forceps are used to grasp the ICRS’s midsection and lift it from the case. The original incision is reopened with Sinskey hooks, and subsequently the Intacs segment is rolled slightly superiorly to achieve the proper entry angle. Once the leading edge is inserted into the pocket and half of the segment is in the tunnel, the grasp on the forceps is released. The remainder of the segment is then nudged into the tunnel using the Sinskey hook.

Postoperative prescriptions include tobramycin and dexamethasone drops five times a day for 2 weeks.

Combined CXL and ICRS implantation. The complementary effects of CXL and ICRSs have gained increasing attention over the past several years. Sequential or simultaneous combined treatments can result in greater improvements of UCVA and BCVA, greater reduction of myopia and astigmatism, and reduction of mean and steepest keratometry readings. For more information on a combined procedure, see Corneal Collagen Crosslinking: Patient Selection, on page 26.

POSTOPERATIVE COMPLICATIONS

After tunnel creation with the mechanical technique, the following moderate complications can occur: epithelial cysts, epithelial ingrowth, and diffuse collagen fibril disruption. Epithelial defects at the keratotomy site, anterior and posterior perforations during channel creation, extension of the incision toward the central visual axis or the limbus, shallow and/or uneven placement of Intacs segments, infectious keratitis with the introduction of epithelial cells into the channel during channel dissection, asymmetric placement, persistent incisional gap, decentration, stromal thinning, and corneal stromal edema around the incision and channel from surgical manipulation are also associated with a mechanical tunnel technique.

Regardless of the channel creation method, chronic pain and persistent discomfort after ICRS implantation can occur due to direct contact between the segment and a corneal nerve. For resolution of pain in these cases, ICRS removal is suggested. We have also noticed that, after implantation of Intacs, an extracellular intrastromal substance can accumulate in the lamellar channel around the segments; however, its presence has not altered the device’s optical performance nor caused any anatomic changes or physiologic corneal deterioration.

CONCLUSION

ICRSs are a proven, safe, and effective technology for the correction of corneal ectasia, astigmatism, and keratoconus. Whether using a mechanical or femtosecond-assisted tunnel creation technique, implantation of these segments can flatten the corneal surface and provide patients with a desirable refractive adjustment.

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