Dissection of corneal stroma by an intrastromal corneal ring segment during implantation

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We present the case of a 50-year-old man with keratoconus in both eyes. While the inferior intrastromal corneal ring segment (ICRS) was being implanted in the right eye, the segment dissected the corneal stroma and moved toward the limbus. The segment was redirected to its initial position and secured by a 10-0 nylon suture, which was removed 2 weeks later. To our knowledge, this is the first report of intraoperative corneal stroma dissection by an ICRS and its management.

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First approved to correct low to moderate myopia, intrastromal corneal ring segments (ICRS) are now used to correct the visual loss associated with keratoconus and other corneal ectasias.[1,2] We report a case in which an ICRS dissected the corneal stroma and moved toward the limbus and describe the management of this intraoperative complication.

CASE REPORT

A 50-year-old man with a diagnosis of bilateral keratoconus was referred to our practice for assessment of therapeutic and surgical options. There was no significant family or personal history. In the right eye, the uncorrected distance visual acuity (UDVA) was counting fingers (CF). With a correction of −4.00 −9.75 × 80, the corrected distance visual acuity (CDVA) was 20/400 (Snellen). In the left eye, the UDVA was CF. With a correction of −1.5 −9.75 × 80, the CDVA was 0.50. The keratometric values (55.30/40.00 diopters [D] and 53.70/39.60 D, respectively) were obtained using a corneal topographer (Orbscan II, Bausch & Lomb) because the autorefractor keratometer (KR8000, Topcon Medical Systems, Inc.) was unable to detect them. The ophthalmologic examination showed central corneal thinning with a clear central cornea. No significant alterations were recorded for the rest of the anterior segment, posterior segment, or intraocular pressure (IOP).

Corneal topography of both eyes (Figure 1) showed an altered keratometric map with astigmatism of 15.0 D and pachymetric reduction in the central thickness of the cornea (460 μm in the right eye and 450 μm in the left eye). To correct irregular astigmatism as much as possible and to improve the CDVA with glasses, an ICRS was implanted in both eyes.

Using topical anesthesia and sedation and after appropriate aseptic measures had been performed, 2 ICRS (Keraring SI6, Mediphacos Ltda.) with a thickness of 250 μm and arc of 120 degrees were implanted (based on the topographic map) in the right eye on the 90-degree meridian at a depth of 400 μm using the guided handheld mechanical dissection technique. The procedure began by marking the geometric center, the incision, and the position of the ICRS in the vertical meridian. The 2 main incisions were made with the diamond knife, and the tunnels were then created with the hook and the symmetrical spatula. The centering guide was placed for suction, and the tunnels were created to introduce the segments.

As the nasal end of the inferior segment was being pushed with the spatula to center it at 90 degrees, the ICRS dissected the stroma inferiorly and was displaced toward the limbus. The anterior chamber was not perforated. Gentle pressure with a hook on the corneal surface beyond the segment was applied in a centripetal direction, and the segment was redirected to its original location. The dissection left a 2.0 mm space along the inferior margin of the ICRS with a large bubble. The segment was secured using 1 interrupted 10-0 nylon suture to avoid further dislocations (Figure 2). The suture was placed on the 270-degree meridian surrounding the ICRS so the inferior margin of the ICRS could rest

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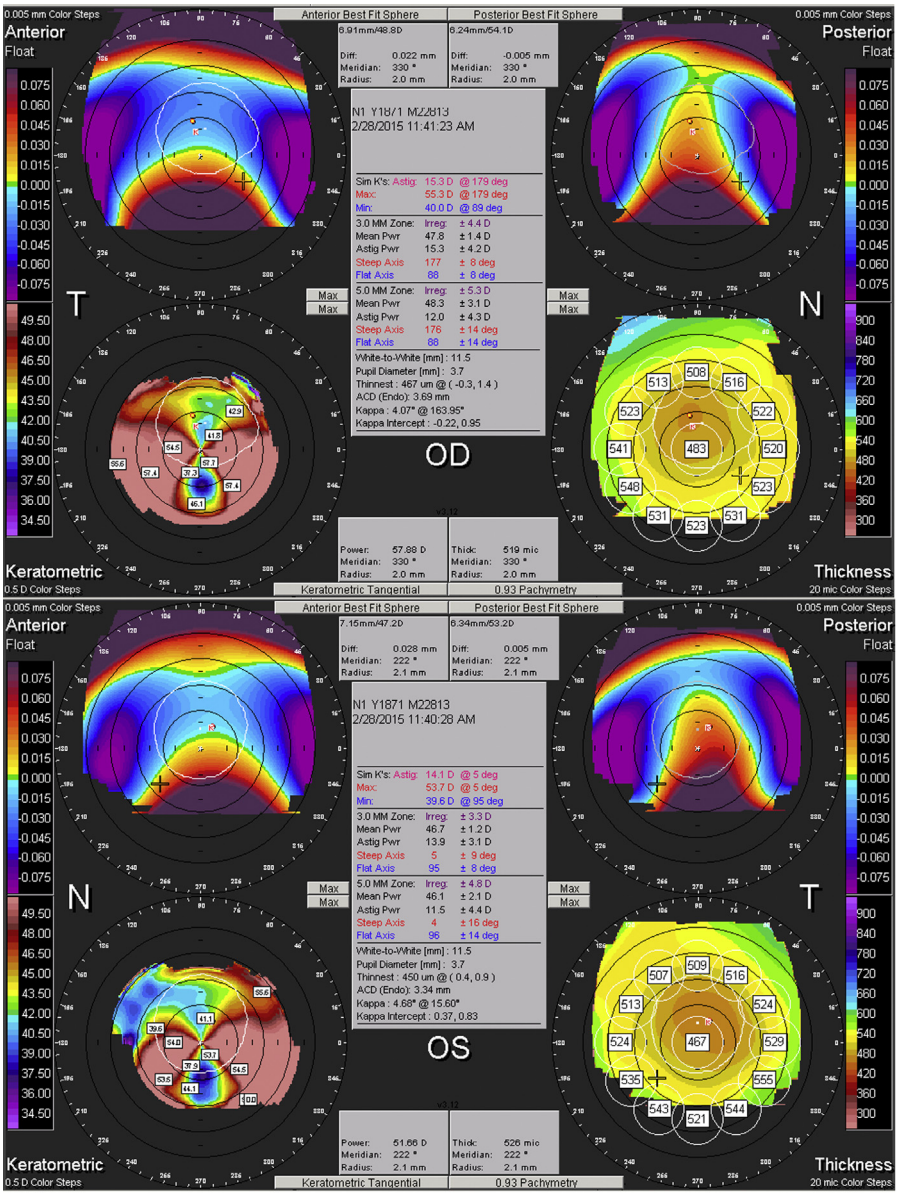

Figure 1. Preoperative corneal topography maps of both eyes.

against it. Finally, cefuroxime was injected into the tunnels, the surgical wounds were closed with 10-0 nylon interrupted sutures, and a soft bandage contact lens was placed. Postoperatively, tobramycin–dexamethasone (Tobradex) and moxifloxacin (Vigamox) eyedrops were prescribed every 6 hours for 1 week.

At the 5-day postoperative examination, the intrastromal bubbles had disappeared–but the space left by the dissection was still visible (Figure 3). The contact lens was removed. At 14 days, the intrastromal space had closed and the holding suture was removed. At 8 months, the UDVA in the right eye was 20/100. With a correction of −4.50 −.00 × 71, the CDVA was 20/40. The IOP was 11 mm Hg, and the ophthalmologic examination showed neither corneal edema nor ICRS dislocation (Figure 4).

Four months after surgery in the right eye, an ICRS was implanted in the left eye, following the parameters for segment and corneal locations used in the right eye. There were no intraoperative complications. Figure 5 shows the final corneal topography maps of both eyes.

DISCUSSION

Keratoconus is a noninflammatory progressive degenerative disorder of the cornea characterized by stromal thinning and conical ectasia.[3] During the initial stages, glasses and contact lenses are the most common treatment methods. Intrastromal corneal ring segments are usually recommended for total or partial correction of irregular astigmatism.[4,5] The selection criteria for patients are progressive deterioration of vision, unsatisfactory visual acuity with glasses, contact lens intolerance, clear central cornea, mild to moderate keratoconus, keratometry (K) reading less than 58.0 D, and corneal

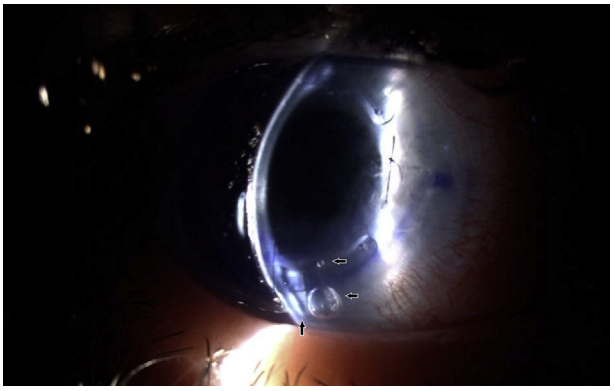

Figure 2. Immediately after surgery in the right eye, moderate corneal edema is seen around the segment. The space left in the dissected stroma can be seen inferior to the inferior segment (*vertical arrow*), as can 2 intrastromal bubbles (*horizontal arrows*). The 10-0 nylon suture holds the segment in place.

Figure 3. Five days after surgery in the right eye, the cornea shows no intrastromal bubble, but the space in the dissected stroma is still visible.

thickness of at least 400 μm in the incision area.[6,7] The segments can also be combined with crosslinking with riboflavin to achieve additional flattening and improve corneal resilience.[5] The advantage of the segments is that they can be removed without modifying the central area of the cornea. Intrastromal corneal ring segments can be placed using a handheld mechanical device or a femtosecond laser. Since the results of both techniques are similar, the femtosecond laser approach is not generally used even though it is easier and quicker and provides a greater guarantee of achieving the desired depth, especially with inexperienced surgeons.[8,9] In the case we report, the ICRS was implanted using the guided manual technique.

Placement of an ICRS does not alter corneal biomechanical properties, although it significantly alters the curvature pattern and redistributes the stress in a manner that leads to improvement over time.[10] The change in curvature pattern is characterized by central flattening and peripheral steepening over the rings. Intraoperative complications of ICRS implantation include segment decentration, asymmetry of the implants, inadequate channel depth, superficial channel dissection with anterior Bowman layer perforation, mechanical epithelial defects, placement of the ICRS too close to the incision, extension of the incision toward the central visual axis or the limbus, uneven placement of the segments, and posterior corneal perforation during channel creation.[9,11]

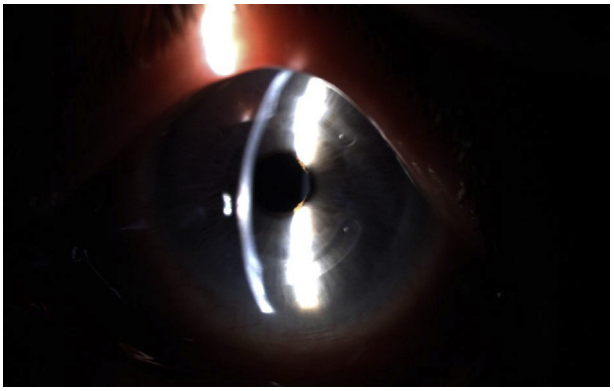

Figure 4. The cornea in the right eye 4 months after surgery.

Postoperative complications include microbial keratitis, implant extrusion, implant dislocation into the anterior chamber, superficial or asymmetric implantation of the segment, corneal thinning over the segments, reduced corneal sensitivity, induced astigmatism, stromal edema around the incision, intrastromal deposits, deep neovascularization in the incision area, persistent epithelial defects, and iritis and/or uveitis.[9,12–15] In our opinion, there are no potential common mechanisms between late dislocation of ICRS and our findings. Spontaneous dislocation of ICRS usually occurs along the tunnel toward the main incision. In this case, a virtual space is already present.

In the case we report, the ICRS dissected the deep stroma during implantation of the inferior segment and was displaced 2.0 mm toward the limbus, creating an intrastromal space. In the literature we reviewed, we found no reports of this complication. In vitro studies did show that keratoconic corneas were significantly "weaker" or had a lower elastic modulus than normal corneas.[16] Corneas with a low elastic modulus stretch or deform more under the same load than corneas with a higher elastic modulus. In addition, corneal tensile strength decreases gradually in the deeper 60% throughout the central stroma in a normal cornea.[17,18] In the present case, we postulated that the dissection of deep stroma occurred because the patient had advanced keratoconus with high K values (maximum K was 55.3 D and minimum K, 40.0 D) and thin central pachymetry (460 μm). We were able to reposition the

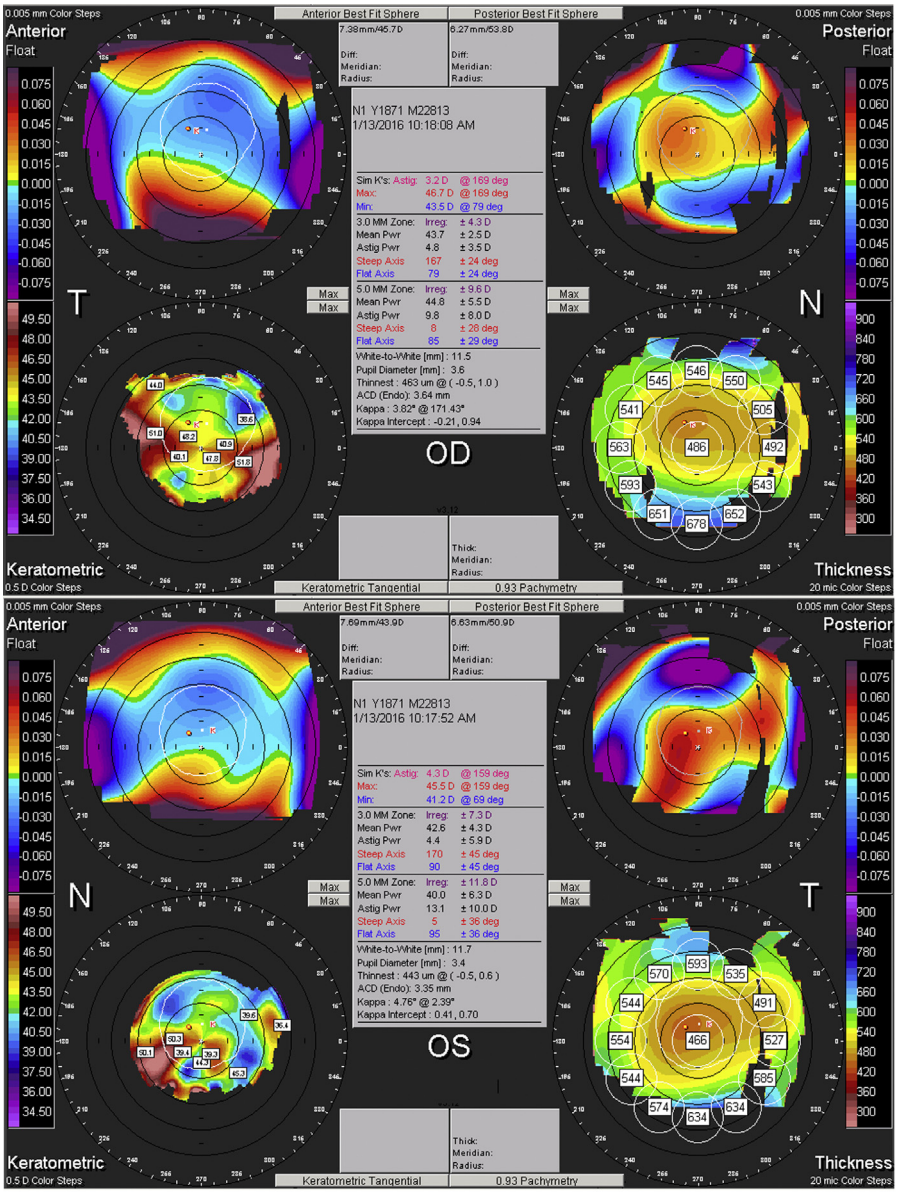

Figure 5. Corneal topography map of the right eye at 8 months and of the left eye at 5 months.

segment easily with a simple centripetal movement over the dislocated segment. One interrupted suture was used to maintain the segment in its original tunnel. The suture that entered the anterior chamber was removed as soon as the intrastromal space disappeared.

In our practice, the use of moxifloxacin in ICRS implantation to reduce the risk for corneal infection is based on our findings in corneal laser refractive surgery.[19] The safety and efficacy of intracameral cefuroxime in cataract surgery for reducing the risk of endophthalmitis encouraged us to include it in our ICRS implantation practice.[20] However, to our knowledge, there are no published data to support the use of moxifloxacin or intracameral cefuroxime in ICRS surgery.

In conclusion, clinically significant intraoperative complications are very uncommon during implantation of an ICRS. The segment can dissect the corneal stroma in eyes with keratoconus. The procedure can be concluded by repositioning and securing the ICRS with a suture.

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