Ferrara Ring: An Overview

The Ferrara Ring corrects corneal deformities and restores physiologic curvature.

BY PAULO FERRARA, MD, PHD; AND LEONARDO TORQUETTI, MD, PHD

The Ferrara Intrastromal Corneal Ring (Ferrara Ophthalmics, Belo Horizonte, Brazil) is a minimally invasive surgical option designed to treat ectatic corneal disorders, particularly keratoconus. The ring is used as an orthopedic procedure to improve the shape of the cornea, decrease keratoconus-induced astigmatism, and improve BCVA and UCVA. The PMMA ring segments are inserted into the peripheral stroma, preserving the anterior prolate shape of the anterior corneal surface. This article provides an overview of the Ferrara ring and discusses long-term clinical follow-up on treatment of keratoconus with the ring.

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CHARACTERISTICS AND INDICATIONS

The Ferrara intrastromal ring segments have a 5-mm diameter and variable thickness, ranging from 150 µm to 300 µm. The ring segments, which are made of yellow PMMA, have a 4.4-mm internal diameter, a 5.6-mm external diameter, and a 600-µm flat base. Arc segments of 90°, 120°, 160°, and 210° are available. The 210° segment was most recently introduced.

The chief indication for Ferrara Intrastromal Corneal Ring implantation is keratoconus. Patients with keratoconus who have poor BCVA and are contact lens intolerant are good candidates for the Ferrara Ring. Those with highly asymmetric or quickly evolving keratoconus are also good candidates. Other indications for the Ferrara device include highly irregular astigmatism after penetrating or lamellar keratoplasty, irregular astigmatism after radial keratotomy, and post-LASIK ectasia.

The Ferrara Ring is not indicated for use in advanced keratoconus with keratometry (K) readings greater than 75.00 D and significant apical opacity and scarring; corneas with hydrops; corneas with thickness of less than 300 µm; intense atopy (these patients should be treated before implantation); or any active local or systemic infection.

LONG-TERM FOLLOW-UP

We retrospectively reviewed records of 340 patients (age range, 11 to 58 years) consecutively implanted with Ferrara Ring segments. All procedures were performed by

TABLE 1. WHAT TO EXPECT FROM FERRARA RING IMPLANTATION

Keratoconus grade	UCVA 20/60 or better	BCVA 20/60 or better
Grade 1	59.00%	94.00%
Grade 2	53.00%	92.60%
Grade 3	30.70%	71.70%
Grade 4	19.30%	80.00%

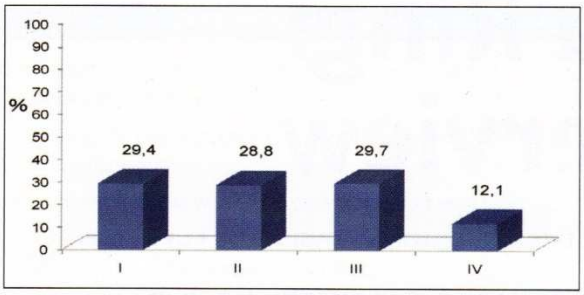

Figure 1. Characterization of patients according to keratoconus grade.

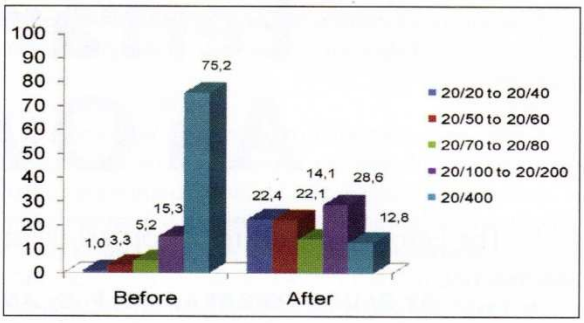

Figure 2. Patients' pre- and postoperative UCVA.

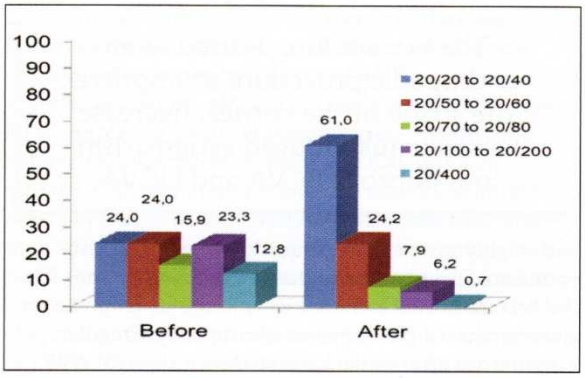

Figure 3. Patients' pre- and postoperative BCVA.

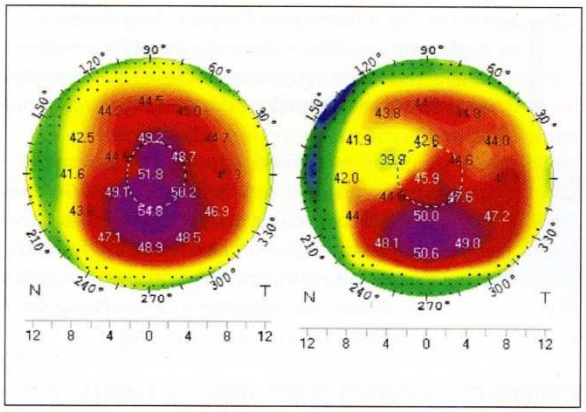

Figure 4. Topography demonstrates a decrease in corneal steepness, flattening of the central cornea, and displacement of the central cornea to a more physiologic position postoperatively.

Paulo Ferrara, MD, PhD, and the standard technique for Ferrara Ring implantation was used. Patients included in the study presented with clear corneas and a minimum corneal thickness of 300 µm at the ring track. Patients were contact-lens intolerant and/or showed progression of ectasia. The average follow-up was 18 months.

Pre- and postoperative evaluations included UCVA and BCVA, slit-lamp examination, corneal thickness measurement, and videokeratographic corneal topography (Pentacam; Oculus Optikgërate GmbH, Wetzlar, Germany). We used the Minitab software (Minitab Inc., State College, Pennsylvania) for statistical analysis. The Friedman test was used to compare pre- and postoperative data.

Most patients in the series had stage 1, 2, or 3 keratoconus preoperatively (Figure 1). Mean UCVA improved from 20/400 preoperative (range, 20/30 to 20/400) to 20/80 postoperative (range, 20/20 to 20/800; $P<.001$; Figure 2). Mean BCVA improved from 20/70 preoperative (range, 20/20 to 20/400) to 20/40 postoperative (range, 20/20 to 20/200; $P<.001$; Figure 3).

Mean K decreased from 51.85 preoperative (range, 33.37 to 81.03) to 47.60 postoperative (range, 31.84 to 80.5; $P<.001$). Mean manifest refraction spherical equivalent decreased from -8.93 preoperative to -3.60 postoperative ($P<.001$). Topography demonstrated a decrease in corneal steepness, central corneal flattening, and displacement of the central cornea to a more physiologic position postoperatively (Figure 4).

Visual acuity of 20/60 or better was attained with spectacle correction in 85.2% of patients. It is important to state that the corneal ring implant does not hinder or prevent the fitting of contact lenses. Patients who are intolerant to contact lenses preoperatively can comfortably use contact lenses with a better fitting process as a consequence of improvement of the ocular surface after Ferrara ring implantation.

THE 210° FERRARA RING

The newest Ferrara Ring design, the 210° ring, has three major advantages over conventional rings: (1) minimal induced astigmatism, (2) induced corneal flattening, and (3) implantation of a single segment. This ring is especially useful for the nipple type of kerato-

conus. The 210° Ferrara Ring is an efficient method for keratoconus correction because it significantly decreases keratometric values and improves UCVA, BCVA, and spherical equivalent.

We retrospectively reviewed records of 80 eyes of 76 consecutive patients receiving the 210° ring.[1] Statistical analysis included pre- and postoperative UCVA, BCVA, spherical equivalent, and K readings. Mean follow-up time was 6.5 months.

Mean UCVA improved from 20/350 preoperative to 20/136 postoperative (P=.001). Mean BCVA improved from 20/125 preoperative to 20/55 postoperative (P=.0001). Mean spherical equivalent decreased from -5.22 D preoperative to -2.26 D postoperative (P=.050). Corneal topography showed corneal flattening in all eyes. Mean K1 decreased from 51.49 to 47.40 D (P =.00014), and mean K2 decreased from 54.33 to 49.14 D (P=.00022). Mean keratometric astigmatism decreased from 3.65 preoperative to 2.69 D postoperative (P=.0001).

POSTOPERATIVE OBSERVATIONS

We have observed that visual rehabilitation and refractive stabilization occur by 3 months after surgery. Generally, visual improvement is quick, and on the day following surgery patients usually report subjective and objective improvements in visual acuity. However, visual acuity usually regresses within the early postoperative weeks. By the end of the first postoperative month, the patient typically reports that his vision was better immediately after surgery. The same fluctuation is detected in relation to refraction and keratometry. After the first postoperative month, vision starts to improve, and refractive and keratometric fluctuation decrease. By month 3, refraction and keratometry stabilize. At this time, it is possible to correct residual ametropia, if necessary, with spectacles, rigid or soft contact lenses, or phakic IOLs for high myopia correction.

Patients with central cones have a longer rehabilitation time because the central flattening process is slower. By comparison, patients with decentralized cones have faster rehabilitation. We believe this is due to the dislocation of the corneal apex toward its physiologic position in front of the pupil. In some cases, we have observed an increase in myopia and in K readings after ring implantation, caused by this same phenomenon. As the 210° Ferrara Ring study showed, results in these types of cones, especially nipple cones, are satisfactory with this newer device.

The Ferrara Ring has a minimal effect on the corneal endothelium. In our study, we observed endothelial cell loss of 1.4% per year. Considering that most patients included in the study were young, the rate of endothelial cell loss was slightly higher than in normal eyes (1.1%).

TAKE-HOME MESSAGE

- Keratoconic patients with contact-lens intolerance and poor BCVA are good candidates for Ferrara Rings, as are patients with highly asymmetric or quickly evolving keratoconus.
- The Ferrara Ring does not preclude contact lens use.
- Visual rehabilitation and refractive stability are achieved by 3 months postoperative.

Symptoms such as photophobia, visual discomfort, eyestrain, and itching diminish or disappear after surgery. Rubbing the eye after surgery can displace the segments and stimulate disease progression. Rubbing could also theoretically change the regularity of the corneal surface, leading to visual acuity loss.

The incidence of complications is low (3% to 5%). However, the rate of complications is higher in more advanced stages of keratoconus because the cornea is thinner, and pressure generated inside the stroma after ring implantation can cause displacement of segments toward the incisions, with eventual extrusion.

CONCLUSION

As an orthopedic technique, the Ferrara Ring corrects corneal deformity and restores physiologic curvature. Because the Ferrara Ring preserves the structure of the cornea with a low rate of complications, 95% of patients quickly reintegrate themselves into everyday activities. We believe that corneal intrastromal ring implantation should be formally adopted as an option for treating corneal diseases. ■

Paulo Ferrara, MD, PhD, is Director of the Paulo Ferrara Eye Clinic, Belo Horizonte, Brazil, and the inventor of the Ferrara Ring. Dr. Ferrara may be reached at e-mail: pferrara@ferrararing.com.br.

Leonardo Torquetti, MD, PhD, is a Consultant Ophthalmologist at the Paulo Ferrara Eye Clinic. He states that he is a consultant to Ferrara Ophthalmics and has no financial or proprietary interest in the Ferrara Ring. Dr. Torquetti may be reached at e-mail: leonardotorqueti@yahoo.com.br or leonardo@ferrararing.com.br.

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