

Case Report

# Spontaneous breakage of intracorneal ring segments (ICRS) 8 years after implantation



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## Abstract

We present a case of spontaneous in situ breakage of intracorneal ring segments (ICRSs) 8 years after their implantation in a patient with keratoconus. The patient presented to our clinic with a red and painful right eye that had not improved despite topical steroids and antibiotics. The decision was made to explant the broken ICRSs from the cornea and send them for laboratory analyses, by which manufacturer defects were excluded. It is noteworthy that corneal curvature re-steepening was observed 4 months after ICRS removal despite the performance of crosslinking (CXL) 1 year prior to ICRS implantation.

**Keywords:** Intracorneal ring segments, Keratoconus, Crosslinking

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## Introduction

Keratoconus is a corneal disorder characterized by ectasia leading to progressive corneal thinning that causes progressive myopia, regular and irregular astigmatism and decreased visual acuity. It typically starts during puberty and progresses until the third decade of life, during which it usually becomes stable. There are various options available for managing keratoconus, including collagen crosslinking (CXL), spectacles, contact lenses (rigid gas permeable, soft or hybrid), intracorneal ring segments (ICRSs), and lamellar or penetrating keratoplasty.<sup>1</sup> ICRS (single or paired) implantation induces corneal flattening in keratoconus, which leads to improvements in both visual acuity and refractive parameters. It is usually a safe and reversible procedure. ICRSs act by

exerting an “arc-shortening effect” on the corneal lamellae, leading to central corneal flattening.<sup>2</sup> In this report, we discuss a case of spontaneous breakage of ICRSs in a patient with keratoconus without any known cause.

## Case report

A 37-year-old Caucasian male patient who underwent implantation of 2 ICRSs for keratoconus (Ferrara Ophthalmics, Belo Horizonte, Brazil) 8 years ago and CXL one year before ICRS implantation presented to our outpatient clinic with pain, redness and a foreign body sensation in the right eye. Our records revealed an uneventful surgery with uncomplicated implantation and the slit lamp photographs one month after implantation showed intact ICRS

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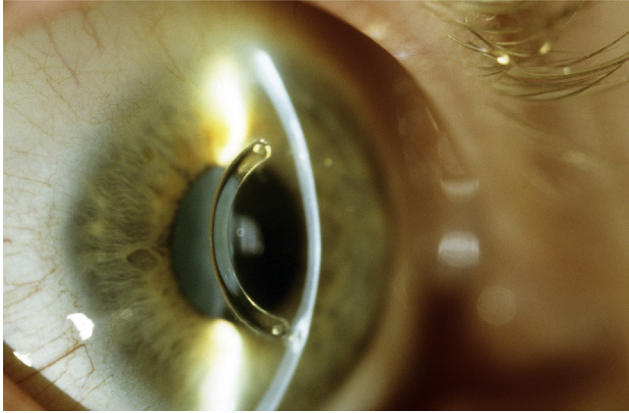
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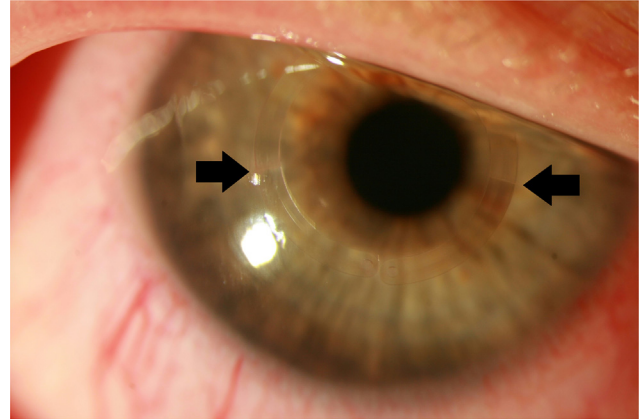
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**Fig. 1.** Clinical color photograph of the right eye showing an intact ICRS one month after the uneventful implantation.



**Fig. 2.** Clinical color photograph taken after the patient presented to our clinic complaining of redness, pain and a foreign body sensation in his right eye. The photo demonstrates the intracorneal breakage of the 2 ICRSs in their midportions (arrows).

(Fig. 1). On the presentation, the slit lamp examination of the right eye revealed the breakage of both ICRSs at the 3 and 9 o'clock positions (in the midportions of the ICRSs) and localized inflammation around the temporal ring segment. (Figs. 2 and 3) Signs of trauma or corneal or conjunctival infection were excluded. The patient also denied any history of trauma to the eye or rubbing the eye. Conservative treatment comprising topical antibiotics and corticosteroid eye drops was initiated to control any localized inflammation around the broken rings that may have been causing the patient's symptoms; however, as these symptoms persisted despite topical treatment, we decided to perform surgical explantation of both ICRSs three weeks later. The rings were sent to the Intermountain Ocular Research Center at the University of Utah to identify any possible causes of spontaneous breakage, such as manufacturer defects. After ring explantation, the patient's symptoms of pain, redness and a foreign body sensation improved dramatically.

The patient's hospital records pertaining to the ICRS implantation eight years earlier described an uneventful treatment course, followed by visual improvement after ICRS implantation. The initial uncorrected visual acuity of the right eye was 20/100, and the preoperative keratometry values were 56.08D @ 91° and 51.56D @ 1°. Manual implantation of a nasal 200 μm 150° arch Ferrara ring segment and a temporal 250 μm ring segment was performed without any peri- or postoperative complications. The initial follow-up exam performed shortly after ICRS implantation demonstrated an uncorrected visual acuity of 20/32 and keratometry values of 47.83D @ 98° and 42.71D @ 7°.

Four months after explantation of the ICRSs due to their spontaneous breakage, the BCVA was 20/32; however, obvious corneal curvature re-steepening was noted (the keratometry values were 48.3D@166.5° and 50.2D@76.5°, with a K. Max (anterior surface) of 64.0D). The central corneal thickness had been 490 μm just before ICRS explantation and had decreased to 450 μm 4 months after explantation (Fig. 4).

#### Laboratorial analyses

The ICRSs were submitted for analysis in a plastic container in the dry state and were attached to an adhesive tape. Gross examination was performed, after which the specimens

were evaluated and photographed under a light microscope (Olympus Optical Co., Ltd. – Tokyo, Japan). The ICRSs were then analyzed via electron microscopy at the Surface Science and Nano-Imaging Lab, University of Utah. The adhesive tape and specimens were carefully placed onto an aluminum mounting cup, which was subsequently placed inside an FEI Quanta 600F ESEM and imaged under low-vacuum mode. The analysis was performed under a pressure of 1 torr at a temperature of 23 degrees Celsius and an accelerating voltage of 15 kV. The low-vacuum technique does not require prior specimen coating. An EDAX X-ray detector was used to evaluate the elemental compositions of the devices and any deposits.

Gross and light microscopy demonstrated some proteinaceous deposits on the rings but no clear signs of surface degradation. ESEM and EDAX analyses confirmed that there were some salt (sodium/chloride) and proteinaceous deposits on the surfaces of the segments. The inner surfaces of the positioning holes in their extremities were irregular, and one of the positioning holes contained tissue, most likely corneal tissue. The external surfaces of the segments were regular and smooth overall. One of the segments contained some scratches on its surface, which were likely caused by the explantation procedure. All the broken sides appeared similar, exhibiting some irregularities (Fig. 5).

#### Discussion

The aim of ICRS implantation is to improve visual acuity, which may delay the need for keratoplasty. ICRS implantation is performed to treat keratoconus and has become a popular procedure among cornea specialists.<sup>2</sup> In this case, we observed obvious corneal curvature re-steepening, which may have been a sign of keratoconus progression 4 months after the removal of the broken ICRSs or an indication that the effects exerted by ICRSs on the corneal curvature are reversible. After explantation, the K. Max, K1 and K2 values increased despite the performance of CXL several months prior to ICRSs implantation 8 years ago, highlighting the value of ICRSs with respect to maintaining corneal curvature stability. It is widely believed that performing CXL after ICRS implantation facilitates disease stabilization and limits its

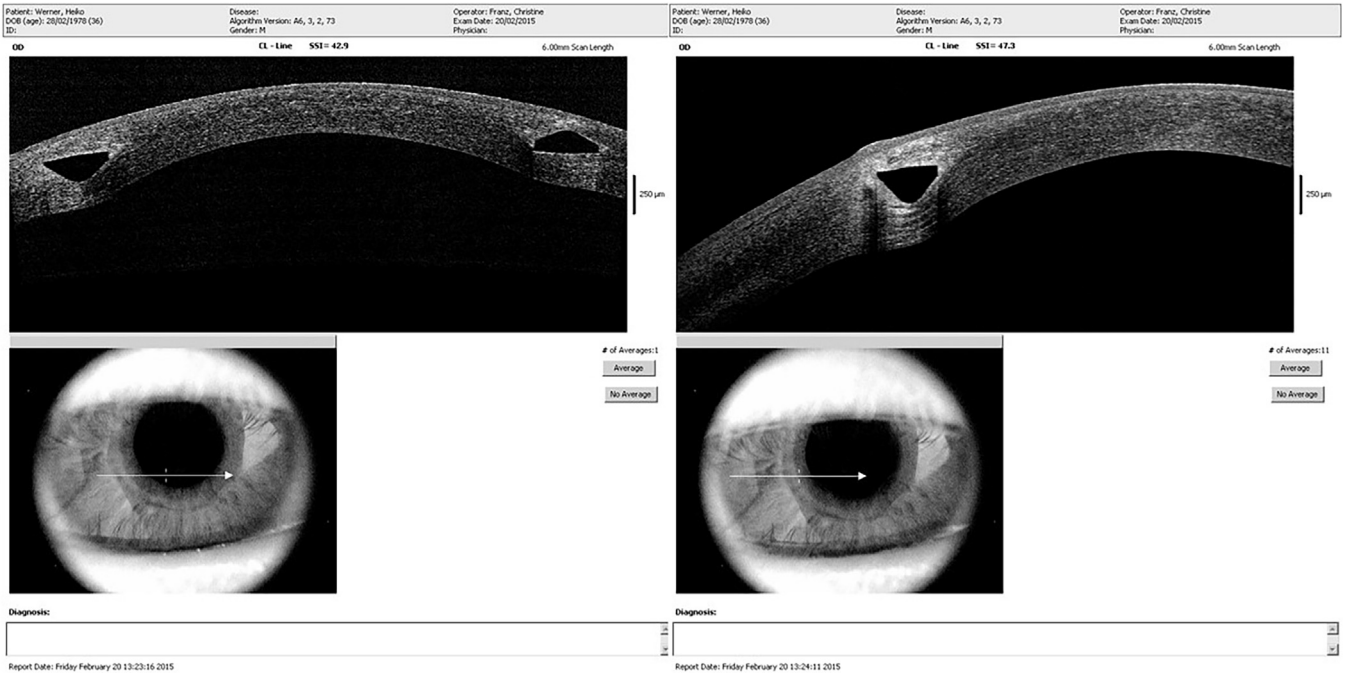


Fig. 3. Corneal OCT images obtained after ICRS breakage and before ICRS explantation. The left ring exhibited significant hyperreflectivity corresponding to leukocytic infiltration, as noted via slit lamp examination (Optovue, RTVue-100 Fourier Domain OCT).

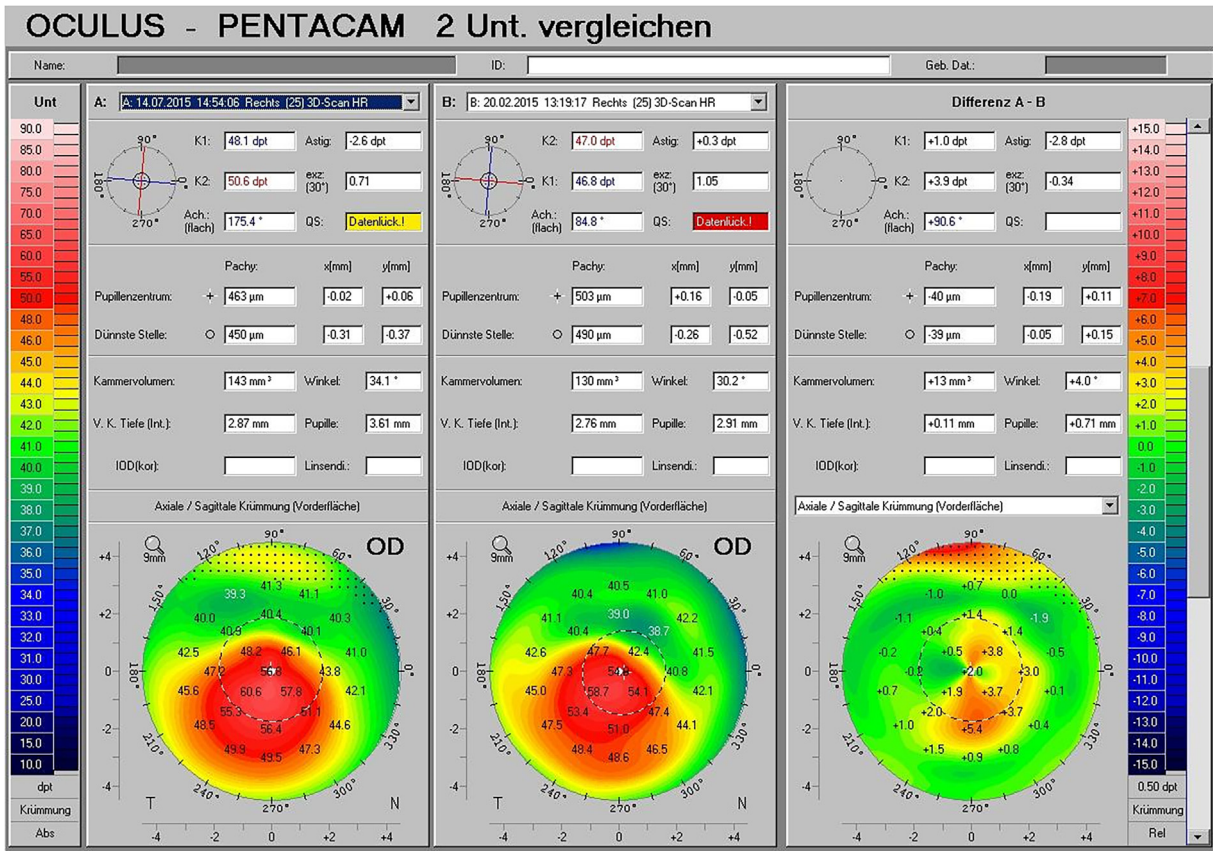
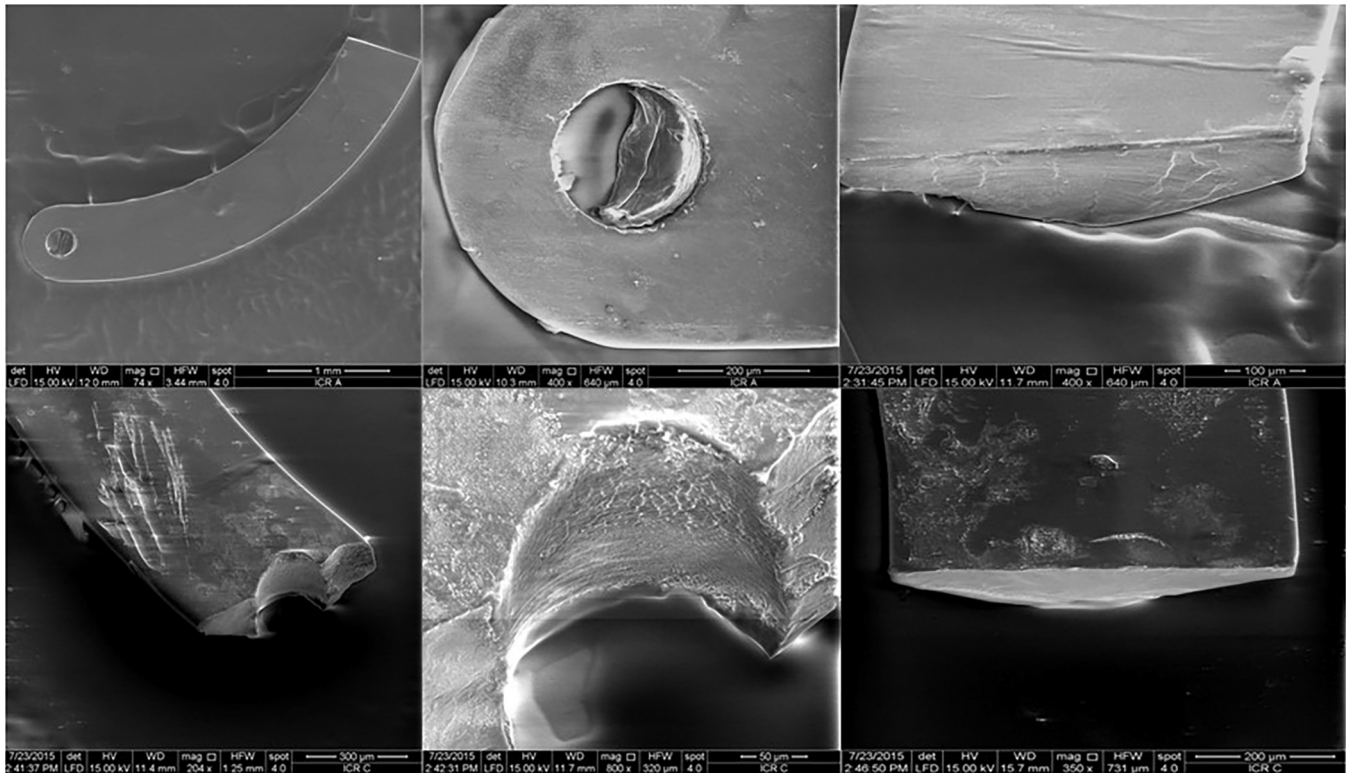


Fig. 4. Pentacam image comparing the patient's corneal parameters 2 weeks before (middle) and 4 months after ICRS explantation (left) and showing a significant increase in the sagittal curvature of more than 5 diopters, a finding consistent with keratoconus progression, in the comparison map (right) (Oculus Pentacam HR, Typ 70,900 - Wetzlar, Germany).



**Fig. 5.** SEM images of the explanted ICRSs showing the breakage of both rings in their midportions, as well as their smooth and regular surfaces, which exhibited salt and protein deposits but no signs of degradation.

progression;<sup>3,4</sup> however, in this case, CXL was performed before ICRS implantation.

ICRS segment explantation is usually performed after segment extrusion and migration, infection,<sup>5</sup> or unexpected visual or refractive outcomes.<sup>6</sup> A previous study has discussed the causes of intrastromal ring segment explantation, where extrusion was described as the most common cause attributing to 48.2% of cases followed by refractive failure, microbial keratitis and corneal melting.<sup>7</sup> However, this case report describes the removal of ICRSs after their breakage 8 years after an uneventful implantation without any complaints from the patient. Possible keratoconus progression after ICRS removal was also observed in this case even though it is widely believed and proved that ICRS cannot stabilize keratoconus. In a previous study performed to evaluate pathological changes in the cornea after ICRS implantation (Intacs<sup>®</sup>), some focal epithelial hypoplasia was observed immediately above the Intacs<sup>®</sup> tunnel in some eyes. Normal epithelial thickness was noted toward the center of the cornea, and no evidence of inflammatory cells, foreign body granulomas, or corneal neovascularization that may have contributed to the spontaneous breakage of the ICRSs at any time was noted.<sup>8</sup> Our laboratory investigations did not reveal any focal manufacturing weaknesses, nor did they uncover evidence of material degradation around the broken Ferrara Rings. Despite our best efforts, we could not find a reason for the symmetrical in situ breakage of both ICRSs. We believe that the initial CXL is unlikely to have contributed to the spontaneous breakage of the ICRSs. However, the symmetry of the breaks along the horizontal axes of the segments implies that environmental factors (e.g., unknown trauma or UV exposure) may have caused this unusual com-

plication. It is also possible that the patient misled the treating ophthalmologist regarding a recent history of eye trauma; however, we did not find any evidence of trauma during our examination. Hence, we believe that this complication is worth reporting to the corneal and refractive surgery community.

### Financial disclosure

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