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# The use of two 90-degree arc intracorneal ring segments in management of crab-claw topographic pattern

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## Abstract

**Background**
Keratoconus and pellucid marginal degeneration (PMD) are bilateral, progressive, and ectatic corneal disorders characterized by thinning of the cornea.

**Aim**
To assess the visual and refractive outcome of using two 90-degree arc intrastromal corneal ring segments (ICRS) in the management of crab-claw topographic pattern.

**Patients and methods**
This study included 17 eyes of nine patients with crab-claw topographic patterns, either pellucid-like KC or PMD, needing ICRS. Preoperative evaluation included detailed ocular history, full ophthalmic examination, including uncorrected visual acuity (UCVA), manifest refraction, best spectacle-corrected visual acuity, and Pentacam.

**Results**
Regarding visual outcome, the mean UCVA improved significantly from 0.12 ± 0.09 to 0.86 ± 0.16 postoperatively ($P < 0.001$). The UCVA improved in all eyes (100%). The mean best spectacle-corrected visual acuity in LogMAR improved significantly from 0.31 ± 0.18 to 0.91 ± 0.11 postoperatively ($P < 0.001$). The mean cylinder was −8.00 ± 1.30 preoperatively that improved to −1.50 ± 1.00 at the end of the follow-up ($P < 0.001$), while the mean sphere improved nonsignificantly from + 2.00 ± 1.00 to + 2.50 ± 1.00 postoperatively.

**Conclusion**
Two 90-degree arc ICRS implantations are a safe and efficient surgical option in the management of patients with crab-claw topographic patterns, which was either PMD or pellucid-like KC with a good visual and refractive outcome.

**Keywords:** Arc intrastromal corneal ring segments, crab-claw topographic pattern, pellucid marginal degeneration

## Introduction

Keratoconus (KC) and pellucid marginal degeneration (PMD) are bilateral, progressive, ectatic corneal disorders characterized by thinning of the cornea. In PMD, the thinning extends 1–2 mm away from the inferior limbus, and the corneal protrusion occurs above the area of thinning [1].

Crab claw or butterfly patterns on the sagittal topographic map of anterior corneal curvature reveal steepening of the inferior corneal periphery and flattening of the cornea along the vertical meridian [2].

In KC, corneal thinning usually occurs in the paracentral region, and corneal topography shows central or inferior steepening and asymmetric bowtie patterns [3]. Inferior KC, in which the cone is localized away from the corneal center, and a crab-claw pattern is seen on the sagittal topographic map, is often confused with

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PMD [4,5]. Similarly, a study by Sinjab and Youssef [6] recorded some cases of KC mimicking the tomographical appearance of PMD, and they called that pellucid-like keratoconus (PLK). However, both prognosis and management of PMD and KC are different, and PMD should be distinguished from KC [7].

Intracorneal ring segments (ICRS) are small polymethyl methacrylate devices implanted into the cornea to alter its geometry and improve its refractive properties and patient's visual acuity [8]. Many different types of ICRS with variable thickness, geometries, and diameters have been developed and used for restoring visual acuity. The implantation of ICRS was initially mechanical, but femtosecond laser-assisted procedures gained increasing significance over the last few years and gradually replaced the conventional mechanical technique. Nowadays, there are implantation nomograms offered by the ICRS manufacturers, indicating the appropriate ring-segment characteristics and suggesting the most suitable parameters for ICRS implantation for each case [9].

We aimed to assess the visual and refractive outcome of using two 90-degree arc ICRS in the management of crab-claw topographic patterns.

## Patients and Methods

A prospective interventional study of 17 eyes of nine patients with crab-claw topographic patterns, either PLK or PMD, that need ICRS, was carried out at the International Eye Hospital (IEH), Egypt, from January 2020 to December 2021. Informed consent was obtained from all patients; the institute's ethical committee approved the study. Inclusion criteria: patients with crab-claw topographic pattern, no previous corneal surgery, and a high cylinder that needs ICRS for correction. Exclusion criteria: patients with central corneal opacity, very thin cornea less than 400 μm, and previous ocular surgery were excluded.

The questionnaire assessed the following: clarity of vision, far vision, reading, night vision, and general satisfaction using a scale from 1 to 5 (1 means very bad and 5 means very good). Also, glare, haloes, foreign body sensation, and vision fluctuation were checked for being present or absent.

Preoperative evaluation included detailed ocular history, full ophthalmic examination, including uncorrected visual acuity (UCVA), manifest refraction, best spectacle-corrected visual acuity (BSCVA), and Pentacam.

### Surgical technique

The femtosecond laser (VisuMax femtosecond laser system, Carl Zeiss Meditec,Inc., Dublin, CA.) was used in all cases for tunnel and incision creation. Implantation of the ICRS was carried out under the full aseptic technique.

### Statistical analysis

Statistical analyses had been performed using statistical package for social sciences (SPSS) version 21.0 (SPSS Inc, Chicago, USA). Dates are given as mean ± SD and percent. We used paired-sample *t* test to compare between preoperative and postoperative data. Values of *P* value less than 0.05 were considered significant.

## Results

The study evaluated 17 eyes of nine patients (seven males and two females) with a mean age of 24.41 ± 7.11 years and ranging from 22 to 29 years. The mean duration of follow-up was 12 months and ranged from 6 to 18 months.

Regarding visual outcome, the mean UCVA (LogMAR) improved significantly from 0.12 ± 0.09 to 0.86 ± 0.16 postoperatively ($P < 0.001$). The UCVA improved in all eyes (100%). The improvement in mean UCVA was approximately eight lines of LogMAR. At the end of the follow-up period, 15 (88.2%) eyes had a UCVA of 20/40 or more. The mean BSCVA in LogMAR improved significantly from 0.31 ± 0.18 to 0.91 ± 0.11 postoperatively ($P < 0.001$). The improvement in mean BSCVA was two lines postoperatively. By the last visit of each patient, 12 (70.6%) of the eyes gained more than or equal to two lines of BSCVA (Table 1).

Regarding refractive and keratometry outcomes, the mean cylinder was − 8.00 ± 1.30 preoperatively that improved to − 1.50 ± 1.00 at the end of the follow-up ($P < 0.001$), while the mean sphere improved nonsignificantly from + 2.00 ± 1.00 to + 2.50 ± 1.00 postoperatively [Table 1].

A significant reduction was observed in mean keratometry (K) after ICRS from 49.10 ± 2.30 to 43.50 ± 2.40 D ($P < 0.001$) with a mean reduction of 5.60 D (Table 2).

**Table 1: Visual and refractive outcomes**

| | Preoperative | Postoperative | *t* | *P* |
|---|---|---|---|---|
| UCVA | | | | |
| Mean±SD | 0.12±0.09 | 0.86±0.16 | 16.620 | <0.001* |
| Range | 0.05–0.20 | 0.60–1.0 | | |
| BSCVA | | | | |
| Mean±SD | 0.31±0.18 | 0.91±0.11 | 11.727 | <0.001* |
| Range | 0.10–0.50 | 0.90–1.00 | | |
| Cylinder | | | | |
| Mean±SD | −8.00±1.30 | −1.50±1.00 | −11.313 | <0.001* |
| Range | −6.00 to−10.00 | −0.75 to−3.00 | | |
| Sphere | | | | |
| Mean±SD | +2.00±1.00 | +2.50±1.00 | 1.458 | 0.155 |
| Range | +0.50 to±3.50 | +0.50 to±3.50 | | |

**P* value is significant. BSCVA, best spectacle-corrected visual acuity; UCVA, uncorrected visual acuity.

**Table 2: Comparison between preoperative and postoperative keratometric values**

| Keratometric values | Preoperative | Postoperative | *t* | *P* |
|---|---|---|---|---|
| Mean±SD | 49.10±2.30 | 43.50±2.40 | −6.946 | <0.001* |
| Range | 43.60–51.20 | 41.00–46.70 | | |

**P* value is significant

Regarding satisfaction, the clarity of vision was good for 44.4% of patients, and none of them complained of very bad clarity of vision. However, this was different with night vision, as 22.2% of patients complained of bad night vision, while it was acceptable for 33.3% of the patients, and it was very bad for only one patient and good for three patients. The patients were almost equally distributed between good, acceptable, and bad regarding far vision and reading. Considering general satisfaction, the patients were almost equally distributed between acceptable (11.1%), good (33.3%), and very good (44.4%) (Table 3).

Considering postoperative symptoms, there was 22.2% of the patients complaining of haloes, and one patient complained of each of glare, fluctuation of vision, and foreign body sensation (Table 4).

## Discussion

Appropriate and effective treatment of PMD is a challenge in ophthalmology. The management of PMD depends on the severity of the disease. The ICRS is a semicircular mechanical device that has been successfully used in PMD to avoid penetrating keratoplasty, improve contact-lens intolerance, and improve visual results [10].

This work studied 17 eyes of nine patients with crab-claw topographic patterns who had ICRS implantation. Moreover, the study concentrated on two major areas. First, visual and refractive outcomes were assessed. Second, patients' satisfaction was acquired postoperatively along with their ocular symptoms. To the best of our knowledge, there has been a lack of academic publications associated with two 90-degree arc ICRS implantations on patients with crab-claw topographic patterns. The uniqueness of this study regarding content and the considerable differences in the findings have made this unprecedented work more valuable. The outcomes of our study showed that two 90-degree arc ICRS implantations on patients with crab-claw topographic patterns were efficient in flattening the cornea and thereby improving UCVA and BSCVA in the patients. A significant reduction was observed in mean keratometry after ICRS from 49.10 ± 2.30 to 43.50 ± 2.40 D. The improvement in the mean UCVA after ICRS implantation was approximately eight lines. Furthermore, the mean BSCVA gain was two lines.

**Table 3: Distribution of patients regarding satisfaction**

| | Cases ($n$=9) [$n$ (%)] | | | | |
|---|---|---|---|---|---|
| | Very bad | Bad | Acceptable | Good | Very good |
| Clarity of vision | 0 | 1 (11.1) | 2 (22.2) | 4 (44.4) | 2 (22.2) |
| Night vision | 1 (11.1) | 2 (22.2) | 3 (33.3) | 3 (33.3) | 1 (11.1) |
| Reading | 0 | 1 (11.1) | 3 (33.3) | 4 (44.4) | 1 (11.1) |
| Far vision | 1 (11.1) | 2 (22.2) | 2 (22.2) | 3 (33.3) | 1 (11.1) |
| Satisfaction | 0 | 1 (11.1) | 1 (11.1) | 3 (33.3) | 4 (44.4) |

**Table 4: Distribution of patients regarding postoperative symptoms**

| | Cases ($n$=9) [$n$ (%)] |
|---|---|
| Haloes | 2 (22.2) |
| Glare | 1 (11.1) |
| Fluctuation of vision | 1 (11.1) |
| Foreign body sensation | 1 (11.1) |

With respect to corneal topography, we observed a significant reduction in keratometric values. Corneal topography showed a strong decrease in astigmatism in all cases. In most of the studies, ring-segment implantation contributed a mean reduction of the K readings between 3 and 5 D [11–13]. Our study showed a mean reduction of 5.60 D for K readings.

ICRS implantation leads to increase both UCVA and corrected visual acuity in patients, which is attributed to a reduction of spherical equivalent and cylinder, and to enhanced visual quality by modifying corneal high-order aberrations. Asymmetric aberrations (coma and coma-like) and especially those higher than 3.0 μm, are reduced after ICRS implantation [14].

A significant reduction (6.50 D) was observed in the manifest cylinder postoperatively in our study. The amount of reduction was in agreement with the study results by Mularoni *et al.* [15], who reported a significant change in the cylinder (4.59 D) based on ICRS implantation in PMD.

The amount of reduction in the spherical component of the manifest refraction varied in different studies. In particular, in the studies of Pinero *et al.* [16], Kubaloglu *et al.* [17], and Ertan and Bahadir [18], this reduction was equal to 0.01, 2.70, and 1.09 D, respectively. Our study showed a nonsignificant change in the manifest sphere of 0.5 D.

Regarding the improvement in postoperative UCVA, we observed a remarkable increase in UCVA (eight lines), which was in accordance with the results of studies by Mularoni *et al*. [15] (eight-line improvement) and Kubaloglu *et al.* [17] (seven-line improvement). In contrast to our study, Pinero *et al.* [16] reported no improvement in UCVA at 6 months after the surgery. We also observed a significant increase in BSCVA postoperatively, which was in agreement with previous studies.

We believe that the significant improvement in UCVA and BSCVA resulted from using two 90-degree arc ICRS, which could have a more significant effect on the corneal power.

We did not observe any serious complications in terms of postoperative clinical complications, including decentration, extrusion, explantation, keratitis, or vascularization. Two 90-degree arc ICRS implantations are a safe technique with a low incidence of complications to correct KC and post-LASIK ectasia [19–22].

Although diurnal changes in the visual acuity and visual symptoms are well-known phenomena after ICRS

insertion [23,24], they were not a significant cause of patient dissatisfaction in our study. The majority of the patients were satisfied with arc ICRS implantation: 33.3% of patients were good, and 44.4% were very good at the end of the follow-up. Only one patient had bad satisfaction at 6-month follow-up because of severe glare and night-vision problems. In order to minimize these symptoms, pilocarpine 1% eye drops were prescribed.

A small number of patients limits our study, and some studies should be performed to analyze the outcomes of this surgical technique, depending on the severity of the disease.

## Conclusion

We concluded that two 90-degree arc ICRS implantations are a safe and efficient surgical option in the management of patients with crab-claw topographic patterns, which was either PMD or PLK with a good visual and refractive outcome.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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