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REVIEW ARTICLE

# How to improve Visual Acuity after Intrastromal Corneal Ring Segments? Implantation for Keratoconus and Post-LASIK Ectasia

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## ABSTRACT

Keratoconus (KC) is an ecstatic corneal disease that causes irregular astigmatism which cannot be corrected by glasses, the irregular astigmatism causes loss of visual acuity (VA) both the uncorrected and the corrected VA, in addition to deterioration in the quality of vision. Contact lenses (CLs) improve the VA but cannot be tolerated in many cases due to several causes, such as loss of motivation, atopic and allergic conjunctivitis that are more frequently associated with KC and dry eyes. Intrastromal corneal ring segments implanted in keratoconic eyes improve uncorrected visual acuity (UCVA), best spectacle corrected visual acuity (BSCVA), reduce myopia, astigmatism, high order aberrations (HOA) and regularizes the cornea (less irregular astigmatism), similar results are achieved in the treatment of post-LASIK and post PRK ectasia. These results were confirmed in long-term follow-up. The more advanced the KC the more is the effect of the ICRS but the less the functional VA achieved and vice versa. Thicker rings are more effective, and the smaller the optical zone the more is the effect of the ICRS. The aim of ICRS implantation in KC is not to be free of glasses or CL but to enable the patient of seeing with glasses or to tolerate CL in order to prevent or delay the need for penetrating keratoplasty (PKP) or deep anterior lamellar keratoplasty (DALK). In many cases, we can achieve a functional and satisfactory UCVA with no need for glasses and this is the case in nonadvanced KC but not in the advanced cases. In some cases, the results achieved need additional means to improve VA in order to get satisfactory VA. There are nonsurgical and surgical means to improve VA after ICRS, these means will be reviewed in this article.


**Keywords:** Keratoconus, Intrastromal, Cornea, Rings, Intacs, Ferrara rings, Penetrating keratoplasty, Deep lamellar keratoplasty, Collagen, Cross-linking, PRK, Lasik, Ectasia.

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## INTRODUCTION

Keratoconus (KC) is an ecstatic corneal disease that causes irregular astigmatism which cannot be corrected by glasses, the irregular astigmatism causes loss of visual acuity (VA) both the uncorrected and the corrected VA, in addition to deterioration in the quality of vision. Contact lenses (CL) improve the VA but cannot be tolerated in many cases due to several causes such as loss of motivation, atopic and allergic conjunctivitis that are more frequently associated with KC and dry eyes.

Intrastromal corneal ring segments (ICRS) are crescent shape PMMA segments, produced in different geometric shapes, thicknesses and length and may be divided in two groups:

*Intacs*: Have hexagonal shape, 150º of arc long, 7 mm optical zone with variable thicknesses from 250 to 450 um in a 50 µm steps, Intacs SK (SK for severe keratoconus) have oval shape, 6 mm optical zone 400 to 450 µm thickness both are produced by Addition Technology, USA.

*Ferrara rings*: Have a pyramidal shape, flat base 600 µm, 5 mm optical zone, available also in 6 mm optical zone, variable thickness:150 to 350 µm in 50 µm increments and a length of 90, 120, 160 or 210º of arc. Ferrara rings are yellow in order to reduce halos and glare and are produced by AJL Spain. Kerarings are similar to Ferrara Rings produced by Mediphacos Brazil.

Intrastromal corneal ring segments implanted in keratoconic eyes Improve uncorrected visual acuity (UCVA), best spectacle corrected visual acuity (BSCVA), reduce myopia, astigmatism, high order aberrations (HOA) and regularizes the cornea (less irregular astigmatism), similar results are achieved in the treatment of post-LASIK and post PRK ectasia. These results were confirmed in long-term follow-up.[1-11] The more advanced the KC the more is the effect of the ICRS but the less the functional VA achieved and *vice versa*. Thicker rings are more effective, and the smaller the optical zone the more is the effect of the ICRS.

The aim of ICRS implantation in KC is not to be free of glasses or CL but to enable the patient of seeing with glasses or to tolerate CL in order to prevent or delay the need for penetrating keratoplasty (PKP) or deep anterior lamellar keratoplasty (DALK).

In many cases, we can achieve a functional and satisfactory UCVA with no need for glasses and this is the case in nonadvanced KC but not in the advanced cases.

In some cases, the results achieved need additional means to improve VA in order to get satisfactory VA. There are nonsurgical and surgical means to improve VA after ICRS.

## NONSURGICAL

Glasses, all the studies mentioned above report improvement in BSCVA, unlike candidates for refractive surgery patients glasses are welcome by patients suffering from KC.

Contact lenses, ICRS flatten the cornea and make it more regular hence facilitate CL tolerance in patients suffering from KC.

A study of 12 contact lens intolerant keratoconic eyes that underwent Intacs implantation with no intra- or postoperative complications found improved measures in UCVA, best corrected visual acuity (BCVA) and K readings. Eight eyes were then able to wear contact lenses.[12] A different study which followed 24 keratoconic eyes of 14 patients for a period of 1 year after Intacs implantation found that 60% of the patients tolerated CL.[13] Guel et al reported on one patient who was successfully fitted with a soft CL after Intacs implantation for KC[14] Most of the studies mentioned in this review report better tolerance of CL after ICRS.

I have fitted patients following intacs implantation with soft CL, soft KC (Soft K) CL and rigid gas-permeable (RGP) CL with no special requirements from the manufacturers of the lenses. Some patients who had been intolerant to RGP CL became tolerant to normal soft CL. In a retrospective study of 19 patients who were intolerants to CL prior to ICRS implantation, two patients (10.5%) did not achieved good comfort with CL and underwent PKP, all the others 17 patients showed good or medium comfort after the implantation of ICRS. Four were fitted with RGP CL, one piggyback CL (soft CL and RGP CL over it), 3 toric soft CL, 2 soft lenses specially design for keratoconus and 7 disposable soft lenses.[15] Hladun L et al report on a case of a 51-year-old man with KC who underwent ICRS implantation for KC 7 months earlier in an attempt to obtain acceptable vision without CL, he was not satisfied with his vision in the right eye but the patient was able to achieve 20/25-vision and adequate comfort in his right eye with a piggyback CL. The authors concluded that the changes in the corneal anatomy created by the ICRS may make CL fitting more challenging due to corneal irregularity and variations in corneal elevation over the ICRS and directly adjacent to the ring and may lead to difficulty in centering the lens and bubbles forming under the CL over areas of corneal depression.[16] An other patient was successfully fitted with a soft CL for visual rehabilitation 5 months after Intacs placement.[17]

Miniscleral rigid lens design was used successfully in a case of advanced keratoconus after implantation of Intacs[18] Lovisolo et al reported on several patients who had been 'absolutely contact lens intolerant' and subsequently were comfortable wearing RGP contacts on a daily basis some months after intacs implantation followed by CXL. They claimed that the regularization of the anterior corneal surface, which follows this combined treatment, might explain the positive shift. The same authors also reported that overnight corneal molding by RGP contact lens lasted longer in these patients than in 'vergine keratoconic eyes.' The surface reshaping in virgin keratoconic eyes does not last longer than 2 to 3 hours after contact lens wear is suspended, due to unexplained biomechanical changes in the cornea after intacs implantation.[19]

## SURGICAL

### Reimplantation and Reposition

We may have under correction or over correction, Pokroy et al reported on intacs surgery that required additional surgery, such as removal, exchange, addition, or shifting of an intacs segment in a cohort of 58 keratoconic eyes, 7 eyes underwent adjustments surgery. The indications for Intacs adjustments were increased astigmatism in 4 eyes, induced hyperopia (overcorrection) in 3, and under correction in 1. The adjustments were performed in 7 eyes out of the 58 eyes, approximately 10%. Induced astigmatism and hyperopia were most often managed by removing the superior segment. The under corrected eye, having initially received a single inferior segment, was treated by implanting a superior segment they report a good outcome after the adjustment surgery.[20] Alio et al reported on the visual, refractive, and corneal aberrometric outcomes in eyes with KC that had implantation of new ICRS after previous segment explantation for an unsuccessful outcome which are segment extrusion or poor visual outcomes 21 eyes of 21 patients were evaluated. There was a significant improvement in in UCVA, manifest refraction, keratometry readings and corneal aberrometry 6 months after the second surgery. There were no statistically significant differences in any visual, refractive, keratometric, or aberrometric parameter between eyes that had ICRS explantation for segment extrusion and eyes that had explantation for poor visual outcomes.[21]

### Kerarings after Intacs

Coskunseven reported on three eyes (two keratoconic patients) with previous Intacs implantation that underwent adjuvant single Keraring (Mediphacos) intrastromal corneal ring segment implantation, UCVA, BCVA improved significantly and K readings were reduced.[22] Lovisolo et al

reported on 'LASIK-on keratoconus' eye which received four ring segments: a pair of 450 μm intacs 2 years after excimer surgery, and a pair of 250 μm Ferrara Rings 3 years postoperatively. Eight years after the original surgery, the same eye was treated with collagen corneal cross-linking (CXL). Two years after crosslinking and 10 years after the original surgery, the eye showed topographic and refractive stability, the patient complied well with a 20/90 uncorrected VA, and a 20/30 spectacle corrected acuity was obtained with glasses. Only for night driving did the patient require a custom-made RGP CL, which restored 20/20 vision.[19]

### MyoRing after Intacs

MyoRing which is a round intrastromal corneal ring of variable thicknesses, 5 mm diameter developed by Dr Albert Daxer (Austria), was implanted in a keratoconic patient who had undergone a previous Intacs implantation surgery 4 years previously without Intacs explantation and had residual refractive error. There were no intraoperative or postoperative complications. After 1 year; mean keratometric power decreased from 50.3 to 43.6 diopters, UCVA improved from 20/400 to 20/50, and BCVA improved from 20/200 to 20/30.[23]

### Collagen Corneal Crosslinking

The aim of CXL is to arrest the progression of KC. Since, the introduction of this technique by the Dresden group hundreds of papers were published on the efficacy of this procedure in stabilizing the ecstatic corneas either in KC or in post-LASIK ectasia, moreover improvement of UCVA, BSCVA, reduction of astigmatism and keratometry readings were reported in the majority of the treated eyes.[24-29] Additive effect of CXL and ISCR was reported.[30] Better results are achieved if the ICRS are implanted and then CXL performed than CXL and later ICRS implantation.[31] Ertan et al evaluated the efficacy of transepithelial CXL in keratoconic eyes after Intacs implantation in 25 eyes of 17 patients with bilateral KC. The patients underwent Intacs implantation with subsequent CXL. CXL performed after Intacs treatment yielded an additional 1.2 Snellen lines ($p < 0.05$) of UCVA and 0.36 Snellen lines ($p < 0.05$) of BCVA. The decrease in spherical, cylindrical, mean K and steepest K values was 2.08 diopters (D) ($p < 0.05$), 0.47 D ($p > 0.05$), 2.22 D ($p < 0.05$) and 1.27 D ($p < 0.05$) respectively, after Intacs treatment with an additional 0.5 D ($p < 0.05$), 0.15 D ($p > 0.05$), 0.35 D ($p > 0.05$) and 0.76 D ($p < 0.05$) of improvement gained after CXL in each respective parameter.[32] Kamburoglu et al demonstrated the additive effect of CXL after Intacs SK in a case of post-LASIK ectasia. At 1 month follow-up, UCVA decreased to 20/100 and BSCVA to 20/40, with a manifest refraction of –5.00 –3.00 × 170 and keratometric values of 46.80/51.70 D (mean: 49.20 D). At 8 months post CXL, UCVA was 20/30 and BSCVA was 20/25 with a cylinder refraction of –1.50 × 170. Keratometry was 45.00/49.50 D (mean: 47.20 D).[33] El Awady H et al reported on 21 of 13 patients with mild to moderate degree of KC. All eyes had implantation of Kerarings followed by CXL treatment after at least 3 months of the implantation (mean 4.56 ± 3.2 months) the mean baseline UCVA and BCVA were 0.05 ± 0.02 and 0.18 ± 0.1, respectively; after Keraring the mean UCVA and BCVA were 0.23 ± 0.17 and 0.39 ± 0.18 ($p = 0.000$), respectively. CXL after Keraring resulted in an additional change in UCVA and BCVA to become 0.23 ± 0.17 ($p = 0.951$) and 0.41 ± 0.18 ($p = 0.08$) respectively. CXL results in an additional change in spherical equivalent, cylindrical and mean keratometric values. The decrease in spherical equivalent, cylindrical, and mean keratometric value was 2.8 D ($p < 0.05$), 2.1 D ($p < 0.05$), and 2.5 D ($p < 0.05$), respectively, after Keraring treatment. An additional decrease of 0.11 D ($p > 0.05$), 0.01 D ($p > 0.05$), and 0.09 D ($p > 0.05$) was obtained after CXL in each respective parameter.

### Photorefractive Keratectomy (PRK)

PRK was safely used to reduce astigmatism in KC it was first reported by Jes Mortensen,[34,35] safety and efficacy of PRK in forme fruste KC has been reported.[36,37] ICRS change positively the biomechanical properties of the cornea by inducing central flattening peripheral steepening over the rings and stress redistribution.[38,39] CXL as a stabilizing procedure gives PRK in KC an additional protective value, several reports confirm predictability, efficacy, stability and safety of PRK combined with PRK and particularly if no more than 50 microns are ablated.[40-42] Tan BU et al report on PRK for the correction of residual refractive error with Intacs in place. This retrospective case series comprised patients who had Intacs segment implantation and subsequently developed myopic regression. Eight eyes of 5 patients had PRK over the Intacs for the correction of the residual refractive error. Three months postoperatively, all eyes had planorefraction with 20/20 or better acuity. At the last follow-up examination (up to 2 years), all eyes had near plano vision (20/10 to 20/25). The corneal surface epithelium in all eyes healed in 3 to 5 days. One patient had subepithelial haze in both eyes, which resolved with epithelial scraping with mitomycin C (MMC) application and a PTK enhancement. The UCVA was 20/25 or better in all cases after PRK enhancement.[43] PRK with and without CXL is reported after ICRS with various sequences Kremer I et al report simultaneous PRK and CXL in KC after

previous ICRS implantation. This study comprised patients with moderate KC who had previous Intacs implantation assisted by Intralase laser at least 6 months before PRK-CXL. Wavefront-guided PRK and CXL were performed simultaneously. They procedure was safe and effective, it significantly improved the UCVA, BCVA and central K value, and consequently the visual function, of patients with moderate keratoconus.[44] Dirani et al report on Non-topography-guided PRK for the correction of residual mild refractive errors after ICRS implantation and CXL in KC. This retrospective study included 17 eyes of 14 patients with mild to moderate KC. The ICRS implantation and CXL were performed sequentially with a 4-week interval and nontopography-guided PRK was performed at least 6 months after CXL. Data were collected preoperatively and at the 6-month follow-up visits. At the 6-month follow-up after PRK, UCVA significantly improved to 0.18 ± 0.06 logMAR and BCVA was 0.15 ± 0.05 logMAR. The mean spherical error and mean cylinder significantly decreased to –1.10 ± 0.41 D ($p = 0.02$) and 0.98 ± 0.37 D ($p = 0.046$), respectively. No intraoperative or postoperative complications occurred. PRK was found to be an effective and safe option for correcting residual refractive error and improving VA in patients with moderate KC.[45] Al-Tuwairqi W et al report on ICRS implantation followed by same-day topography-guided PRK and CXL in low to moderate KC. All patients first underwent femtosecond laser-enabled placement of ICRS (Keraring). Sameday topography-guided PRK and CXL were subsequently performed in all patients after the refraction was stable [average 6 months (3-11 months)]. Thirteen eyes from 13 patients were included in the study. Based on values before the first step and 6 months after the second step, significant improvements were noted in UCVA (0.7 ± 0.32 logMAR *vs* 0.08 ± 0.08 logMAR), BCVA (0.16 ± 0.19 logMAR *vs* 0.02 ± 0.04 logMAR), sphere (–3.65 ± 3.08 D *vs* 0.06 ± 1.6 D), astigmatism (–3.31 ± 1.5 D *vs* –0.98 ± 0.75 D), average K (47.28 ± 1.99 D *vs* 41.42 ± 3.22 D), and coma (2.36 ± 1.23 μm *vs* 1.47 ± 0.68 μm) ($p < 0.05$). Approximately 63% of eyes gained ≥2 lines of BCVA, whereas no change in BCVA was reported in 27% of eyes. No eyes lost lines of BCVA. The authors concluded that the combination of ICRS implantation followed by sequential same-day topography-guided PRK/CXL may be a reasonable option for improving VA in patients with low to moderate KC.[46] Coskunseven E et al report on topography-guided transepithelial PRK after ICRS and CXL in a three-step procedure for KC. In this prospective case series, 10 patients (16 eyes) with progressive KC were included. All patients underwent topography-guided transepithelial PRK after Keraring implantation, followed by CXL treatment. The follow-up period was 6 months after the last procedure for all patients. Time interval between both ICRS implantation and CXL and between CXL and topography-guided transepithelial PRK was 6 months. LogMAR mean UCVA and BCVA improved ($p < 0.05$) from 1.14 ± 0.36 and 0.75 ± 0.24 preoperatively to 0.25 ± 0.13 and 0.13 ± 0.06 after the completion of the three-step procedure, respectively. Mean spherical equivalent refraction was significantly reduced ($p < 0.05$) from –5.66 ± 5.63 D preoperatively to –0.98 ± 2.21 D after the three-step procedure. Mean steep and flat keratometry values were significantly reduced ($p < 0.05$) from 54.65 ± 5.80 D and 47.80 ± 3.97 D preoperatively to 45.99 ± 3.12 D and 44.69 ± 3.19 D after the three-step procedure, respectively. The authors concluded that the procedure seems to be an effective, promising treatment sequence offering patients a functional VA and ceasing progression of the ectatic disorder. A longer follow-up and larger case series are necessary to thoroughly evaluate safety, stability and efficacy of this innovative procedure.[47] Iovieno A reports on ICRS implantation followed by same-day PRK and CXL in KC. Four patients (five eyes) were included in the study. All patients first underwent femtosecond laser-enabled placement Intacs, UCVA, BCVA and keratometry readings remained stable for 6 months. Same-day PRK and CXL were subsequently performed in all patients. Six months after Intacs plus PRK/CXL, significant improvements were noted for UCVA, BCVA, spherical equivalent refraction, keratometry and total aberrations. No patient lost lines of BCVA or developed haze.[48] Yeung SN et al reports on phototherapeutic keratectomy (PTK) combined with implantation of a single ICRS and CXL performed sequentially on the same day in the management of KC. This retrospective review comprised consecutive patients with progressive KC having transepithelial PTK followed by femtosecond laser-enabled placement of a single inferior ISCR and CXL on the same day. Sixteen eyes of 13 patients were included in the study. Six months after same-day PTK combined with ICRS and CXL, there was a significant improvement in UCVA, BCVA and the mean and steep k-values. No patient lost BCVA lines. The procedure was safe and effective treatment for improving VA in patients with progressive KC.[49]

### Intraocular Lenses (IOLs)

In some cases, although Intacs reduce astigmatism and myopia and improve corneal irregularity, high ametropia — uncorrectable by glasses—remains. In cases of high ametropia, in patients unable to tolerate or unwilling to wear contact lenses, phakic intracorneal rings can be considered to improve uncorrected refractive error or pseudophakic intraocular lenses (IOLs) in patients with cataract.

The corneal rings are usually inserted 3 months before the intraocular lens insertion[50] Good outcomes have been reported when used in combination with both the Visian ICL and the Verisyse Phakic IOL.[51-54] This is a reversible procedure that is less invasive than penetrating keratoplasty. Kamburoglu et al reported on Artisan toric phakic IOL implantation after Intacs, to correct residual myopic and astigmatic refractive errors. Five months postoperatively, the UCVA was 0.6 and the BCVA was 0.7.[55] Budo et al implanted Artisan toric phakic intraocular lenses (pIOLs) in both eyes of 3 patients with KC. Postoperatively, 4 of the 6 eyes were within 1.00 D of emmetropia.[54] Colin and Velou implanted an anterior chamber pIOL after Intacs implantation in a patient with KC. The refractive results were satisfactory, there was minimal residual myopia.[53]

El-Raggal et al conducted a 24 months follow-up of 8 KC eyes of 6 patients who had maximum k values of 60 D and underwent sequential Intacs and a Verisyse pIOL implantation for refractive improvement.[52] All eyes achieved UCVA of 20/40 or better. The final spherical error ranged from –1.75 D to 1.00 D and the cylindrical error ranged from 1.25 to 2.50 D. No eye lost lines of preoperative BCVA. These results were relatively stable throughout the follow-up period. The authors concluded that the procedure was safe, stable and effective in selected cases of KC. Guell implanted in 2 eyes of the same patient toric phakic iris-claw Artisan IOL (Ophtec BV Groningen, The Netherlands) to correct the remaining refractive error in keratoconic patients who had Intacs implantation.[56] El-Raggal et al reported on simultaneous and sequential implantation of Intacs and Verisyse Phakic Intraocular Lens for refractive improvement in keratectasia. They collected data from 19 eyes of 12 patients (5 eyes, post-laser *in situ* keratomileusis ectasia and 14 eyes, KC). Intacs segments were implanted followed by the insertion of a phakic Verisyse lens at the same session (12 eyes) in the 'simultaneous group,' or several months later (7 eyes) in the 'sequential group'.[57] No intraoperative or postoperative complications were observed. At the last follow-up (19 ± 6 months), in the simultaneous group, mean spherical error was −0.79 ± 1.0 D (−2.0 to +1.50 D) and cylindrical error +2.06 ± 1.21 D (+0.5 to +3.75 D). In the sequential group, at the last follow-up, at 36 ± 21 months, the mean spherical error was −1.64 ± 1.31 D (−3.25 to +1.0 D) and cylindrical error +2.07 ± 1.03 D (+0.75 to +3.25 D). There was no significant difference in mean UCVA or BSCVA between the two groups preoperatively or postoperatively. No eye lost lines of preoperative BSCVA. Coşkunseven E reported on a case series of ICRS implantation followed by CXL and then toric implantable collagen copolymer phakic intraocular lens (pIOL) implantation. The study enrolled 14 eyes (9 patients). After the combined treatments, the mean decimal UCVA and BCVA were significantly improved from 0.01 and 0.14, respectively, preoperatively to 0.44 and 0.57, respectively ($p < 0.0001$). The mean manifest refraction spherical equivalent decreased from –16.40 D ± 3.56 (SD) (–11.50 to –22.50 D) to –0.80 ± 1.02 D (–2.00 to +2.00 D) after the combined treatments ($p < 0.0001$). The mean refractive astigmatism decreased from –4.73 ± 1.32 D (–3.00 to –7.00 D) to –0.96 ± 0.35 D (–0.50 to –1.50 D) ($p < 0.0001$). The mean steep and mean flat keratometry values reduced from 60.57 D and 56.16 D respectively, to 54.48 D and 53.57 D ($p < 0.0001$) respectively. No intra operative or postoperative complications were reported.[58]

Jarade et al reports on sequential implantation of Keraring Implantable Collamer Lens phakic intraocular lens (pIOL) with corneal relaxing incisions for refractive correction of KC.[59] Alfonso et al reports 40 eyes of 31 patients, the ICRS implantation was followed 6 months later by pIOL implantation with corneal relaxing incisions. The mean UCVA (decimal) was 0.11 Snellen ± 0.05 (SD) preoperatively, 0.18 ± 0.14 Snellen 6 months after ICRS implantation ($p = 0.001$), and 0.50 ± 0.27 Snellen 6 months after pIOL implantation ($p < 0.0001$). The mean BCVA was 0.56 ± 0.23 Snellen, 0.68 ± 0.25 Snellen and 0.73 ± 0.20 Snellen, respectively (all $p < 0.0001$). Six months after pIOL implantation, the efficacy index was 0.88 and the safety index, 1.28. At 6 months, 65% of eyes were within ± 1.00 D of the desired refraction and 45% were within ± 0.50 D. The mean spherical equivalent after pIOL implantation was –1.19 ± 1.33 D.[60] Toric pIOLs may be preferred in eyes with high astigmatic refractive errors. Controlled randomized studies with longer follow-up are needed to decide which type of lens to use and to evaluate safety, predictability and stability. Lee SA et al Report on 49 years male suffering from severe KC patient had a sequential ICRS and cataract surgery. Preoperatively UCVA was 20/1000, BCVA 20/400, keratometric readings of K1 = 59.88, K2 = 45.88 the first step was the insertion of asymmetrical pair of kerarings with the assistance of a femtosecond laser. Three months after the kerarings were implanted, clear-cornea phacoemulsification and IOL implantation were performed. After surgery, both the UCVA and the BSCVA of the left eye improved by eight lines. Postoperative central keratometry showed a decrease of 7.35 D in the left eye and remained stable 1 month following the procedures.[61]

## SUMMARY

ICRS change positively the corneal shape in keratoconic and post-LASIK ectasia eyes, reduce the irregular astigmatism, reduce keratometry readings, myopia, astigmatism and high order aberrations and improve UCVA and BSCVA.

ICRS change the biomechanical properties of the cornea. Nonsurgical means, such as glasses and CL (all kinds from sclera, minisclera, RGP, soft, soft K, Piggy –back, beck). And surgical means, such as CXL which flattens the cornea and improve UCVA and BSCVA after ICRS, PRK which reduces myopia and astigmatism and improve UCVA. IOLs which correct myopia and astigmatism and improve UCVA. All these surgical techniques can improve further the VA of keratoconic eyes implanted with ICRS to satisfactory levels and even to independence from glasses and CL.

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