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Treatment strategies for corneal ectasia

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Abstract

Purpose of Review—The aim of this article is to review the most recent management strategies for corneal ectasia after keratorefractive surgery.

Recent Findings—Management options for postoperative ectasia include conservative management with various types of contact lenses such as rigid gas permeable lenses, custom wavefront-guided soft contact lenses, hybrid lenses and tandem soft contact lens-rigid gas permeable lenses. Minimally invasive surgical options include corneal ring segment implantation with Intacs, KeraRings or Ferrara rings have shown to have good results in the initial time period after insertion. However there appears to be some evidence that this initial effect may regress with time. Collagen cross-linking is also minimally invasive and has been documented to stop the progression of ectasia and in some cases may cause regression. Recently, techniques combining collagen cross-linking with intracorneal ring segments or with topography-guided excimer laser treatments have shown to have promising results.

Summary—Early management of ectasia is essential to prevent its progression and to preserve visual potential. There are several management options that are available that may be used to reduce the need for corneal transplantation for these patients.

Keywords

Corneal ectasia; laser in situ keratomileusis; intracorneal ring segments; contact lenses; collagen cross-linking; keratoplasty

Introduction

Despite the establishment and validation of risk factors to screen patients prior to refractive surgery, corneal ectasia still develops in a small percentage of people.(1,2,3*) It is a very serious complication that can occur even after uneventful excimer laser corneal refractive surgery. Postoperative corneal ectasia has been estimated to occur in 0.004% to 0.6% of post LASIK patients (3*). The clinical onset of keratoectasia can occur months or even years after the surgery. (1,2,4,5*). Newer treatment modalities have been developed to tackle this

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rare, yet devastating complication of refractive surgery. These modalities include management with various types of contact lenses and minimally invasive procedures, including intracorneal ring implantation and collage-cross linking. There is also the potential to gain added benefit by combining treatment modalities. When all else has failed, corneal transplantation is possible utilizing both traditional full thickness techniques as well as deep anterior lamellar keratoplasty. The aim of this paper is discuss current management options and outcomes for visual rehabilitation for postoperative ectasia.

Specialized Contact Lens Fitting Strategies

The severity of post-operative ectasia may range from mild to severe and its progression is often unpredictable. Mild cases have been reportedly managed successfully with spectacles. (1,4,5*); however, irregular astigmatism limits the efficacy of spectacles for most patients. (5*).

Rigid gas permeable lenses are often sufficient for visual rehabilitation because they are successful in addressing the irregular astigmatism encountered with corneal ectasia. They create a spherical anterior refractive surface over the ectatic cornea and the tear film provides an optical bridge between the posterior aspect of the contact lens and the irregular cornea. (5*). Up to 80% of ectatic eyes may be successfully managed with rigid gas permeable lenses alone. Fitting parameters of rigid gas permeable lenses should be determined on an individual case basis as post-operative ectactic corneas can vary significantly from each other. Patients who could not tolerate rigid contact lenses often cite similar reasons to those of keratoconic patients such as poor visual acuity, discomfort and intolerance to lens wear, or the inability to fit the shape of the ectatic cornea properly. Soft contact lenses in tandem use, hybrid contact lenses and scleral lenses have reportedly been used to improve fitting tolerance when patients cannot tolerate rigid gas permeable lenses. (5*)

Newer modalities of custom wavefront-guided soft contact lenses have been utilized in come cases of keratoconus and may be applicable to postoperative corneal ectasia. (4,6) Two studies by Marsack et al. demonstrated that custom contact lenses provide equivalent photopic high contrast logMAR visual acuity compared with rigid lenses and may actually decrease low and high order aberrations. (4,6). Hybrid lenses (ex. SynergEyes, SynergEyes Inc.) consist of a rigid center with a soft skirt. This combination results in the good visual acuity provided by rigid lenses as well as the comfort of a soft contact lens. Tandem contact lenses are composed to a soft silicone hydrogel lens fitted between the RGP les and the cornea. This improves comfort as well as fitting. Tandem lenses can be used initially as lens adaptation or they may be used as long-term management (5*). Finally, scleral contact lenses may be a viable option for some patients with advanced corneal ectasia that cannot be fit with other forms of contact lenses (7).

Intracorneal Ring Segments

Intrastromal corneal ring segments, including Intacs (Addition Technology Inc.) and KeraRings intracorneal ring segments (Ferrara Ophthalmics), may improve visual function with corneal ectatic diseases (3*,5*,8–10*). They improve visual function by potentially decreasing irregular astigmastism and reducing corneal steepening (9). The rings are inserted in a concentric deep intrastromal tunnel created with either a microblade or a femtosecond laser (8,11). The ring segments are peripherally space-occupying, which induces central corneal flattening (10*). The magnitude of flattening is directly proportional to the thickness of the implant and inversely proportional to its diameter (3*). KeraRings intracorneal ring segments (Ferrara Ophthalmics) are also available for ectasia and keratoconus, however these are not currently available in the United States (5*,9,10*).

Intracorneal rings are placed symmetrically or asymmetrically and are based on the steep keratometric axis or about the cone (3*,5*,8–10*). The wound location, size, symmetry and number of Intacs placed may vary per patient and per surgeon. Torquetti et al recently reported a more current nomogram for KeraRings ring selection which is the result of approximately 10 years of study of more than 6000 patients(9). The authors suggest that ring selection should be based on corneal thickness, the amount of topographic corneal astigmatism, and the distribution of the ectatic area on the cornea. Refraction is notably absent from their nomogram. Two equal ring segments should be used for symmetric bow-tie patterns of ectasia or keratoconus and asymmetrical segments should be used for peripheral cones. Lastly, thickness should not exceed 50% of the thickness of the cornea on the track of the ring . Their study documented long term (>5 years) results of KeraRings intracorneal ring implantation and concluded that KeraRings result in topographic and visual stability, delayed the progression of keratoconus and at the very least postponed the need for keratoplasty (9).

Pinero et. al documented in a recent study that intracorneal ring segment inplantation (Intacs and KeraRings) is successful in treating coma-like aberrations and astigmatism in post-LASIK corneal ectasia (3*). During a 2 year follow-up period a reduction in aberrations leading to a significant improvement in BSCVA was documented. This was the first report on anterior corneal aberrometric outcomes after intracorneal ring segment implantation. The authors stressed the importance of the interface between the air and cornea and its contribution to the total power of the eye because of the large difference in refractive index at this point. In ectatic eyes the corneal aberrations of the anterior surface are the most important source of optical errors. Both Intacs and KeraRings induced a spherical correction as well as central flattening of the cornea initially. However a regression of these effects was observed 12 months after the surgery. This is significant in that it indicates that Intacs did not stop the progression of ectasia in all cases (3*). The authors also concluded that ectatic corneas with high irregularity and a pronounced conic protrusion are poor candidates for intracorneal ring segment implantation. They did not find any significant differences in corneal aberrometric outcomes between Intacs and KeraRings, however the sample sizes were small. It was noted that a higher amount of higher-order residual aberrations were found in eyes that underwent the mechanical procedure versus the femtosecond-assisted procedure in the initial postoperative period. This led the authors to conclude that the femtosecond technology may be a better procedure for implanting intracorneal ring segements in post-LASIK ectasia (3*).

Several advances in intracorneal ring segment design have been made recently. Intacs are now available in smaller diameter ring (inner diameter of 6 mm) with a thickness of 0.40 to

0.45 mm. The aim of this new ring is to treat moderate to severe keratectasia with steep keratometric values of >57.00 Diopers (10*). KeraRings has reported the clinical outcomes of 80 eyes after implantation of a new intracorneal ring segment with a 210-degree arc length versus the previous rings which had 160-degrees of arc length. The newer KeraRings were effective in treating keratoconus by improving visual acuity and reducing corneal steepening. The advantages over the conventional rings are: 1) minimal astigmatic induction, 2) corneal flattening, and 3) implantation of a single segment (10*).

Problems associated with intracorneal ring implantation include patient dissatisfaction with visual quality, discomfort, ring segment extrusion or migration. For example in the Pinero et al. study 6 eyes required segment ring explantation. Five of the six explanted ring segments were Intacs and 1 was a KeraRing. Two cases required ring segment repositioning (3*). A study by Mulet et al. evaluated the incidence of microbial keratitis after intrastromal corneal ring segment implantation. In their study, 212 eyes of 149 patients underwent either Intacs implantation (63.2%) or KeraRings (36.8%) implantation. The corneal tunnels were created in 56.1 % of the eyes using a manual laser and in 43.9% using the femtosecond laser. The incidence of acute microbial keratitis in this study was 1.4%. There was not a statistical significance between techniques of implantation or the segment type. The most frequent infection was with gram-positive cocci (12).

Corneal Collagen Cross Linking

Introduced by Wollensak et al. (13), collagen cross-linking involves using riboflavin as a photosensitizer followed by ultraviolet-A light. It has been well documented to halt the progression of keratoconus as well as postoperative corneal ectasia (5,14*–18). The collagen fibers in the cornea respond to this treatment by developing chemical covalent bonds by photopolymerization. The cross-linking of the collagen fibers that occurs increases porcine corneal rigidity by 71.9% and human corneas by 328.9% (19). However most of the cross-linking effect occurs in the anterior stroma, which is functionally decoupled from the posterior stroma in LASIK after the creation of the flap (5*). Cross-linking has been found to be effective for post-operative ectasia by strengthening the remaining central and posterior cornea for up to 5 years after the procedure (13). The preliminary results from a 12-month randomized controlled trial study conducted by Wittig-Silva et al. were recently reported in which the authors conclude that there is at least a temporary stabilization of all treated eyes after collagen cross-linking (20*).

Riboflavin and UVA have been reported to only stiffen the cornea in the anterior 200 microns. This may be due to the absorption behavior of UVA after riboflavin treatment (21). A study involving immunofluorescence confocal microscopy of porcine corneas after collagen cross-linking treatment with riboflavin and UVA light confirms that corneal epithelium acts as a barrier to riboflavin absorption; therefore, removal is a crucial initial step in the treatment and allowed for a quantitative analysis of cross-linking treatment. Corneas without deepithelialization prior to treatment with riboflavin and UVA showed only minimal cross-linking effect. The corneas that did undergo deepithelialization prior to treatment showed a very organized anterior fluorescence zone of 182.5 +/− 22.5 microm (22). Partial epithelial removal results in a limited and inhomogeneous uptake of riboflavin and therefore diminishes the efficacy of collagen cross-linking (23). The biomechanical and histological changes after corneal cross-linking with and without epithelial debridement have been evaluated. It has been concluded that without epithelial debridement, the biomechanical effect of corneal cross-linking is reduced by approximately one fifth compared to that with standard cross-linking and full removal of the epithelium (23).

The study results reported thus far on collagen cross-linking appear to be very promising for the treatment of post-operative ectasia. The results of the ongoing randomized studies will further define the indications for this technique.

Future Directions: Combination treatments

The future of full visual rehabilitation for corneal ectatic disorders may lie in combination treatments focused on addressing both structural and refractive issues. The most promising options include combining intracorneal ring segments with collagen crosslinking, and crosslinking combined with advanced Excimer laser ablation profiles.

Chan et al. were the first to report that a combined treatment of CXL with Intacs in eyes with keratoconus led to better results than Intacs insertion alone (24). More recently, Kamburoglu and Ertan (16) reported a patient with postoperative LASIK ectasia who underwent Intacs severe keratoconus (SK) implantation in both eyes followed by CXL in the left eye one day post ring implantation and in the right eye 1 month after ring implantation. This patient had improvement in UCVA, BSCVA and refraction initially after Intacs implantation. There was a slight regression in the initial effect seen on 1 month follow up in the right eye however this seemed to subside after CXL (16).

Kymionis et al. reported a new technique using simultaneous customized topography-guided surface ablation followed by collagen cross-linking in patients with keratoconus (14*). The authors found that patients undergoing this treatment showed a rapid and significant improvement in UCVA and BSCVA. They claim that the advantage of this technique is that ablation does not interfere with the already cross-linked part of the cornea.

Kanellopoulos recently compared the outcomes of combined corneal collagen cross-linking and topography-guided photorefractive keratectomy using different sequence and timing of the treatments for keratoconus. 325 eyes were included in this study and divided between two groups. One group underwent CXL with subsequent topography-guided PRK performed 6 months later. The other group had simultaneous CXL and PRK in a combined procedure on the same day. Mean follow up time was 36 +/− 18 months. Statistically the group receiving simultaneous treatment had improvement in UCVA, BSCVA, greater mean reduction in spherical equivalent refraction, keratometry and less corneal haze. This lead the author to conclude that same-day simultaneous treatment was superior to sequential CXL with later PRK in the visual rehabilitation of progressing keratoconus (15*). This study shows promise as well for the treatment of post-operative corneal ectasia.

Conclusion

While rare, postoperative corneal ectasia remains a significant complication of keratorefractive surgery. Currently the most commonly used management for visual rehabilitation is rigid contact lenses, however there are some patients who cannot tolerate these. New treatments such as collagen cross-linking used alone or with other treatment modalities are showing encouraging results and will hopefully eliminate the need for corneal transplantation and allow for significant visual rehabilitation.

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