• Brief Report •

Management of cataract in keratoconus: early visual outcomes of different treatment modalities

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Received: 2018-10-17 Accepted: 2019-04-08

Abstract

• A review of 31 eyes with keratoconus who developed cataract and underwent phacoemulsification. Visual acuities were measured 1mo postoperatively. Six eyes with a history of good corrected distance visual acuity (CDVA) and a similar refractive and topographic astigmatic axis were implanted with toric intraocular lenses (IOLs). The mean postoperative uncorrected distance visual acuity (UDVA) was 0.2 logMAR with a spherical equivalent (SE): 0.75D. Eleven eyes with a history of good CDVA and different refractive and topographic axis were implanted with monofocal IOL+/-Toric implantable collamer lenses to treat anisometropia and ametropia; mean UDVA was 0.25 logMAR with a mean SE: -0.51 D postoperatively. Six eyes with poor CDVA were first treated with intra-corneal ring segments, followed by phacoemulsification, the mean postoperative UDVA was 0.82 logMAR with an SE: 0.22 D. Eight eyes had advanced ectesia and received combined phacoemulsification and penetrating keratoplasty. Our approach is efficient in addressing ametropia after cataract surgery in keratoconic eyes.

• **KEYWORDS:** keratoconus; cataract surgery; residual ametropia; algorithm

DOI:10.18240/ijo.2019.10.21

Citation: Arej N, Chanbour W, Zaarour K, Amro M, El-Rami H, Harb F, Jarade E. Management of cataract in keratoconus: early visual outcomes of different treatment modalities. *Int J Ophthalmol* 2019;12(10):1654-1658

INTRODUCTION

Keratoconus is a bilateral asymmetric noninflammatory disorder characterized by progressive thinning and cone-shaped protrusion of the cornea leading to a decreased visual acuity and irregular astigmatism[1]. Advances have been made in stopping progression of the disease with the advent of corneal crosslinking[2]. Visual impairment still needs to be managed with spectacles or rigid gas-permeable (RGP) contact lenses in the early stages of the disease or may require surgical correction such as with intrastromal corneal ring segments (ICRSs)[3], phakic toric implantable collamer lenses (TICL)[4-5], corneal transplants[6], sometimes combined with a cataract surgery. The latter becomes of major interest when patients with keratoconus present with a cataract which contributes to a further visual decline. Furthermore, it has been shown that keratoconic eyes are more likely to develop cataracts and at a younger age than the general cataract population[7]. Not to mention the increase of life expectancy worldwide[8], which by itself increases the incidence of cataracts in the keratoconus population.

Patients with both cataract and keratoconus present a unique challenge for ophthalmologists who will need to tailor a particular treatment for each and every case in a customized approach that usually encompasses different steps, among which cataract extraction might not always occur in the first place. In all cases, particular attention should be accorded to the intraocular lens (IOL) calculation since accurate or reproducible biometric measurements are hard to attain in keratoconus. First, the relation between the radius of curvature of the anterior and posterior corneal surfaces has changed. Second, the corneal apex may be decentered with an anterior bulging which may lead to a variability in axial length measurements[9] and third, because of the corneal optical multifocality different measurements of the optical parameters may be obtained in the same eye[10].

In this study, we retrospectively report the results of our case series of cataract surgeries in keratoconus and, in the absence of a standardized protocol for the management of cataract in keratoconic eyes, we suggest in what follows a treatment algorithm that would help patients achieve the best visual outcome.

SUBJECTS AND METHODS

Ethical Approval This is a retrospective review of patients with keratoconus who underwent cataract surgery at Beirut Eye & ENT Specialist Hospital (Beirut, Lebanon) between January 2010 and October 2017. All patients were older than 18 years of age and had a stable keratoconus with a cataract in one or both eyes that required surgery at the time of enrolment. Institutional Review Board (IRB)/Ethics Committee ruled that approval was not required for this study.

The severity of keratoconus was classified according to the Amsler-Krumeich grading system[11]. Pentacam Scheimpflug imaging was performed using the WaveLight® Allegro Oculyzer™ (WaveLight, GmbH, Erlangen, Germany). Topographic patterns and K-readings were consequently obtained. Therapeutic decisions were then made following the algorithm (Figure 1).

Eyes with advanced corneal ectasia and/or scarring were at once scheduled for a combined cataract surgery with a penetrating keratoplasty (PKP). The remaining cases were addressed in terms of the corrected distance visual acuity (CDVA) that preceded the installation of cataract. In eyes with a history of good CDVA, cataract surgery was performed with IOL implantation. If the astigmatism axis of the manifest refraction corresponds to that of the corneal topography, a toric IOL was implanted in order to give the best possible uncorrected distance visual acuity (UDVA) postoperatively. Whereas, in cases of discrepancy between the astigmatism axes, a regular monofocal aspheric IOL was initially implanted, followed by the implantation of a TICL to correct residual ametropia (as indicated by the patient's need for emmetropia) or anisometropia. In eyes with a history of low CDVA with a minimum corneal thickness greater than 400 mm at the optical zone, a single ICRS was initially inserted according to our protocol[12], in order to regularize the corneal surface, followed by cataract surgery with the implantation of a monofocal aspheric IOL and then possibly a TICL as a separate additional procedure.

IOL calculations were performed by averaging results from three formulas using standard and corneal topography-derived keratometries, with the desired refraction aiming for emmetropia. Average K-reading of central 2.3 optical zone was used for IOL calculation after ICRS implantation[13]. In patients with post-LASIK ectasia, K-reading were derived using Jarade's method for deriving the new index of refaction[14].

All cataract surgeries were performed by a single surgeon (Jarade E) using clear-cornea phacoemulsification (or open-sky when combined with PKP) with implantation of either a monofocal or toric IOL from Rayner (Rayner Intraocular Lenses Ltd., Worthing, UK) or Alcon AcrySoft® IQ and SA 60AT (Alcon laboratories, Fort Worth, TX, USA), in the posterior capsular bag. Patients with severe keratoconus benefited from an RGP contact lens-assisted cataract surgery in order to enhance optical performance and decrease optical distortion due to corneal irregularities, which may impede on the depth of perception and accurate focusing, and could subsequently lead to an increased risk of posterior capsular rupture[15]. The RGP contact lenses (diameter =11 or 12 mm, base curve =7.3) were manually customized by trimming their edges to meet the surgeon's preferred site of incision. At the end of the cataract procedure, the incision site was secured with a single 10-0 nylon suture.

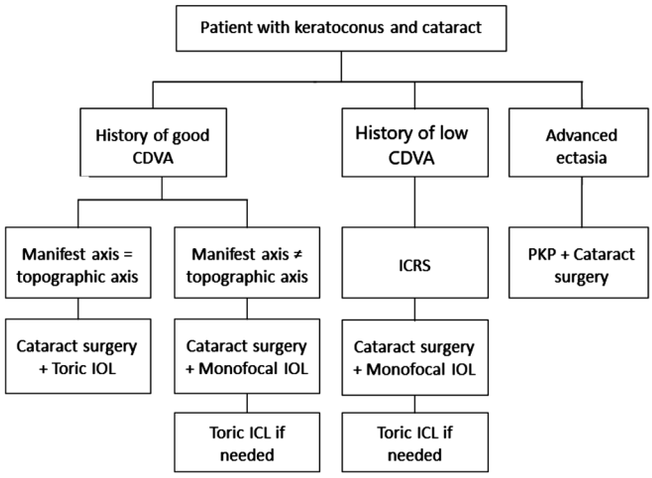

Figure 1 Dr. Jarade's algorithm for the management of keratoconic eyes with cataract CDVA: Corrected distance visual acuity; ICRS: Intrastromal corneal ring segments; PKP: Penetrating keratoplasty; IOL: Intraocular lens; ICL: Implantable collamer lens.

UDVA and CDVA were measured with a logMAR scale at baseline and at 1mo following every therapeutic procedure. Statistical calculations were performed using MS Excel 2016.

RESULTS

Thirty-one eyes of 23 patients were treated according to the algorithm in Figure 1. Their characteristics and their treatment outcomes are displayed in Table 1 and detailed in the following section.

Category 1: Eyes with a History of Good CDVA and a Manifest Astigmatism Axis Matching with Topography Six eyes had a history of good visual acuity and a manifest astigmatism axis that matched the topography and, therefore, could benefit from a cataract surgery with the implantation of a toric IOL. Most of them (83.33%) had a stage 2 keratoconus; their mean UDVA was 0.5 logMAR (20/60) at baseline and improved to 0.2 logMAR (20/30) postoperatively. A similar improvement was noted in terms of CDVA. Spherical equivalent (SE) improved from -3.35 to 0.75 D. Statistical significance could not be assessed due to the small number of eyes.

Category 2: Eyes with a History of Good CDVA and a Manifest Astigmatism Axis not Corresponding to

Table 1 Patients' characteristics and treatment outcomes in each category of the algorithm

Category	Mean age	Male-to-female ratio	Keratoconus stage	Topographic pattern	Mean UDVA (logMAR) at baseline	Mean CDVA (logMAR) at baseline	Mean SE (D) at baseline	Performed procedure	Mean UDVA (logMAR) postop.	Mean CDVA (logMAR) postop.	Mean SE (D) postop.
Category 1 (6 eyes): history of good CDVA, manifest= topographic astigmatism axis	56.5	1:2	Stage 2: 83.33%; stage 3: 16.67%	Asymmetric bow-tie: 83.33%; pellucid: 16.67%	0.5	0.46	-3.35	Cataract surgery+Toric IOL	0.2	0.1	0.75
Category 2 (11 eyes): history of good CDVA, manifest ≠ topographic astigmatism axis	55.82	3:8	Stage 1: 45.45%; stage 2: 36.36%; stage 4: 18.18%	Asymmetric bow-tie: 45.45%; skewed radial axis: 9.09%; inferior steepening: 9.09%; pellucid: 9.09%; post-LASIK ectasia: 18.18%	1.1	0.18	-3.85	Cataract surgery+Monofocal IOL±TICL	0.25	0.12	-0.51
Category 3 (6 eyes): history of low CDVA	48.5	0:6	Stage 3: 16.67%; stage 4: 66.67%	Asymmetric bow-tie: 16.67%; pellucid: 83.33%	1.73	0.37	-6.72	ICRS followed by cataract surgery+IOL	0.82	0.34	0.22
Category 4 (8 eyes): advanced ectasia	60	5:3	Stage 4: 100%	Asymmetric bow-tie: 37.5%; skewed radial axis: 25%; superior steepening: 12.5%	1.34	0.94	-15.66	Combined PKP+cataract surgery	0.57	0.18	0.85

UDVA: Uncorrected distance visual acuity; CDVA: Corrected distance visual acuity; SE: Spherical equivalent; ICRS: Intrastromal corneal ring segment; PKP: Penetrating keratoplasty; IOL: Intraocular lens; TICL: Toric implantable collamer lens.

Topography Eleven eyes had a history of good visual acuity but their manifest astigmatism axis did not match the topography. The majority had mild to moderate keratoconus (stages 1 and 2) and showed an asymmetric bow-tie pattern (45.45%). Mean UDVA, CDVA and SE were 1.1 logMAR (20/250), 0.18 logMAR (20/30) and -3.85 D respectively at baseline; 0.25 logMAR (20/35), 0.12 logMAR (20/25) and -0.51 D postoperatively. Two out of the 11 eyes had an additional implantation of a TICL in order to correct the remaining astigmatism and they achieved good UDVA of 0.1 logMAR (20/25) and 0.3 logMAR (20/40) with a residual cylinder of 0.5 and 0.75 D respectively.

Category 3: Eyes with a History of Low CDVA Six eyes were included in this category, out of which 83.33% had a pellucid-like pattern on the corneal topography; they had relatively advanced keratoconus (stages 3 and 4). Mean UDVA, CDVA and SE were 1.75 logMAR (20/1100), 0.37 logMAR (20/45) and -6.72 D respectively at baseline; 0.82 logMAR (20/130), 0.34 logMAR (20/45) and 0.22 D postoperatively. Noteworthy, one eye which was implanted with a toric IOL after ICRS insertion achieved a final UDVA of 0 logMAR (20/20) from a baseline UDVA of 0.9 logMAR (20/160) and a SE of -3.5 D.

Category 4: Eyes with an Advanced Corneal Ectasia Eight eyes had stage 4 keratoconus with advanced ectasia and scarring in the pupillary axis and were addressed for combined PKP and cataract surgery. Mean UDVA, CDVA and SE were 1.34 logMAR (20/440), 0.94 logMAR (20/175) and -15.66 D respectively at baseline; 0.57 logMAR (20/75), 0.18 logMAR (20/30) and 0.85 D postoperatively. In one case, significant residual ametropia persisted with a UDVA of 2 logMAR (20/2000). A TICL was then secondarily implanted, UDVA improved to 0.9 logMAR (20/160), CDVA reached 0.2 logMAR (20/30) with an SE of 0 D.

DISCUSSION

Keratoconus is characterized by progressive steepening of the cornea that leads to a highly irregular astigmatism. While age hold down the progression of keratoconus, the natural onset of cataract contributes to further visual impairment in this population. When patients develop decreased vision, a careful evaluation should be performed to determine whether the cause is the result of corneal changes, cataract formation, or other pathology. For the patients with cataract, different options have been proposed and are largely dependent on the stage of keratoconus and the history of the patient[16].

Phacoemulsification with the implantation of a toric IOL has been shown to be a safe and effective procedure in eyes with topographically stable, fairly regular corneal astigmatism[17-18]. Eyes who benefit the most from this treatment are those who have mild keratoconus, with an astigmatism that is stable and having an invariable axis on both manifest refraction and topography. This option can also be considered in cases of intolerance to RGP[19]. Conversely, toric IOL implantation is not recommended for eyes with markedly irregular astigmatism or in which RGP are intended to be used postoperatively.

In this study, we included all the cataract surgeries performed on patients with keratoconus, eyes were categorized into four groups according to the CDVA, stage of keratoconus, and the similarity between the refractive and the corneal astigmatism. All the patients were treated according to Dr. Jarade algorithm (Figure 1) and had favorable outcomes in all the categories. In category 1, despite the small number of eyes, favorable visual acuity outcomes were obtained and this was primarily attributable to a careful patient selection.

Eyes that were unfit for a toric IOL were included in the category 2 of our series and have also achieved good visual outcomes, though farther from emmetropia compared to those of the category 1. Interestingly, final uncorrected visual acuity could be optimized in 2 eyes that were initially considered as borderline candidates for toric correction, and this through the implantation of a TICL. Posterior chamber TICLs have been previously shown to be efficient in the visual correction of phakic keratoconic eyes[20-21]. However, to our knowledge, they haven't been used so far for the purpose of correcting residual ametropia after cataract surgery in keratoconus.

Alfonso *et al*[22] demonstrated that sequential ICRS and IOL implantation provided good visual and refractive outcomes and was an effective, safe, predictable, and stable procedure for the treatment of patients with keratoconus and cataract. This approach was adopted for the eyes in the category 3 of our series, which had a history of low CDVA (non-RGP correction). Correction of corneal irregularities prior to cataract surgery is of a particular interest, in terms of enhancing the intraoperative visibility and improving the predictability of the final visual outcome after phacoemulsification and IOL implantation. This has also allowed us to implant a toric IOL in an eye that was found to have a less irregular astigmatism after ICRS insertion and had an axis that coincide with the manifest refraction of the patient.

Simultaneous PKP with cataract extraction (either by open-sky extracapsular extraction or phacoemulsification) and IOL implantation, aka the "TRIPLE" procedure, is the method of choice for combined lens and corneal opacities[23]. It was applied to all eyes in category 4 of our series and achieved satisfactory results. Closed-system phacoemulsification was made possible prior to PKP due to the use of customized RGP contact lenses which allowed to overcome intraocular image distortions, and hence, to avoid potential complications such as posterior capsular rupture and corneal endothelial cell damage.

This was a series of cases of coexisting cataract and

keratoconus that we managed according to the algorithm in Figure 1. Further studies with a larger number of eyes and longer follow-ups are still needed to better establish the usefulness of the suggested strategies. The importance of patient selection has to be highlighted, since the final visual outcome is highly depended on the preoperative characteristics of each eye; *i.e.*, eyes with mild keratoconus and relatively regular astigmatism could benefit from a simple cataract surgery with toric IOL implantation, while eyes with more advanced disease might require a multi-staged approach in an attempt to better restore their UDVA. Yet, residual refractive errors can occur, but could often be anticipated by a careful IOL calculation, or alternatively addressed by a postoperative correction with spectacles, RGP or even the implantation of TICLs that could be selectively considered as an option.

In the light of our results, as well as those published in previous studies and individual case reports, we believe that our algorithm will be a simple and useful tool for practitioners who encounter cataract in eyes with keratoconus.

ACKNOWLEDGEMENTS

Conflicts of Interest: Arej N, None; **Chanbour W,** None; **Zaarour K,** None; **Amro M,** None; **El-Rami H,** None; **Harb F,** None; **Jarade E,** None.

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