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Comparison of Capsular Tension Ring Implantation before vs. after Toric Intraocular Lens for Rotational Stability

Vergleich der Kapselspannring-Implantation vor vs. nach torischer Intraokularlinse in Bezug auf Rotationsstabilität

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ABSTRACT

Purpose To compare the effect of implanting the capsular tension ring (CTR) before or after a toric intraocular lens (IOL) on rotational stability in patients with cataract and astigmatism.

Methods This is a randomized retrospective study. Patients who underwent phacoemulsification combined with toric IOL implantation due to cataract and astigmatism between February 2018 and October 2019 were enrolled in the study. Group 1 consisted of 53 eyes of 53 patients in whom the CTR was placed into the capsular bag after the implantation of the toric IOL. On the other hand, group 2 consisted of 55 eyes of 55 patients in whom the CTR was placed into the capsular bag before implantation of the toric IOL. The two groups were compared in terms of preoperative and postoperative astigmatism, uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), and postoperative IOL rotation degree.

Results There were no significant differences between the two groups related to age and sex ($p > 0.05$) or the mean preoperative spherical value, UCVA, BCVA, and corneal astigmatism ($p > 0.05$). Although the mean postoperative residual astigmatism of the first group (-0.29 ± 0.26) was lower than that of the second (-0.43 ± 0.31), the difference was not statistically significant ($p = 0.16$). The mean degree of rotation was $0.75 \pm 2.66°$ in group 1 and $2.90 \pm 6.57°$ in group 2, which was found to be statistically significant ($p = 0.02$).

Conclusion The implantation of CTR after a toric IOL provides further rotational stability and more effective astigmatic correction.

ZUSAMMENFASSUNG

Ziel Es sollte die Auswirkung der Implantation des Kapselspannrings (CTR) vor oder nach der torischen Intraokularlinse (IOL) auf die Rotationsstabilität bei Patienten mit Katarakt und Astigmatismus verglichen werden.

Methoden Diese Studie ist eine randomisierte retrospektive Studie. Patienten, die sich zwischen Februar 2018 und Oktober 2019 einer Phakoemulsifikation in Kombination mit einer torischen IOL-Implantation aufgrund von Katarakt und Astigmatismus unterzogen, wurden in die Studie aufgenommen. Gruppe 1 bestand aus 53 Augen von 53 Patienten, bei denen die CTR nach Implantation der torischen IOL in den Kapselsack eingebracht wurde. Andererseits bestand Gruppe 2 aus 55 Augen von 55 Patienten, bei denen die CTR vor der Implantation der torischen IOL in den Kapselsack eingebracht wurde. Beide Gruppen wurden in Bezug auf präoperativen und postoperativen Astigmatismus, unkorrigierten Visus (UCVA), bestkorrigierten Visus (BCVA) und postoperativen IOL-Rotationsgrad verglichen.

Ergebnisse Es gab keine signifikanten Unterschiede zwischen den beiden Gruppen in Bezug auf Alter und Geschlecht ($p > 0,05$) oder den mittleren präoperativen sphärischen Wert, UCVA, BCVA und Hornhautastigmatismus ($p > 0,05$). Obwohl der mittlere postoperative Restastigmatismus der 1. Gruppe

(− 0,29 ± 0,26) niedriger war als der der 2. (− 0,43 ± 0,31), war der Unterschied statistisch nicht signifikant (p = 0,16). Der mittlere Rotationsgrad betrug 0,75 ± 2,66° in Gruppe 1 und 2,90 ± 6,57° in Gruppe 2, was statistisch signifikant war (p < 0,001).

Schlussfolgerung Die Implantation von CTR nach der torischen IOL sorgt für weitere Rotationsstabilität und effektivere astigmatische Korrektur.

Introduction

Today, cataract surgery is considered one of the types of refractive surgery. Patients generally do not want to wear eyeglasses and/or contact lenses after the operation. They may have preexisting astigmatism, or cataract surgery itself may induce the condition. Approximately 60 % of cataract patients have at least 0.75 diopter (D) and 15–29 % have 1–3 D astigmatism. Before and after the operation, astigmatism can be corrected with spectacles, contact lenses, excimer laser, limbal relaxing incisions, opposite clear corneal incisions, laser arcuate incisions, and toric intraocular lens (IOL) implantation. Toric IOL implantation is one of the effective ways to correct astigmatism in patients with cataracts, which can be performed as a single procedure together with cataract surgery, with successful and predictable visual outcomes, stability, and without serious complications [1 – 3].

Effective visual outcomes after toric IOL implantation depend on the stability of the IOL on the targeted axis and postoperative IOL rotation. IOL axis rotations decrease visual acuity. There will be a 3.3 % cylindric power loss for every 1-degree rotation. Maximum acceptable rotation should be less than 30 degrees [4, 5].

To prevent or minimize the IOL axis rotation, a capsular tension ring (CTR) can be implanted together with the toric IOL, as it can provide stability and prevent rotation. CTR supports the capsular sac, makes it flatter, and thus has a supportive effect on IOL, decreasing its axial rotation [6 – 10]. Although many studies have shown that CTR reduces the rotation of the toric IOL, it has been reported that it cannot completely eliminate the postoperative toric IOL rotation [8]. However, in all of these studies, the CTR was implanted before the toric IOL, and only the capsular bag supporting effect of the CTR was utilized [7 – 10]. Therefore, in order to achieve greater toric IOL stabilization, we started to implement the implantation of the CTR after the toric IOL. With the implantation of the CTR after the toric IOL, we aimed for the CTR to overpress the toric IOL haptics and increase the friction between the capsular bag and the IOL haptics. Thus, we wanted to benefit from the CTR's mechanical compression on the IOL haptics and its friction force-increasing effect, as well as the capsular bag supportive effect. To our knowledge, this is the first study to evaluate the effect of CTR implantation after or before the toric IOL in terms of rotational stability. The aim of this study was to retrospectively evaluate whether the implantation of the CTR after the toric IOL had an effect on the postoperative rotational stability of the toric IOL.

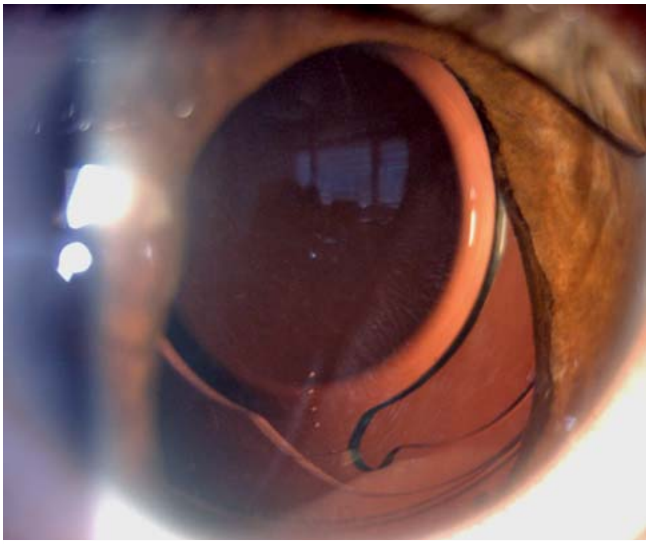
Materials and Methods

The protocol of this retrospective comparative study was approved by the local ethics committee (KTO Karatay University, Faculty of Medicine Ethics Committee, Konya, Turkey). A written informed consent was obtained from all patients before the surgery. The study was conducted in accordance with the Helsinki Declaration.

Patients who underwent phacoemulsification combined with toric IOL implantation due to cataract and astigmatism between February 2018 and October 2019 and who completed 6 months of follow-up in our clinic were enrolled in the study. Group 1 consisted of 53 eyes of 53 patients in whom the CTR was placed into the capsular bag after the implantation of the toric IOL. On the other hand, group 2 consisted of 55 eyes of 55 patients in whom the CTR was placed into the capsular bag before the implantation of the toric IOL.

Patients who had any ocular or systemic diseases that might affect the postoperative visual acuity and those who had intraoperative complications such as posterior capsule rupture and vitreous loss were excluded from the study. All patients included in the research had regular astigmatism, greater than 1.5 D, measured with an auto-kerato-refractometer (Tonoref II, Nidek, Japan) and compared with the keratometry of the optical biometer (Nidek AL-Scan, Nidek Co, Gamagori, Japan) and the corneal topography (Costruzione Strumenti Oftalmici, Florence, Italy). Tecnis toric IOL (13 mm haptic diamaters, Tecnis Toric ZCT, Johnson & Johnson Vision, Inc., Santa Ana, CA, USA) and 13 mm sized CTR (130AO, Hoya, Japan) were implanted in the eyes of all patients. The spherical power of the IOL was calculated through the Holladay 1 formula. A complete ocular examination was performed preoperatively, including uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) with the Snellen chart, intraocular pressure (IOP) measurement by tonometry, slit lamp biomicroscopic examination with pupillary dilation, fundus examination, auto-refractometric, and topographic astigmatism measurements. The cylindrical power and alignment axis of the IOL were calculated with an online calculator (www.tecnistoriccalc.com). The surgically induced astigmatism (SIA) value was 0.3 D.

To eliminate the cyclotorsion effect, 0 and 180 degrees and the axis for toric IOL placement were marked in the sitting position with biomicroscopy before the surgery. All surgeries were performed by the same surgeon (F. U.). Before the commencement of the surgery, a Mendez Ring was placed onto the cornea, and the axis was re-marked. Under topical anesthesia (proparacaine hydrochloride 0.5 %), a 2.8-mm clear corneal incision on the steep axis was made, followed by continuous curvilinear capsulorhexis (CCC) with a diameter of approximately 5.5 mm and hydrodissec-



▸ **Fig. 1** In a patient with iris coloboma, CTR compresses the IOL haptics from the top and increases the friction on the haptics, enhancing rotational stability.

tion. The irrigation and aspiration procedures were performed after nucleus emulsification. In the patients of the first group, after the toric IOL was implanted according to the target axis, the CTR was implanted with the help of forceps into the capsular bag and onto the IOL haptics to provide both capsular bag and haptic stability (▸ **Fig. 1**). For this procedure, the exact position of the CTR was unimportant and its mechanical compression to the haptics from any location was sufficient. If the toric IOL was rotated after CTR implantation, the toric IOL and CTR complex could be rotated at the haptic-optic junction with the help of a Sinski hook and realigned to the target axis. In the second group, after the CTR was implanted first, the toric IOL was implanted, and subsequently, it was aligned to the target axis. After the viscoelastic material was aspirated completely, the accuracy of the IOL axis was checked, and the IOL was rotated back to the alignment axis, if necessary. Finally, the entrances were closed with stromal hydration.

After the surgery, patients used a topical antibiotic (moxifloxacin 0.5 %, Vigamox, Alcon Laboratories, Inc., Fort Worth, TX, USA) 4 × 1 daily and a topical steroid (dexamethasone 0.1 %, Dexa-sine, Liba, Turkey) 6 × 1 daily, both for 1 week; in the subsequent 3 weeks, the steroid dosage was tapered and stopped at the end of 1 month.

Postoperatively, all the patients were examined on the 1st day, 1st week, 1st month, and 6th month. UCVA, BCVA, IOL measurement, biomicroscopic, and fundus examinations, as well as autorefractive and keratometric measurements were performed. After the mydriatic application, the IOL position was tested with a slit lamp examination to determine the extent of the rotation of the IOL axis. Further, the 6th month values were taken for statistical analysis. Groups 1 and 2 were compared in terms of preoperative patient characteristics, postoperative visual outcomes, and IOL rotation degree.

The software SPSS version 22 was used for statistical analyses. Data were compared between the groups by using the independent samples t-test and the chi-square test and analyzed within the groups by using a paired t-test. A p value smaller than 0.05 was accepted as statistically significant.

Results

The mean age of the first group was 54.36 ± 8.68 (40–83) years. Further, 25 patients were male (47 %) and 28 were female (53 %). The mean age of the second group was 57.23 ± 8.08 (42–81) years. In this group, 27 patients were male (49 %) and 28 were female (51 %).

There were no significant differences between the two groups related to age and sex ($p > 0.05$), the mean preoperative and postoperative spherical value, UCVA, BCVA, and preoperative corneal astigmatism ($p > 0.05$). The mean postoperative spherical and cylindrical values were significantly lower than those of the preoperative values in both groups ($p < 0.05$). The mean postoperative UCVA and BCVA were significantly better than those of preoperative values ($p < 0.05$). The mean axial length (AL) was 23.8 ± 2.3 mm in the first group and 23.6 ± 2.0 mm in the second group ($p = 0.68$).

No intraoperative complications were encountered in any of the cases in both groups. The preoperative and postoperative findings of both groups are presented in ▸ **Table 1**. Although the mean postoperative residual astigmatism of the first group (− 0.29 ± 0.26) was lower than that of the second (− 0.43 ± 0.31), the difference was not statistically significant ($p = 0.16$). In group 1, only 10 degrees of rotation was observed in 4 eyes (7.5%). However, the toric IOL rotation in group 2 was 30 degrees in 1 eye (1.8 %), 20 degrees in 3 eyes (5.4 %), and 10 degrees in 7 eyes (12.7 %). The mean degree of rotation was 0.75 ± 2.66 degrees in group 1 and 2.90 ± 6.57 degrees in group 2, which was found to be statistically significant ($p = 0.02$). In eyes in which the toric IOL was rotated, the AL was greater than 26 mm in 3 eyes (5.6 %) in the first group and in 7 eyes (12.7 %) in the second group. Among these eyes with long AL in group 2, the rotation was 30 degrees in 1 eye, 20 degrees in 3 eyes, and 10 degrees in 3 eyes.

Discussion

Astigmatism affects both visual acuity and quality and should be corrected to get a good vision. During cataract surgery, different techniques such as limbal relaxing incisions, femtosecond laser-assisted corneal arcuate incisions, and toric IOL implantation can be applied to reduce astigmatism [2]. Of these, toric IOL implantation is the most effective. The position of the IOL on the predetermined axis is very important for the maintenance of visual quality. If the IOL is rotated, the quality and acuity of the vision decrease [11, 12]. Asymmetrical capsular contraction, design, and material of the IOL, capsulorhexis size, insufficient removal of viscoelastic material, Nd : YAG capsulotomy, axial myopia, long axial length, large capsular sac, loose capsule, postoperative itching, and IOP increase are the factors that may affect postoperative IOL rotation [8, 9].

▶ **Table 1** Preoperative and postoperative findings of patients.

Parameter	Group 1 (CTR after toric IOL) (n = 53)	Group 2 (CTR before toric IOL) (n = 55)	P value
Age (year)	54.36 ± 8.68 (40–83)	57.23 ± 8.08 (42–81)	0.723
Sex (male/famale ratio)	25/28 (47–53 %)	27/28 (49–51 %)	0.816
Preoperative spherical value (D)	− 1.17 ± 1.22 (− 6.00 to + 4.00)	− 1.21 ± 1.34 (− 6.50 to + 4.25)	0.656
Postoperative spherical value (D)	− 0.16 ± 0.19 (− 0.7 to + 0.75)	− 0.14 ± 0.17 (− 0.75 to + 0.75)	0.603
Preoperative corneal astigmatism (D)	− 3.25 ± 1.57 (− 6.00 to − 1.75)	− 3.50 ± 1.66 (− 6.00 to − 1.75)	0.891
Postoperative residual astigmatism (D)	− 0.29 ± 0.26 (− 0.50 to + 0.50)	− 0.43 ± 0.31 (− 0.75 to + 0.75)	0.162
Preoperative UCVA (logMAR)	0.91 ± 0.24 (0.60–1.00)	0.87 ± 0.21 (0.60–1.00)	0.442
Postoperative UCVA (logMAR)	0.02 ± 0.05 (− 0.10 to 0.10)	0.03 ± 0.06 (− 0.10 to 0.10)	0.397
Preoperative BCVA (logMAR)	0.71 ± 0.36 (0.30–0.90)	0.74 ± 0.34 (0.30–0.90)	0.323
Postoperative BCVA (logMAR)	0.01 ± 0.06 (− 0.10 to 0.10)	0.02 ± 0.06 (− 0.10 to 0.10)	0.285
IOL rotation (degree)	0.75 ± 2.66 (0–10)	2.90 ± 6.57 (0–30)	0.02

Abbreviations: D: diopter, logMAR: logarithm of the minimum angle of resolution, UCVA: uncorrected visual acuity, BCVA: best-corrected visual acuity, IOL: intraocular lens, CTR: capsular tension ring.

A 10-degree deviation will reduce the correctional effect by a third, while a 20-degree deviation will decrease it by two-thirds. The maximum acceptable axis shift is less than 30 degrees. If the rotation is 30 degrees or more, postoperative astigmatism increases, and photic phenomena may be seen. For a 1-degree rotation, the cylindrical power loss will be 3.3 % [4, 8, 13]. Bauer et al. [14] reported that the IOL rotation after the operation was 2.5 ± 2.1 degrees. Ferreria et al. [15] found the postoperative IOL rotation to be 3.15 ± 2.62 degrees. Grohlich et al. [16] observed that the postoperative rotation was 4.92 ± 4.10 degrees in the Tecnis group and 4.31 ± 4.59 degrees in the Acrysof group. However, a CTR was not used in these studies.

CTRs are made up of polymethylmethacrylate (PMMA). They make the capsular bag unwrapped and flat, enhance capsular bag symmetry, and control capsular contraction. They also reduce the gap between the optic of the IOL and posterior capsule and inhibit the migration and proliferation of the cells, thus improving the rotational stability of IOL [8 – 10]. The effect of a CTR on toric IOL rotational stability was first described by Wiley [17]. Zhao et al. [8] compared the impact of toric IOL implantation with and without a CTR in patients with axial myopic astigmatism who had undergone cataract surgery. They observed that the toric IOL was situated in the capsular bag in all the cases, but there were more cases with IOL rotation (12 eyes) in the standalone group than in the combined group (4 eyes). They concluded that in patients with axial myopic astigmatism, a CTR can effectively increase the rotational stability of a toric IOL, achieving improvement in corneal astigmatism and visual acuity.

Rastogi et al. [9] compared the rotational stability of a toric IOL implanted with a CTR to that of a toric IOL without a CTR. They observed that the mean degree of rotation at 3 months postoperatively was 1.85 ± 1.72 in group A and 4.02 ± 2.04 in group B. The difference was statistically significant. They concluded that the co-implantation of a CTR was a safe and effective technique for better rotational stability of toric IOLs. Miyoshi et al. [10] evaluated the effect of CTR on surgical outcomes of toric and multifocal IOLs in eyes with zonular instability. They found that in toric IOLs, the co-implantation of a CTR significantly decreased decentration and misalignment of the IOL axis, resulting in better UCVA and BCVA after surgery. They further concluded that a CTR decreased the tilt of multifocal IOL, achieving improvement of postoperative visual acuity in eyes with suspected zonular instability. Sagiv and Sachs [18] reported that two CTRs were required to fixate the toric IOL in the correct position in a 74-year-old patient with cataract and high myopia. Hahn et al. [19] evaluated the clinical outcome in cohorts with simultaneous implantation of a CTR and toric IOL versus without a CTR. They found that primary endpoint incidences for the total sample without and with CTR were 90, 92, and 88 %. The median absolute rotations were 1.73, 1.79, and 1.72 degrees; median absolute cylinder deviations were 0.55, 0.53; and 0.55 D; and median visual acuity was 1.0, 1.0, and 1.0, respectively. They concluded that no clinically relevant differences among CTR subgroups were found, and a satisfying 3-month rotational stability was achieved.

In all of the abovementioned studies that performed combined CTR implantation with a toric IOL, the CTR was implanted before the toric IOL. Conversely, in our technique, since the CTR is implanted into the capsular bag after the toric IOL, not only does the CTR stabilize the capsular bag, but it also compresses the IOL haptics from the top and increases the friction on the haptics, enhancing rotational stability. According to our results, the mean degree of rotation was 0.75 ± 2.66 degrees in group 1 and 2.90 ± 6.57 degrees in group 2. This statistically significant difference between the two groups indicated that implantation of the CTR after the toric IOL helped achieve much more toric IOL stabilization. We used a 13-mm haptic diameter IOL and a 13-mm closed diameter CTR for the different refractive eyes (− 6.5 D to + 4 D) in this study. Probably, in eyes with a short AL, CTR loops closed in

13 mm diameters and superposed to IOL haptics. This superposition provides better overpress of the toric IOL haptics and increases the friction between the capsular bag and the IOL haptics. Thus, the IOL achieved better stabilization in these eyes as we hypothesized and expected at the beginning of the study. But in the longer AL eyes, CTR loops may stay open and have diameters greater than 13 mm. Therefore, CTR and IOL haptics are not superposed because of the different diameters of CTR and IOL haptics. Thus, the IOL was not overpressed by CTR and the stabilizing effect of the CTR was not adequately exploited in eyes with a longer AL. On the other hand, Jiang et al. [20] implanted a four-eyelet CTR with two extra eyelets that adjusted in front of the toric IOL. They reported that two extra eyelets can compress the IOL on the posterior capsule and provide a greater contact area with the toric IOL, increasing friction and reducing the risk of rotation. However, the main limitation of this technique is that the four-eyelet CTR is not widely available in all clinics. After suturing the CTR to the toric IOL haptic, Ucar and Ozcimen [21] placed the toric IOL-CTR complex in the capsular bag and reported highly satisfactory postoperative visual outcomes. Although in their study, similar to our technique, the CTR applied top pressure to the toric IOL haptic, and they also took advantage of the rivet feature of the toric IOL-CTR complex. However, only CTR implantation without suture is a relatively easier technique than the CTR and toric IOL suturing technique described by Dr. Ucar [21].

Conclusion

This study had some limitations. Firstly, the study had a retrospective design, and the patient population was small. Secondly, a longer follow-up period is required, especially for the follow-up of complications that may cause late rotation of the toric IOL, such as capsular fibrosis, PCO (posterior capsule opacification), or late zonular damage. Another limitation was that no digital marker system was used. Nevertheless, to avoid bias, the intended axis of the IOL was double-checked with both the goniometer of the slit lamp and the Mendez ring. Despite all these limitations, the results of our study showed that the implantation of a CTR after the toric IOL provides further rotational stability and more effective astigmatic correction. However, further multicenter studies with larger patient participation should be planned for long-term and definitive results.

CONCLUSION BOX

Already known:

- Postoperative toric IOL rotation is the main factor responsible for nonoptimal visual outcomes after toric IOL implantation.
- To prevent the IOL axis rotation, the CTR can be implanted before the toric IOL, as it can provide stability and prevent rotation.
- However, implantation of the CTR before the toric IOL cannot eliminate the toric IOL rotation.

Newly described:

- The implantation of the CTR after the toric IOL provides further rotational stability. Furthermore, this method provides greater IOL stabilization than the conventional method (CTR implantation before the toric IOL), even in eyes with a long AL.
- In this method, the CTR overpresses the toric IOL haptics and increases the friction between the capsular bag and the IOL haptics, and it provides much more toric IOL stability.

Conflict of Interest

The authors declare that they have no conflict of interest.

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