Indications and clinical outcomes of capsular tension ring implantation in phacoemulsification surgery at a tertiary teaching hospital: A review of 4316 cataract surgeries

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Summary
Purpose. — To reveal the indications, clinical outcomes and complications of capsular tension ring (CTR) implantation in a series of consecutive phacoemulsification surgeries during a three-year interval.
Methods. — A review of all patients undergoing cataract surgery with insertion of a CTR between 2010 and 2013 was conducted at our tertiary teaching ophthalmology department. The demographic details of patients, indications and clinical outcomes of CTR implantation were evaluated.
Results. — Between 2010 and 2013, 4316 phacoemulsification surgeries were performed and of these surgeries CTR implantation was done in 41 eyes of 36 patients. The indications of CTR implantation were zonular dehiscence or weakness associated with mature cataract (29.2%), trauma (24.3%), pseudoexfoliation syndrome (19.5%), retinitis pigmentosa (14.6%), degenerative myopia (9.7%), and lens coloboma (2.4%). Posterior chamber intraocular lens (PCIOL) was
implanted into the capsular bag in all eyes. Dislocation of PCIOL was not observed in any case. Transient IOP increased in 5 eyes (12%) and corneal edema in 14 eyes were noted. Posterior capsular opacification in 1 eye (2.4%), anterior capsule phimosis in 1 eye (2.4%) and cystoid macular edema in 1 eye (2.4%) were detected as late complications.

Conclusion. — The frequency of CTR implantation was 0.97% due to our study. In complicated cataract surgeries, CTR implantation seems to improve clinical outcomes.

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**Introduction**

Capsular tension rings (CTR) are used for zonular reinforcement to stabilize the capsule in eyes with zonular weakness or dehiscence. Pseudoxefoliation syndrome, mature cataract, high myopia, post-traumatic cataract and intraoperative surgical trauma represent the majority of the indications. Other applications include capsule contraction syndrome and inhibition of posterior capsule opacification (PCO) [1,2]. Although, CTR insertion has been widely used in recent years; there is limited data defining the frequency and the profile of the patients requiring CTR during phacoemulsification surgery (Table 1).

The aim of this study was to evaluate the frequency, indications, and clinical outcome of CTR implantation in consecutive phacoemulsification surgeries performed during the years 2010 through 2013 in our tertiary teaching clinic.

**Materials and methods**

The records of cataract surgeries performed between the years 2010 and 2013 at Sakarya University Medical Education and Research Hospital Ophthalmology Department were reviewed retrospectively. Since the first documentation of CTR implantation, indications and clinical outcomes of subsequent cases were analyzed. Information on history and demographic details, preoperative visit data, surgical steps and postoperative management data of

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| Table 1 Preoperative characteristics and indications of CTR insertion. |
|--------------------------|------------------|
| **Mean age (years)**     | 64.13 ± 17.01    |
| **Sex, n (%)**           |                  |
| Male                     | 26 (72.2%)       |
| Female                   | 10 (27.8%)       |
| **Diagnosis, n (%)**     |                  |
| Mature cataract           | 12 (29.2%)       |
| Traumatic cataract        | 10 (24.3%)       |
| Pseudoxefoliation syndrome| 8 (19.5%)        |
| Retinitis pigmentosa     | 6 (14.6%)        |
| Lens coloboma            | 1 (2.4%)         |

CTR: capsular tension ring.
patients were obtained from case folders. Ophthalmological examinations were performed prior to surgery and at the follow-up visits. Examination included the assessment of best corrected visual acuity (BCVA), intraocular pressure (IOP) by applanation tonometry, and biomicroscopic evaluation of the anterior segment and fundus. B-scan ultrasound was performed for posterior segment evaluation if the fundus was not visible.

Prior to the operation, tropicamide 1% and phenylephrine hydrochloride 2.5% were instilled in patients’ eyes for pupil dilation. The procedures were performed under topical anesthesia achieved with proparacaine HCl 0.5%. Eyelids, eyelashes and conjunctiva were disinfected with povidone-iodine 5%. A clear corneal incision was created with a 2.8 mm slit knife. The anterior chamber was expanded with dispersive viscoelastics (Viscoat®, Alcon). If vitreous was present in the anterior chamber, the surgeon injected dispersive viscoelastic material at the start of surgery to displace any vitreous in the anterior chamber posteriorly toward the vitreous cavity or performed vitrectomy if required. Trypan blue was used to visualize the anterior capsule in surgeries on mature cataracts. Phacoemulsification was performed with the Infinity Vision System (Alcon, Inc., USA) or AMO Whitestar Signature Phaco System (Abbott Medical Optics, Santa Ana, CA, USA). When a posterior chamber tear was recognized, surgery was halted. To avoid collapse of the anterior chamber and enlargement of the tear, viscoelastic material was injected immediately to maintain anterior chamber depth and tamponade the vitreous through the posterior capsule defect before the phaco needle was removed. Anterior vitrectomy was performed when posterior capsule rupture occurred. The decision to insert the CTR (Morcher® Type 14C, 11–13 mm, PMMA) was made intraoperatively when zonular weakness or dialysis was detected. In all eyes, a CTR was successfully introduced into the capsular bag expanded with viscoelastic material with the help of a forceps and a second manipulating spatula to guide the device. Two types of one-piece hydrophobic acrylic posterior chamber intraocular lens (PCIOL) (Sensar, AMO® AAB00/Alcon® AcrySof SA60AT) were implanted into the capsular bag, placing the haptic in line with the area of zonular dehiscence in all surgeries. The procedure was concluded with intraocular cefuroxime axetil 1 mg/0.1 cc for endophthalmitis prophylaxis as recommended in the ESCRS study on prophylaxis of postoperative endophthalmitis [3].

Postoperatively all patients were treated with topical moxifloxacin 0.5% four times daily and dexamethasone 0.1% eye drops four to eight times daily according to the status of corneal edema. Antiglaucomatous drugs were also used when necessary.

Results

During the period of review of years 2010 through 2013, 4316 cataract surgeries were performed in our clinic. A CTR was implanted in 41 eyes of 36 cases (0.94%). The mean age of 10 female and 26 male patients was 64.13 ± 17.01 years, range 16 to 90 years.

The indications for CTR implantation were zonular dehiscence or weakness associated with mature cataract in 12 eyes (29.2%), trauma in 10 eyes (24.3%), pseudoxefoliation syndrome in 8 eyes (19.5%), retinitis pigmentosa in 6 eyes (14.6%), degenerative myopia in 4 eyes (9.7%), and lens coloboma 1 eye (2.4%). Vitreous was observed in the anterior chamber preoperatively in 3 eyes with traumatic cataracts. At the start of surgery, dispersive viscoelastic material was injected into the anterior chamber to displace the vitreous in 2 eyes, and vitrectomy was performed in 1 eye. In 2 eyes, posterior capsule rupture also occurred and anterior vitrectomy was performed. These capsular tears did not enlarge during surgery and PCIOLs were successfully implanted into the capsular bag in all eyes. Dislocation or decentralization of the PCIOL was not observed in any case.

The mean preoperative LogMAR best corrected visual acuity (BCVA) was 0.96 ± 0.41, and mean postoperative LogMAR BCVA was 0.25 ± 0.24. BCVA was improved in all eyes after surgery. The mean preoperative IOP was 14.7 ± 1.89 mmHg, and the mean postoperative IOP was 16.5 ± 4.89 mmHg at the first week after surgery. In five eyes (12%), a temporary IOP increase was observed and controlled by topical antiglaucomatous agents. In 14 eyes (34.1%), advanced corneal edema was seen the first day after surgery, and all resolved at the first month of follow-up. PCO in 1 eye (2.4%), anterior capsule phimosis in 1 eye (2.4%) and cystoid macular edema in 1 eye (2.4%) were noted as late complications. Retinitis pigmentosa disease was a common factor for these three cases.

Discussion

The present study aimed to assess the frequency, indications, and clinical outcomes of CTR implantation in a large consecutive series of phacoemulsification surgeries. In our study, 0.94% of cataract surgeries required the implantation of a CTR over a three year period. Although severe and complicated forms of cataracts are frequent in our tertiary teaching clinic, this low frequency of CTR insertion may be related to surgeon experience, since complicated cases and severe forms of cataracts are performed by experienced surgeons in our clinic. Also as a rule in our department, where a training surgeon is the primary surgeon, an experienced surgeon is either present at the surgery or easily accessible for advice and management. A similar retrospective study, designed by Tribus et al., involving 69 eyes of 67 patients over a five year period, found that 0.7% of 9528 cataract surgeries required CTR insertion [2]. Wang et al. reported that 87 eyes needed CTR implantation over a large series of over 6000 cataract surgeries [4]. The rates of requirement of CTR insertion in these studies were similar to our results.

The CTR, an open-ended, flexible, horseshoe-shaped polymethylmethacrylate filament with 2 eyelets at each end, was introduced by Hara et al. in 1991 [5]. Over the years, Nagamoto, Witschel, Henderson, Cionni, and Ahmed have contributed with helpful modifications [6,7]. CTRs may be used in many conditions involving zonular dehiscence, such as pseudoxefoliation, trauma, mature cataracts and high myopia. They may also be useful in disorders that weaken the ciliary zonules, such as Marfan syndrome, Marcehsani syndrome, scleroderma, homocysteinuria, spherophakia, and hyperlysineemia [7].
The zonular weakness and dehiscence were caused by various conditions including mature cataract (29.2%), traumatic cataract (24.3%), pseudoexfoliation syndrome (19.5%), retinitis pigmentosa (14.6%), high myopia (9.7%), and lens coloboma (2.4%) in our study. The indications for CTR implantation in our study were similar to other reports. Mature and traumatic cataracts and pseudoexfoliation syndrome are mostly reported as the indication for CTR implantation [4,8,9]. Despite other reports, Tribus et al. found only a 6% frequency of pseudoexfoliation syndrome in their study [2]. The indications for CTR implantation in lens coloboma, degenerative myopia and retinitis pigmentosa were reported rarely in previous reports.

Preoperative examination plays a key role in improving the success rate of CTR implantation. Patients should be examined carefully for phacodonesis, vitreous in the anterior chamber, pseudoexfoliation and other causes of zonular dehiscence. Maintaining anterior chamber depth and avoiding capsular bag collapse during surgery are critical for a successful CTR implantation after lens extraction. Constant, stable anterior chamber depth prevents the posterior capsule from moving forward, which increases stress on the zonules and is effective in maintaining mydriasis during the procedure. Hydrodissection should be performed gently to free the lens nucleus. To ensure less traction on the capsular bag when the phacemulsification progressed, adequate hydrodissection is necessary. The hydrodissection cannula should be inserted in the direction of the zone of disinsertion. A modified stop-and-chop, chop in situ, and lateral separation technique is recommended in emulsification. With these approaches, CTR implantation after lens extraction can be achieved successfully with low complication rates.

We performed slow-motion phacoemulsification at a low rate with a low vacuum and low infusion-bottle height. A modified stop-and-chop, chop in situ, and lateral separation technique allowed us to divide the nucleus with minimal stress on the capsular bag and produce multiple small nucleus fragments, which are easy to remove in the central space. To prevent collapse, we injected high-viscosity viscoelastic material to fill the anterior chamber and bag through the side-port incision before removing the phaco needle. This technique also is useful in cases of posterior capsule rupture in preventing enlargement of the rupture during a cataract procedure. Posterior capsule rupture occurred in 2 eyes in this study but these capsular tears did not enlarge during surgery and PCIOls were successfully implanted into the capsular bag in all eyes.

It is a well-known data that the use of CTRs increases the rate of PCIOl implantation which is usually associated with better visual outcomes [10]. CTR also decreases the risk of capsular rupture, vitreous prolapse and IOL dislocation during phacoemulsification surgery when there is zonular insufficiency [11]. PCIOl implantation into the capsular bag was performed successfully in all cases (100%) in our study. Tribus et al. and Wang et al. reported this finding as 91% and 86% respectively [2,4]. Acar and Acar reported 86.5% frequency of implantation of PCIOl in the bag at patients with pseudoexfoliation syndrome [12]. Bardak et al. reported a frequency of 27% in the bag PCIOl implantation in traumatic cataract group [13]. The reason of this wide range seems to be the different causes and severity of zonular weakness and dehiscence and additional ocular problems.

In our study, the use of CTRs in phacoemulsification surgery revealed visual improvement in all eyes. In comparison, Wang et al. reported that they achieved a rate of 92.9% of eyes having the same or better postoperative visual acuity compared with preoperative visual acuity. And also, European Cataract Outcome Study notified that 89% of eyes achieved a visual acuity of 20/40 or better [14], and the American Society of Cataract and Refractive Surgery National Cataract Database quoted that overall 85.5% of eyes achieved a visual acuity of 20/40 or better [15]. Obviously, functional outcomes may differ from each other because of the heterogeneous group of patients and comorbidity of additional pathologies such as macular degeneration, amblyopia and diabetic retinopathy.

CTR implantation may facilitate cataract surgery in coloboma of the lens [16,17]. Gurler et al. reported 18 eyes of 15 patients with isolated lens coloboma who underwent cataract surgery with implantation of CTR. Significant visual improvement had been achieved by this method [18]. In our study, one eye with lens coloboma underwent phacoemulsification surgery with CTR insertion, and visual acuity improved from 0.1 to 0.8 by the first month after surgery.

CTR is a useful device in eyes with traumatic cataract and helps to improve visual acuity [19,20]. In our study, 10 eyes were diagnosed with traumatic cataract with zonular dehiscence. Posterior capsule tear occurred in only one eye, and a PCIOl could be placed in the bag in all eyes. Georgopoulos et al. reported high success rates of PCIOl implantation even in eyes with traumatic cataract and large zonular dialysis with the help of a CTR [21].

The development of cataract is a well-known complication observed in eyes with retinitis pigmentosa [22]. In a study evaluating long-term clinical outcomes after cataract surgery with and without CTR in eyes with retinitis pigmentosa, it was reported that the most common complication was PCO, occurring in 44% of eyes, followed by increased IOP (10%) and capsular contraction syndrome (4%). And also, it was emphasized that surgery with CTR resulted in fewer long-term postoperative complications such as PCO and capsular phimosis [23] (Table 2). Interestingly, complications of PCO, capsular phimosis and cystoid macular edema were all seen in eyes with retinitis pigmentosa in our study.

In conclusion, our study revealed that 0.94% of 4316 phacoemulsification surgeries required the implantation of a CTR over a three year period. The indications for CTR

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<tr>
<th>Table 2 Postoperative complications of study participants.</th>
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<td>Complications</td>
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<td>-----------------------------------------------</td>
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<tr>
<td>Corneal edema</td>
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<tr>
<td>Raised IOP</td>
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<td>PCO</td>
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<tr>
<td>CME</td>
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<td>Anterior capsule phimozis</td>
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IOP: intraocular pressure; PCO: posterior capsule opacification; CME: cystoid macular edema.
implantation were mature cataract, traumatic cataract, pseudoxfoliation syndrome, retinitis pigmentosa, high myopia, and lens coloboma. CTR implantation is a useful technique and seems to improve clinical outcomes in complicated cataract surgeries.

Disclosure of interest

The authors declare that they have no competing interest.

References