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ORIGINAL RESEARCH

A retrospective study of the indications and outcomes of capsular tension ring insertion during cataract surgery at a tertiary teaching hospital

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Background: The purpose was to determine preoperative indications, intraoperative procedures, and outcomes of capsular tension ring (CTR) insertion during cataract surgery.

Methods: A review of all patients undergoing cataract surgery with insertion of a CTR between July 2000 and June 2010 was conducted at The Royal Victorian Eye and Ear Hospital, a large tertiary teaching hospital in Victoria, Australia. Information relating to each patient's demographic details, preoperative assessment, surgical procedure, and postoperative assessment were obtained.

Results: Eighty-four eyes of 82 patients were included in this study. The main indications for CTR insertion were previous trauma, pseudoexfoliation syndrome, and mature cataracts. Twenty-one eyes (25.0%) did not have any obvious preoperative indication. A posterior capsule tear was the most common intraoperative complication (3.6%). An intraocular lens was successfully implanted in the bag in 72 eyes (85.7%). Postoperatively, the most common complications were a decentered intraocular lens (8.3%) and persistent corneal edema (6.0%). Overall, 61 eyes (72.6%) had better postoperative visual acuity compared with preoperative acuity, with 67 patients (79.8%) achieving vision of 20/40 or better.

Conclusion: For the majority of cases, CTR use in complex cataract surgeries is associated with improved postoperative outcomes. CTR implantation is most commonly required in patients with known risk factors for zonular instability.

Keywords: capsular tension ring, cataract extraction, indications, outcomes

Introduction

A capsular tension ring (CTR) is designed to stretch the lens capsule and thereby maintain the circular contour of the capsular bag after cataract removal.[1] Given their ability to stabilize the capsule, CTRs are most commonly used in eyes with suspected or actual zonular weakness or dialysis, including eyes with pseudoexfoliation syndrome,[2] high myopia,[3] mature cataracts,[4] and lens subluxation.[3] Anterior or posterior capsular tears are relative contraindications to CTR implantation.[4]

CTR implantation is becoming increasingly common in cataract surgery. There are numerous CTR designs[4] and methods for their insertion.[5] Despite this, there is limited evidence detailing the profile of patients requiring CTRs during cataract surgery and the outcomes of cataract surgery where CTRs are used.

The aim of this study was to investigate the use of CTRs in cataract surgery and more specifically, to determine the preoperative indications, intraoperative procedures, and

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outcomes of CTR insertion during cataract surgery over the past 10 years at a tertiary teaching hospital in Australia.

Materials and methods

This retrospective study was conducted at The Royal Victorian Eye and Ear Hospital in Victoria, Australia. The case notes of all patients who underwent cataract surgery with the insertion of a CTR from July 2000 to June 2010 were reviewed. Patients were identified for review through medical coding, using the terms "cataract extraction" and "capsular tension ring." Patients whose cases notes were unable to be located after a minimum of three attempts, or for whom cataract extraction was not the primary reason for surgery, were excluded from this study.

Information pertaining to each patient's demographic details, preoperative assessment, surgical procedure, and postoperative management (up to 3 months postoperatively) were obtained from the case notes. As there are no standardized guidelines for CTR insertion in cataract surgery, the ocular assessment, including the extent of zonulysis and the appropriateness of CTR insertion, were not evaluated in this study. The decision to insert a CTR was determined by each individual surgeon. The surgical characteristics of training surgeons were compared with senior surgeons, and comparisons of planned versus unplanned CTR insertions were also made.

We reviewed all known preoperative risk factors for zonular weakness or dialysis, as documented in the case notes. These included mature cataract (grade 4 nuclear sclerosis cataract or dense brunescent cataract), trauma, pseudoexfoliation syndrome, high myopia (spherical equivalent greater than or equal to –6.00 diopters), previous vitrectomy, and genetic disorders.

The patient database was de-identified, and each patient allocated a number that was subsequently used during data analysis. Results were analyzed using SPSS statistical software (Version 18.0, IBM, Armonk, NY, USA).

This study complied with the Declaration of Helsinki.

Results

Over 6000 cataract extractions take place at The Royal Victorian Eye and Ear Hospital each year. In the study period, 87 eyes had the insertion of a CTR during cataract extraction. The case notes for three eyes were unable to be located and were excluded from this study. Therefore, 84 eyes of 82 patients were included in this study.

Of the 84 eyes used in this study, 35 were male eyes and 49 were female eyes. The mean age of study participants was 66.2 ± 17.9 years and ranged from 10 to 90 years.

Preoperative assessment

Preoperative visual acuities ranged from 20/20 to "hand movements," with a mean visual acuity of 20/60. Thirty-one eyes (36.9%) had a preoperative visual acuity of 20/40 or better. Sixty-three eyes (75.0%) had an identifiable preoperative indication for CTR insertion, most commonly mature cataract (29.8%), trauma (19.0%), and pseudoexfoliation syndrome (19.0%). Eleven eyes (13.1%) had two identifiable indications. Six eyes (7.1%) had phacodonesis in the absence of pseudoexfoliation or known history of trauma (Table 1).

Surgical procedure

Eighty-two cataract extractions (97.6%) performed during the study period were elective procedures and two cataract extractions (2.4%) were emergency procedures. The two emergency procedures were both associated with phacomorphic glaucoma. The cataract extractions involved 66 different surgeons as the principal surgeon.

The characteristics of the surgical procedures are outlined in Table 2. Sixty-one eyes (72.6%) had phacoemulsification alone, while 23 eyes (27.4%) had one or more additional procedures performed in addition to the phacoemulsification. This included anterior vitrectomy in 25.0% of eyes and conversion to an extracapsular cataract operation in 8.3% of eyes. Twenty-six eyes (31.0%) had an Alcon ReFORM® Capsular Tension Ring (Alcon Laboratories Inc, Fort Worth, TX, USA) inserted. This was the most frequently used CTR in this study. The expanded size of CTRs ranged from 10 mm to 14 mm, with a median of 12.0 mm. No sutured CTRs were implanted. The technique for CTR insertion, whether injected or manually inserted, and the stage of surgery when the CTR was inserted was not recorded for most procedures. An intraocular lens (IOL) was successfully implanted into the capsular bag in 72 eyes (85.7%), whereas six eyes (7.1%) required a sulcus IOL. An anterior chamber

Table 1 Identifiable preoperative indications for capsular tension ring insertion (please note that some patients had more than one risk factor)

Risk factors	Participant eyes
None	21 (25.0%)
Mature cataract	25 (29.8%)
Trauma	16 (19.0%)
Pseudoexfoliation	16 (19.0%)
High myopia	7 (8.3%)
Phacodonesis	6 (7.1%)
Previous vitrectomy	2 (2.4%)
Weill–Marchesani syndrome	2 (2.4%)

Table 2 Characteristics of the surgical procedure of study participants

	Participant eyes
Surgical procedure	
Phacoemulsification only	61 (72.6%)
Phacoemulsification and anterior vitrectomy (unplanned)	21 (25.0%)
Phacoemulsification and conversion to extracapsular cataract extraction (unplanned)	7 (8.3%)
Phacoemulsification and iridoplasty (planned)	3 (3.6%)
Phacoemulsification and insertion of iris prosthesis (planned)	1 (1.2%)
Phacoemulsification and bleb needling (planned)	1 (1.2%)
Type of CTR inserted	
Alcon Laboratories ReFORM® Capsular Tension Rings (Fort Worth, TX, USA)	26 (31.0%)
Abbott Medical Optics, Inc, StabilEyes™ Capsular Tension Rings (Abbott Park, IL, USA)	23 (27.4%)
Carl Zeiss Meditec. Tensiobag® Capsular Tension Rings (Jena, Germany)	9 (10.7%)
Morcher GmBH Morcher® Capsular Tension Rings (Stuttgart, Germany)	14 (16.7%)
Type of IOL inserted	
Single-piece IOL	57 (67.9%)
Three-piece IOL	24 (28.6%)
Intraocular lens placement	
Posterior chamber IOL in bag	72 (85.7%)
Posterior chamber IOL in sulcus	6 (7.1%)
Anterior chamber IOL	6 (7.1%)
Intraoperative complications	
None	78 (92.9%)
Posterior capsule tear	3 (3.6%)
CTR explanted	2 (2.4%)
Iridodialysis	1 (1.2%)

Abbreviations: CTR, capsular tension ring; IOL, intraocular lens.

IOL was used in six eyes (7.1%) despite prior insertion of a CTR. Posterior capsular tear was the most common intraoperative complication and occurred in three eyes (3.6%).

Postoperative management

In 17 eyes (20.7%), postoperative complications were reported. The postoperative complications included a decentered IOL in seven eyes (8.3%), persistent corneal edema in five eyes (6.0%), raised intraocular pressure in three eyes (3.6%), and vitreous prolapse in two eyes (2.4%). Fourteen eyes (16.7%) required one or more additional postoperative procedures, including yttrium aluminum garnet (YAG) capsulotomy in nine eyes (10.7%), anterior vitrectomy in four eyes (4.8%), and removal of the CTR in two eyes (2.4%). One eye (1.2%) required repositioning of the CTR, while another eye (1.2%) required intraocular lens exchange. The details of the postoperative complications and secondary postoperative procedures are listed in Table 3.

At 3 months postoperatively, patients visual acuity ranged from 20/15 to "hand movements," with a mean visual acuity of 20/30. Sixty-seven eyes (79.8%) achieved a visual acuity of 20/40 or better. Compared with preoperative visual acuity, 61 eyes (72.6%) had better postoperative visual acuity, 17 eyes (20.2%) had the same postoperative visual acuity, and six eyes (7.1%) had worse postoperative visual acuity.

The type of CTR and IOL inserted did not produce a significant difference in outcome. Eyes with an anterior chamber IOL and those with a posterior chamber IOL in the sulcus also had similar visual outcomes, with 66.6% achieving better postoperative visual acuity, 16.7% maintaining the same postoperative visual acuity, and 16.7% progressing to worse postoperative visual acuity. In eyes with an IOL in the bag, 73.6% had better postoperative visual acuity, 20.8% had same postoperative visual acuity, and 5.6% had worse postoperative visual acuity. There was no significant difference in postoperative complications and secondary postoperative procedures regardless of the IOL position.

Training surgeon versus senior surgeon

Forty-two cataract extractions (50.0%) involved a training surgeon as the principal surgeon, with the remainder performed by a senior surgeon. The intraoperative procedures and outcomes of cataract surgery for training surgeons and senior

Table 3 Postoperative complications and secondary postoperative procedures of study participants

	Participant eyes
Postoperative complication	
None	67 (79.8%)
Decentered intraocular lens	7 (8.3%)
Corneal edema	5 (6.0%)
Raised intraocular pressure	3 (3.6%)
Vitreous prolapse	2 (2.4%)
Suture abscess	1 (1.2%)
Retinal detachment	1 (1.2%)
Decompensated phoria	1 (1.2%)
Secondary postoperative procedures	
None	70 (83.3%)
YAG capsulotomy	9 (10.7%)
Anterior vitrectomy	4 (4.8%)
Removal of capsular tension ring	2 (2.4%)
Repositioning of capsular tension ring	1 (1.2%)
Intraocular lens exchange	1 (1.2%)
Squint surgery	1 (1.2%)
Retinal detachment repair	1 (1.2%)
Trabeculectomy	1 (1.2%)

Abbreviation: YAG, yttrium aluminum garnet.

surgeons are outlined in Table 4. There was no statistically significant difference between the two groups of surgeons ($P > 0.05$).

Planned versus unplanned CTR insertion

Of the 84 CTRs inserted in this study, 28 (33.3%) were planned, 49 (58.3%) were unplanned, and in eight (9.5%), the reasons for insertion were unspecified. All eyes that had planned CTR insertion and 61.2% that had unplanned CTR insertion had known risk factors for zonular weakness. The mean preoperative visual acuity for participants who had planned and unplanned CTR insertion were 20/120 and 20/60, respectively. Both groups had a mean postoperative visual acuity of 20/30. The intraoperative procedures and outcomes of cataract surgery for planned and unplanned CTR insertion are outlined in Table 5.

Discussion

Our study highlights that in the majority of cases, CTR use occurs in patients with known risk factors for zonular instability, most commonly, mature cataract, traumatic cataract, and pseudoexfoliation syndrome. In cataract surgery involving the use of a CTR, a posterior chamber IOL was successfully implanted in 92.9% of cases in this study, with the majority being inserted into the capsular bag. It has been well documented that CTRs increase the likelihood of IOL implantation into the capsular bag,[6] which is often associated with the best visual outcomes[4] and confirmed in our study. CTRs also minimize the risks of vitreous prolapse, capsular rupture, and IOL dislocation in cataract surgeries where there is zonular instability.[4]

The use of CTRs was associated with an improved postoperative visual acuity for the majority of cases within this study; with 79.8% of eyes achieving a visual acuity of 20/40 or better and 92.9% of eyes having the same or better postoperative visual acuity compared with preoperative visual acuity. In comparison, the American Society of Cataract and Refractive Surgery National Cataract Database noted that overall 85.5% of eyes achieved a visual acuity of 20/40 or better,[7] and the European Cataract Outcome Study found similar results, with 89% of eyes achieving a postoperative visual acuity of 20/40 or better.[8] An explanation for this discrepancy is that 75% of eyes in this study had preoperative ocular comorbid conditions, and in the eyes that did not have an obvious comorbid condition, surgery was complicated by zonular dehiscence either due to previously undetected dehiscence or the result of surgical trauma. Indeed, patients with ocular comorbidities have poorer visual outcomes and are more likely to be dissatisfied with the results of cataract surgery.[9]

In this study, phacoemulsification was the initial surgical technique for cataract extraction in all eyes, although 8.3% of eyes subsequently required an unplanned conversion to extracapsular cataract extraction. Interestingly, the rate of anterior vitrectomy was 25.0% in this study. One likely reason for this was that iris or capsular bag hooks were not used to support the lens capsule during phacoemulsification. The lack of iris or capsular bag hook use may have also contributed to the posterior capsular rupture that occurred in 3.6% of eyes in this study. As mentioned previously, posterior capsular rupture is often considered a relative contraindication for CTR insertion; however, all eyes that had posterior capsular rupture in this study were successfully implanted with a posterior chamber IOL in the sulcus.

We also noted that 10.7% of eyes had posterior capsular opacification (PCO) requiring YAG capsulotomy. Although CTRs have been shown to decrease the incidence of PCO following cataract surgery,[10] PCO requiring YAG capsulotomy is not uncommon[10,11] and may be associated with difficulty completely clearing the cortex due to the presence of the CTR. Only two eyes (2.4%) required explantation of the CTR. The reasons for explantation were a subluxated posterior chamber

Table 4 Intraoperative procedures and outcomes of cataract surgery for training surgeons and senior surgeons

	Training surgeon	Senior surgeon
Visual acuity		
Preoperative – mean	20/60	20/60
Postoperative – mean	20/30	20/30
IOL placement		
Posterior chamber IOL in bag	37 (88.1%)	35 (83.3%)
Posterior chamber IOL in sulcus	4 (9.5%)	2 (4.8%)
Anterior chamber IOL	1 (2.4%)	5 (11.9%)

Abbreviation: IOL, intraocular lens.

Table 5 Intraoperative procedures and outcomes of cataract surgery for planned capsular tension ring insertion and unplanned capsular tension ring insertion

	Planned CTR insertion	Unplanned CTR insertion
Visual acuity		
Preoperative – mean	20/120	20/60
Postoperative – mean	20/30	20/30
IOL placement		
Posterior chamber IOL in bag	25 (89.3%)	41 (83.7%)
Posterior chamber IOL in sulcus	1 (3.6%)	4 (8.2%)
Anterior chamber IOL	2 (7.1%)	4 (8.2%)

Abbreviations: CTR, capsular tension ring; IOL, intraocular lens.

IOL that required an anterior chamber IOL and a CTR that subluxated into the anterior chamber.

Our study also highlighted that there was no statistically significant difference between the intraoperative and postoperative outcomes of CTR insertion during cataract surgery carried out by training surgeons compared with more senior surgeons. In all surgeries where a training surgeon was the principal surgeon, a senior surgeon was either present at the surgery or easily accessible for advice and guidance. This, coupled with the likelihood that senior surgeons are more likely to be the principal surgeon in complex surgeries, may explain why there were similar outcomes between the two groups. As previous studies have demonstrated lower rates of success in training surgeons compared with senior surgeons, an alternative explanation is that given the infrequency of CTR insertion, even senior surgeons may be inexperienced in CTR insertion.[7]

There were differences between participants who had planned CTR insertions and unplanned CTR insertions during cataract surgery. Significantly, 61.2% of unplanned CTR insertions actually had risk factors for zonular weakness. As expected, those with planned CTR insertions tended to have worse preoperative visual acuities and were possibly associated with more complex surgeries. Both groups had the same mean postoperative visual acuity, and the planned CTR insertion group had a higher percentage of posterior chamber IOL insertions, with a higher percentage of those inserted into the capsular bag. This suggests that compared with unplanned CTR insertion in cataract surgery, planned CTR insertion in cataract surgery results in better visual outcomes.

The results obtained from this study may have been confounded by several issues. The study was a retrospective rather than prospective study. Multiple CTR manufacturers were used, although we noted no significant difference in outcome between the different manufacturers, thus suggesting that the results of CTR insertion are likely to be due to other factors. There was also the possibility of selection bias, with some surgeons being more likely to insert CTRs during cataract surgery; nevertheless, this is unlikely, given that the 84 cataract extractions involved 66 different principal surgeons and no surgeon was involved in more than four surgeries involving a CTR insertion, during the study period. Unfortunately, planning CTR insertion in cataract surgery is difficult, as there are currently no standardized criteria for the implantation of a CTR. This is reflected in our results, where all CTR insertions were performed at the discretion of the individual surgeon either preoperatively or intraoperatively. Given this, we propose that patients should be carefully assessed preoperatively, in a standardized manner, for risk factors for zonular weakness or dialysis, in order to determine the likelihood of the requirement of a CTR insertion intraoperatively. It would then be worthwhile to prospectively collect results on intraoperative and postoperative outcomes and provide a comprehensive evaluation of the outcomes of these cases.

A similar retrospective study by Tribus et al[3] involving 69 eyes of 67 patients over a five year period, found that only 0.7% of cataract extractions required the implantation of a CTR. The indications for CTR insertion were very similar to our study, including mature cataract (58%), traumatic cataract (33%), pseudoexfoliation syndrome (6%), and subluxed crystalline lenses associated with Marfan syndrome (3%). Similar to our study, Tribus et al showed that the use of a CTR resulted in good surgical outcomes, with a posterior chamber IOL successfully implanted in 97% of cases. However, unlike this previous study, we have investigated a more extensive series of CTR implants over a longer time period, examined the visual and anatomical outcomes of surgeries involving CTRs, and compared the results of training surgeons with senior surgeons as well as planned CTR insertion with unplanned CTR insertion.

In conclusion, our retrospective study demonstrates that in the majority of cases, the use of CTRs in complex cataract surgeries may be associated with improved postoperative visual outcomes whether planned or unplanned and irrespective of the surgeon's experience. CTR implantation is most commonly indicated in patients with known risk factors for zonular instability and particularly in mature cataracts, traumatic cataracts, and pseudoexfoliation syndrome. Careful identification of risk factors preoperatively has significant implications, as it allows for the planning of a CTR in the operating theatre; ultimately resulting in better surgical and visual outcomes for the patient.

Disclosure

The authors declare that they have no conflicts of interest in this work.

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