Int J Clin Exp Pathol 2014;7(7):3733-3738
www.ijcep.com /ISSN:1936-2625/IJCEP0000754

Original Article

Capsular tension ring implantation after lens extraction for management of subluxated cataracts

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Received May 10, 2014; Accepted June 25, 2014; Epub June 15, 2014; Published July 1, 2014

Abstract: Purpose: To evaluate the safety and efficacy of implantation of a capsular tension ring (CTR) and posterior chamber intraocular lens (PCIOL) after lens extraction in subluxated cataracts. Setting: Department of Ophthalmology, General Hospital of PLA, Beijing, China. Design: Prospective case series. Methods: We selected 36 eyes in 34 patients with zonular dialysis <150°. After emulsification and removal of the residual cortex, we inserted a CTR into the capsular bag to center the PCIOL. We measured preoperative and postoperative best corrected visual acuity (BCVA), centration of the CTR and IOL, and perioperative complications. Results: No capsule collapse or fluctuation of the anterior chamber occurred. Most eyes (63.89%) had nuclear sclerosis of ≥3+. A CTR was implanted into the capsular bag without extension of zonular dialysis. A traumatic subluxated cataract was the most common cause (20 of 36 [55.56%]). We found a subluxated cataract in 3 eyes (3 of 36 [8.33%]) with previous acute angle-closure glaucoma. Mean follow up was 20.3±2.4 months. Preoperatively, only 5 eyes (13.89%) had a BCVA of ≥20/40, compared with 30 eyes at the last visit (83.33%, *P*<.001). Improved BCVA was achieved in 33 eyes (91.7%) in week 1, and visual acuity remained stable up to 1 year. The CTRs with PCIOL were well centered at 1 year. Conclusion: In patients with a subluxated hard cataract <120°, CTR implantation should be performed after lens extraction without extension of zonular dialysis and capsular destabilization. Maintaining anterior chamber depth and avoiding capsular bag collapse are critical.

Keywords: Cataract, cataract extraction, lenses, intraocular, ophthalmology

Introduction

Subluxation of the lens and zonular weakness can be caused by conditions such as pseudoexfoliation, trauma, Marfan syndrome and high myopia [1]. Surgical treatment of the subluxated lens still presents many challenges. Now, with wide use of the capsular tension ring (CTR), such surgery is relatively safe. The CTR, an open-ended, flexible, horseshoe-shaped polymethyl methacrylate filament with 2 eyelets at each end, was introduced by Hara et al in 1991 [2]. Once inserted into the capsular bag equator, the CTR supports the area of zonular dialysis and distributes the forces equally over all zonules, stabilizing the capsular bag and intraocular lens (IOL) during and after cataract surgery [3, 4].

The CTR can be inserted any time after creation of the capsulorrhexis and hydrodissection. However, the optimal timing of CTR implantation remains controversial. Many surgeons believe that CTR should be implanted early to center and stabilize the capsular bag and prevent vitreous herniation into the anterior chamber during the most critical times of surgery [3-6]. Ahmed et al, using Miyake-Apple video analysis, found that early CTR implantation significantly increased capsular torque and displacement [7]. Also, it is difficult and tedious to completely remove remaining nuclear and cortex trapped between the ring and the periphery of the capsule [4, 7]. Furthermore, if a complete zonular dehiscence or posterior capsule rupture occurs during cataract surgery, the already implanted CTR is at high risk for dislocation into the vitreous cavity [1]. In developing countries such as China, many patients present with advanced mature and hypermature cataracts. Insertion and rotation of a CTR in a capsular bag with such a dense cataract is challenging and may result in significant zonular stress and capsular bag displacement.

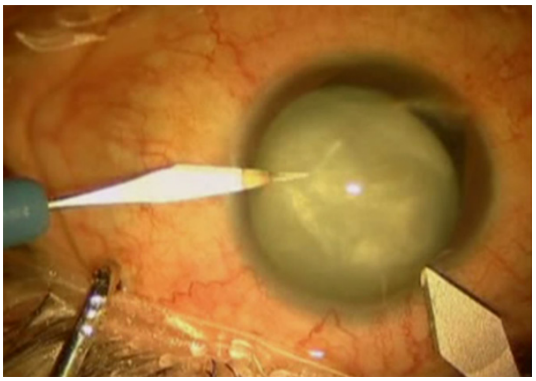

Figure 1. 1-mm auxiliary clear corneal incision prevents collapse of anterior chamber and vitreous prolapse from incision.

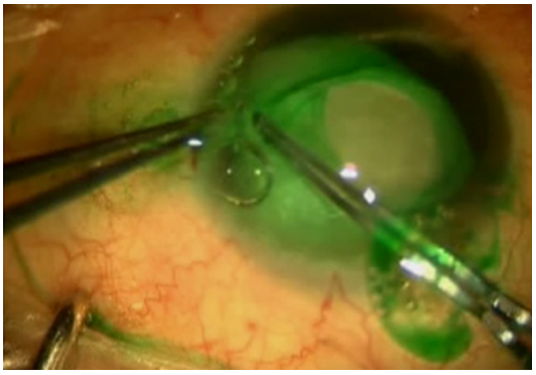

Figure 2. Creation of a continuous curvilinear capsulorrhexis with a forceps, starting away from the area of dialysis.

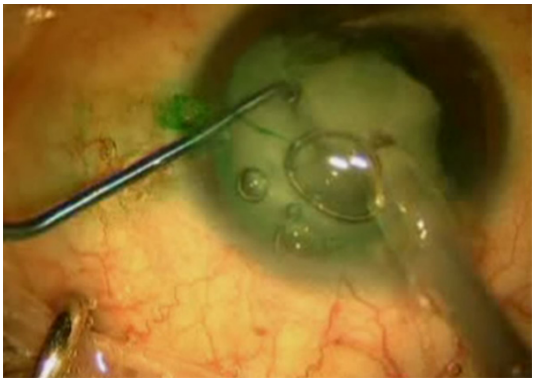

Figure 3. Emulsification of the nucleus using modified stop-chop-chop-and-stuff technique.

In this prospective study, we report the clinical features and postoperative outcomes of patients with a subluxated cataract who had phacoemulsification with CTR and posterior chamber IOL (PCIOL) implantation in the empty capsular bag after lens extraction.

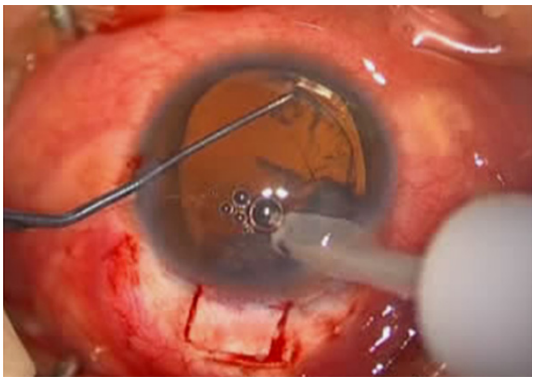

Figure 4. The chopper supports the capsular bag during aspiration at zone of disinsertion.

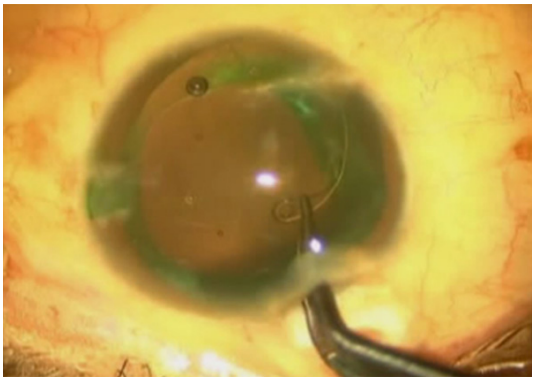

Figure 5. Insertion of capsular tension ring into the capsular bag with forceps.

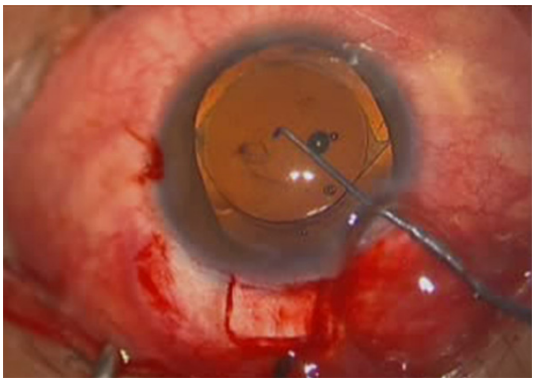

Figure 6. Implantation of foldable posterior chamber intraocular lens in the capsular bag.

Patients and methods

Eyes with zonular dialysis of less than about 150° were included. The study was performed from March 2005 to January 2009 in the Department of Ophthalmology of General Hospital of PLA. Eyes with dialysis >150° or

posterior capsular rupture and vitrectomized eyes were excluded. Patients with Marfan syndrome also were excluded.

We performed a complete ophthalmologic examination, including best corrected visual acuity (BCVA), slit lamp evaluation, applanation tonometry, gonioscopy with a dilated pupil, and fundus evaluation (when possible). A B-scan was performed when the fundus was not visible. Keratometry and IOL power were calculated using the SRK/T formula. BCVA was measured using Snellen charts.

Surgical technique

The same surgeon (DL) performed all surgeries using the same technique under local anesthesia in all eyes. Maximum mydriasis was achieved with a combination of tropicamide 1% and phenylephrine 5%, 1 drop 4 times 1 hour before surgery. A 1-mm auxiliary clear corneal incision was made (**Figure 1**) before viscoelastic material (Viscoat: Alcon Laboratories. Inc, Ft. Worth, TX, USA) was gently injected into the anterior chamber to displace the aqueous humor. Subsequently, the 3-mm corneal incision was made to maintain the anterior chamber depth because collapse of the anterior chamber may cause further vitreous prolapse and zonular stress. 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 posterior to the vitreous cavity or performed vitrectomy, if required.

A continuous curvilinear capsulorrhexis was created with a forceps, starting away from the area of dialysis (**Figure 2**). In traumatic cataracts, the anterior capsule is tough due to inflammation. A knife or 27-gauge needle is usually needed to puncture the anterior capsule at the beginning of continuous curvilinear capsulorrhexis. Hydromaneuvers were performed gently to free the lens nucleus. To ensure less traction on the capsular bag when the phacoemulsification progressed, adequate hydrodissection is necessary. The hydrodissection cannula should be inserted in the direction of the zone of disinsertion. Nuclear phacoemulsification was performed using a modified stop-chop-chop-and-stuff, chop in situ, and lateral separation technique for its safety and relatively low flow rate (**Figure 3**). The nuclei were divided into several free sections with the chopper before emulsification. All nuclear phacoemulsification was performed in the bag to avoid nuclear fragments dropping into the vitreous.

During automated aspiration, the cortex in the area where the zonules were whole and stable was removed first. During aspiration at the zone of disinsertion, the chopper was used to support the capsular bag placed in the direction of zonular dialysis (**Figure 4**). After removal of the residual cortex, viscoelastic material was injected into the anterior chamber and capsular bag (**Figure 5**). To avoid collapse of the anterior chamber, whenever the phaco needle was withdrawn from the eye, the viscoelastic material maintained the anterior chamber. A poly methyl methacrylate CTR was inserted into the capsular bag with forceps or an injector. The open ends of the ring faced away from the zonular dialysis, and no sutures were added. A foldable PCIOL was implanted into the capsular bag in all patients (**Figure 6**). Haptics were placed in the meridian of the zonular dialysis, and the viscoelastic material was removed. The incisions were irrigated and checked for stability. Postoperative topical dexamethasone and tobramycin were started and then tapered according to the amount of inflammation. Postoperative examinations were performed at 1 day, 1 week, 4 weeks, 1 year, and at the final visit. Outcome measures included BCVA, stability and centration of the capsular bag and IOL, and perioperative complications. Statistical analysis was performed using SPSS (version 14.0, SPSS, Inc.). Univariate analysis of categorical data was performed using the χ^2 test.

Results

Our study included 36 eyes of 34 patients with a mean age of 52.5 years ±21.3 (SD) (range, 12 to 82). Mean follow up was 20.3±2.4 months (range, 18 to 24). Two patients had bilateral surgery, and 32 ha unilateral surgery. Patients with bilateral zonular dialysis had pseudoexfoliation syndrome. Of those having unilateral surgery, most had a traumatic subluxated cataract (20 of 36 [55.56%]). Five of 32 (13.8%) had acute angle-closure glaucoma, 3 of 36 (8.33%) had high myopia, and 2 of 36 (5.56%) had a mature cataract. Most eyes (63.89%) had nuclear sclerosis ≥3+. Only 3 eyes (8.33%) did not have a cataractous lens. Eight eyes had anterior-segment abnormalities, including irido-

dialysis, sphincter rupture, and glaucoma. Fundus examination showed age-related macular degeneration in 1 eye and retinal lattice in 2 eyes with high myopia. Twelve eyes with traumatic cataract had vitreous in the anterior chamber preoperatively. Preoperative BCVA ranged from light perception to 20/40, with visual acuity in 13 eyes <20/200, 14 eyes 20/200 to 20/60, and 9 eyes >20/60. Preoperatively, the lens was decentered in 21 eyes and tilted in 10. Twenty-six eyes (80.56%) had 90° to 150° of dialysis, and 4 eyes (19.44%) had <90°.

Intraoperative results

Intraoperative extension of the dialysis did not occur in any eye with CTR implantation after lens extraction. The extent of zonular dialysis or weakness is often underestimated or undetectable preoperatively unless the patient is in supine position. Six eyes with zonule dialysis were identified intraoperatively. Of them, 2 had acute angle-closure glaucoma, 1 had trauma, 1 had a hypermature cataract, and 2 had pseudoexfoliation syndrome. Three eyes had 90° -150° of dialysis, and 3 had <90°. Vitreous was found in the anterior chamber preoperatively in 12 eyes (33.33%), and traumatic cataracts were found intraoperatively in 6 eyes (16.67%). Eight eyes (22.22%) required interior vitrectomy during surgery. A CTR was successfully inserted in all eyes after removal of the residual cortex, with no capsule collapse during surgery. No iatrogenic posterior capsule tear was found, and no eyes required additional surgery. The IOL was placed in the bag, and all eyes had well-centered PC IOL during surgery. No transscleral suture fixation of IOL was needed.

Postoperative results

Preoperatively, only 5 of the 36 eyes (13.89%) had a BCVA of ≥20/40, compared with 30 eyes at 1 week postoperatively (83.33%, $P<.001$). Improved BCVA was achieved in 33 eyes (91.7%) by 1 week, and visual acuity remained stable up to 1 year. BVCA did not improve in only 3 eyes. Two eyes had trauma from optic atrophy or a macular scar and 1 eye had age-related macular degeneration that resulted in a final BCVA <20/200. At 1 week, 30 eyes had a BCVA of ≥20/40. Visual acuity was ≥20/40 in 24 of 28 eyes at 6 months of follow up, in 17 of 20 eyes at 1 year of follow up, and in 13 of 16 eyes at 2 years of follow up. Two years post surgery, 1 eye with a traumatic subluxated cataract had another trauma, displacing the CTR–IOL–capsular bag complexes into the vitreous cavity. A 3-port pars plana vitrectomy and transscleral suture fixation of a PC IOL resulted in a final visual acuity of 20/60.

A dilated pupil examination at 6 months showed a well-centered IOL in all eyes. Five eyes had elevated intraocular pressure after surgery, 3 of them due to viscoelastic material leakage and 2 due to angle closure. All cases responded well to medical therapy, and intraocular pressure returned to normal during follow up without glaucoma surgery. No cases of retinal detachment or endophthalmitis occurred throughout follow up.

Discussion

In the past, surgical intervention in eyes with a subluxated lens was considered difficult and led to many complications. With wide use of the CTR, such surgery is now relatively safe. The CTR can be inserted at any stage of cataract surgery; however, the optimal timing remains controversial. To support the area of zonular weakness and distribute the forces equally over all zonules, the CTR is usually inserted before phacoemulsification [3-6].

While early CTR implantation can stabilize the capsular bag and intraocular lens during and after cataract surgery, weaknesses persist (i.e., difficulty removing cortical material and significant capsular torque) [7]. In our study, we inserted the CTR after lens extraction and had no cases of extension of dialysis during CTR implantation. Postoperative outcomes were positive. In developing countries such as China, many patients with a subluxated lens present with advanced mature and hypermature cataracts. It is difficult to insert a CTR before phacoemulsification in such dense cataracts, and further zonular dehiscence is found due to additional stress on the intact zonules when the CTR is rotated into the capsular bag [6]. The nucleus and cortex can also be completely removed without becoming trapped between the CTR and capsular bag. Thus, our findings agree with previous studies in cadaver eyes by Amed et al, which showed that CTR implantation should be performed after lens extraction [7].

Maintaining anterior chamber depth and avoiding capsular bag collapse are critical to 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. In our study, to minimize turbulence in the anterior chamber and prevent inadvertent vitreous prolapse, we made the side-port corneal incision first. Then we injected viscoelastic material into the anterior chamber to displace the aqueous humor before making a 3-mm corneal incision. We performed slow-motion phacoemulsification at a low rate with a low vacuum and low infusion-bottle height. Many surgeons fail to implant the CTR when the bag collapses completely after removal of the nucleus [6]. 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.

When a posterior chamber tear is recognized, surgery should be halted. However, the simultaneous removal of the phaco needle may collapse the anterior chamber and enlarge the tear. Thus, viscoelastic material should be injected immediately to maintain anterior chamber depth and tamponade the vitreous of the posterior capsule defect before the phaco needle is removed.

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 [8, 9]. We recommend using the stop-and-chop-and-stuff technique and the step-down technique [10] with multiple small fragments to maintain the flow and vacuum rates at safe levels, preventing inadvertent capsule contact and vitreous prolapse. When aspirating at the zone of zonular dialysis, the surgeon routinely places the chopper at the capsular bag of zonular dialysis to support it and prevent iatrogenic traction on the capsular bag. All emulsification was performed within the bag, although most patients had a hard nucleus. Our results were different from those of Jacob et al [5].

Subluxed lenses and zonular weakness can result from trauma, previous surgery, mature cataracts, high myopia, and pseudoexfoliation. In our study, subluxed lenses were also found in patients with previous acute angle-closure glaucoma. Traumatic zonular dialysis was seen most often in our study (68%), while other studies have found that pseudoexfoliation syndrome is the most common cause [1]. This may be because we prefer to insert a CTR in a traumatic cataract in which the remaining zonular fibers are usually stronger and healthier and it is easier to achieve recentration of the capsular bag and intraocular lens than in congenital or progressive zonular weakness such as Marfan syndrome or pseudoexfoliation. Our hospital also cares for more patients with trauma than others because the railway used to own it.

We decided to implant the CTR and assess the extent of zonular dialysis only intraoperatively. In many cases, the extent of zonular dialysis or weakness is underestimated or undetectable preoperatively unless the surgeon attempts to make an opening in the anterior capsule and finds the anterior capsule wrinkled or the lens moved [1]. In our study, 6 eyes with subluxated lenses were detected intraoperatively, 2 eyes had acute angle-closure glaucoma, 1 eye had trauma, 1 eye had a hypermature cataract, and 2 eyes had pseudoexfoliation syndrome.

In Asian countries, careful attention should be paid to cases of shallow anterior chamber, which may be caused by angle-closure glaucoma, or other mechanisms such as a subluxed lens and zonular weakness. Some reports have shown that the CTR cannot supply enough intraoperative and postoperative support to maintain the desired orientation of the capsular bag in cases of extensively weakened or missing zonule fibers [11], and further dislodging or weakening the zonule would occur during surgery even with the CTR in place. In such cases, a Cionni modified capsular tension ring and scleral suture fixation are usually needed.

In a traumatic subluxed lens, the anterior capsule is usually tough from prolonged inflammation, and the capsulorrhexis is difficult to initiate and complete due to the lack of counter traction. In our study, a knife or a 27-gauge

needle was usually used for initial puncture. Adequately sized capsulorrhexis beginning at the area with an intact zonule to the defect area should be made to ensure the placement of the CTR, but a too large capsulorrhexis may cause CTR explantation during aspiration. We found vitreous in the AC preoperatively in 12 eyes with traumatic cataracts and in 6 eyes intraoperatively. Vitreous loss increases the risk of retinal detachment and contributes to the development of glaucoma. Because we injected dispersive viscoelastic material at the start of surgery to displace any vitreous in the AC posterior into the vitreous cavity [6] or performed vitrectomy, no cases of retinal detachment or macular edema occurred throughout follow up. Five eyes had elevated intraocular pressure after surgery. Viscoelastic material leakage and angle closure were the main causes. All cases were controlled medically, and no case required surgical intervention. In 4 eyes with previous acute angle-closure glaucoma, cataract removal normalized the IOP without surgery.

Improved BCVA was achieved in 33 eyes (91.7%) by 1 week, and the visual acuity remained stable up to 1 year. This may be because our study had more mature cataracts than others. In only 3 eyes, BCVA did not improve due to traumatic optic atrophy, macular scars, and age-related macular degeneration. Thirty eyes (83.33%) had a final visual acuity of ≥20/40. The IOL was centered in all eyes at the 12-month follow up, which is comparable to outcomes of other studies [5, 12]. It is also attributable to our selection of patients, who had zonular dialysis of 90° to 150°.

In conclusion, phacoemulsification in eyes with subluxated lens is technically challenging and time-consuming, with a steep learning curve. We believe that our findings are useful in guiding surgeons in treatment of a subluxated cataract. A modified stop-and-chop, chop *in situ*, and lateral separation technique is recommended in emulsification. It is critical to maintain anterior chamber depth to avoid capsular bag collapse. With these approaches, CTR implantation after lens extraction can be achieved successfully with low complication rates.

Acknowledgements

We thank all the volunteers and patients for their participation in the study. This study don't have any grant support.

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