Original Article

Capsular tension ring assisted phacoemulsification of morgagnian cataract

Narayan Bardoloi[1], *Sandip Sarkar*[1,2], *Pankaj Suresh Burgute*[1], *Debaruna Ghosh*[1], *Amit Kumar Deb*[2]

Purpose: To describe a novel technique of phacoemulsification in morgagnian cataract using capsular tension ring (CTR). **Methods:** This was a retrospective, non-comparative, clinical interventional study. Patients with hypermature morgagnian cataract who had undergone CTR-assisted phacoemulsification were included in the study. After capsulorhexis, CTR was inserted in a clockwise manner to stabilize the capsular bag in each case. Phacoemulsification was then performed using either horizontal chopping or vertical chopping. We have used the CTR in these cases without any obvious lens subluxation in order to perform safe emulsification of the nuclear pieces in the capsular bag. We have performed the procedure successfully in eleven eyes with hypermature morgagnian cataract. **Results:** The mean corrected distance visual acuity (CDVA) improved from 2.62 ± 0.25 Log MAR to 0.35 ± 0.28 Log MAR at 3 months postoperatively (P = 0.00008). Total nine out of 11 patients gained CDVA of 20/40 or better at 3 months postoperatively. No intraoperative complications such as posterior capsular rupture, zonular dialysis, iris trauma, vitreous loss were noted. The mean endothelial cell loss was 148.82 ± 41.52 cells/mm^2 after 3 months of surgery. **Conclusion:** The main culprit for intraoperative complications during phacoemulsification in a morgagnian cataract is the vulnerable capsular bag. Following insertion of a CTR after capsulorhexis, the bag becomes stable and the subsequent steps of the surgery become uneventful, thereby, preventing any further complications.

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DOI:
10.4103/ijo.IJO_2723_20

Quick Response Code:

Key words: Capsular tension ring, morgagnian cataract, phacoemulsification

Phacoemulsification in a morgagnian cataract is a challenge even at the hands of the most experienced surgeons.[1] It was named after the Italian anatomist, Giovanni B. Morgagni. The cortex in this type of cataract undergoes liquefaction, resulting in the sinking of the dense nucleus in the capsular bag.[2] Plethora of problems presented to the surgeon during surgery includes a rigid anterior lens capsule, weak zonules, milky cortex with inadequate support for rhexis, and hard nucleus. All these lead to increased risk of posterior capsular rupture (PCR), zonulodialysis, vitreous loss, nucleus drop or inadvertent removal of the entire capsular bag.[3] Different techniques of nuclear fragment management following a PCR include Sheet's glide, hydroxyethyl methacrylate lifeboat, ophthalmic viscosurgical device (OVD) shell, and intraocular lens (IOL) scaffold technique.[3-5] However, after extensive literature search, we could get only two techniques that describe safe phacoemulsification steps to prevent PCR or vitreous loss in a morgagnian cataract – the visco shell technique by Sato *et al.* and the IOL scaffold technique by Parkash *et al.*[3,6] We, hereby, describe a novel and easily reproducible technique of safe phacoemulsification in a morgagnian cataract using a CTR. We do recognize that the capsular bag is fragile and floppy in a morgagnian cataract due to the long-standing nature of the cataract and also due to associated weak zonular support. The bag is, therefore, vulnerable to PCR or zonular dialysis. There may also be instances where the entire capsular bag can get sucked into the phaco tip during phacoemulsification, thereby, resulting in iatrogenic aphakia.[7] CTR is usually used to manage cases of zonular weakness in subluxated cataracts, and traumatic cataracts.[8,9] However, in our technique, we have used the CTR to support the intact but fragile capsular bag to carry out phacoemulsification without any complications.

Methods

We conducted a retrospective, non-comparative, clinical interventional study in a tertiary eye care center to evaluate the efficacy of the capsular tension (CTR) ring-assisted phacoemulsification in morgagnian cataract. Case records of the patients who had undergone phacoemulsification with CTR for management of morgagnian cataract during the period from January 2019 to December 2019 were retrieved from the Electronic Medical Record (EMR). Patients with traumatic cataract, complicated cataract, cataract with zonulopathy, uveitic cataract, pseudoexfoliation, angle-closure glaucoma, and corneal opacity were excluded from the study. Study approval was obtained from the institutional review board (IRB/CPEH/19-01-29) and it followed the Declaration

[1]Cataract & Cornea Services, Chandraprabha Eye Hospital, Jorhat, Assam, [2]Department of Ophthalmology, Jawaharlal Institute of Post Graduate Medical Education & Research, Puducherry, India

Correspondence to: Dr. Sandip Sarkar, Department of Ophthalmology, Jawaharlal Institute of Post Graduate Medical Education and Research, Gorimedu, Puducherry - 605 006, India. E-mail: drsandip19@gmail.com

Received: 21-Aug-2020 Revision: 25-Jan-2021
Accepted: 11-Feb-2021 Published: 18-Jun-2021

Cite this article as: Bardoloi N, Sarkar S, Burgute PS, Ghosh D, Deb AK. Capsular tension ring assisted phacoemulsification of morgagnian cataract. Indian J Ophthalmol 2021;69:1781-5.

of Helsinki. Waiver of consent was obtained as the study was retrospective in nature.

A complete ophthalmological evaluation including detailed medical and ocular history, uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), slit-lamp examination to assess the anterior segment, Goldman applanation tonometry (GAT) to measure the intraocular pressure (IOP), and B-scan ultrasonography to diagnose any posterior segment pathology were performed. Biometry was done using IOL Master-500 (Zeiss, Germany) with partial coherence interferometry. The axial length was measured by immersion A-scan and intraocular lens (IOL) power calculation was done by feeding the values in the IOL Master -500.

Surgical technique

All the surgeries were performed by a single experienced surgeon (NB). Topical anesthetic agent 0.5% proparacaine hydrochloride eye drops were instilled every 10 minutes starting half an hour prior to the surgery. Two paracenteses were made at 3’0 clock and 9’0 clock positions. The anterior capsule was stained with trypan blue. The anterior chamber was then filled with cohesive ophthalmic viscosurgical device (OVD) i.e., sodium hyaluronate 1.4%. An initial puncture was made in the center of the anterior lens capsule (ALC) with a 30 gauge cystotome needle [Fig. 1a]. The liquid cortex, if present, egressed out of the capsular bag making it empty. Cohesive OVD was then injected through the initial capsular opening to fill up the capsular bag. With the help of 23 G microrhexis forceps, the edge of the ALC flap was grasped and capsulorhexis was carried out in a controlled manner [Fig. 1b]. In case of a fibrosed anterior capsule, intra-ocular micro scissors were used along with microrhexis forceps to create a rhexis. Approximately, a 5.5 mm continuous curvilinear capsulorhexis was made in each case. Capsular tension ring (CTR) insertion was then carried out for stabilization of the capsular bag. CTR was introduced manually through the main incision in a clockwise manner [Fig. 1c]. An iris spatula was used to guide the leading end to enter into the capsular bag. The trailing end was hooked in a sinskey hook and brought to the center of the capsulorhexis [Fig. 1d]. The iris spatula was then used to depress the CTR and disengage it from the sinskey hook to facilitate its entry into the capsular bag [Video file 1]. Dispersive OVD (Viscoat, Alcon laboratories Inc) was then injected into the eye. The nucleus was held at the center using 600 mm Hg vacuum in a Centurion Vision System (Alcon Laboratories, USA). It was divided into two halves either by horizontal chopping [Fig. 2a] or vertical chopping [Fig. 2b]. The subsequent chops for further fragmentation of the nuclear pieces were also either vertical or horizontal depending upon the convenience of the situation [Fig. 2c-f]. Step by step chopping with lateral separation was performed at various places to separate the sticky and leathery nuclear fibers [Video file 2].[10] The fragments were removed one by one under the cover of dispersive OVDs [Fig. 3]. Since there was no cortex, irrigation and aspiration were not required. The capsular bag was filled with cohesive OVD and a foldable, hydrophobic, single piece, acrylic intraocular lens (IOL) was implanted into the bag. The surgery was completed by removing the OVD from the anterior chamber and hydrating the wounds. 0.1 ml of preservative-free 0.5% moxifloxacin (Vigamox, Alcon Laboratories, Inc) was injected intracamerally at the end of the surgery. Patients were discharged on the same day after checking the vitals. Patients were prescribed prednisolone acetate (1%) eye drops (Predforte, Allergan India) in a tapering dose for 6 weeks and 0.5% moxifloxacin eye drops (Vigamox, Alcon laboratories, Inc) 4 times/day for 2 weeks starting from the day of surgery.

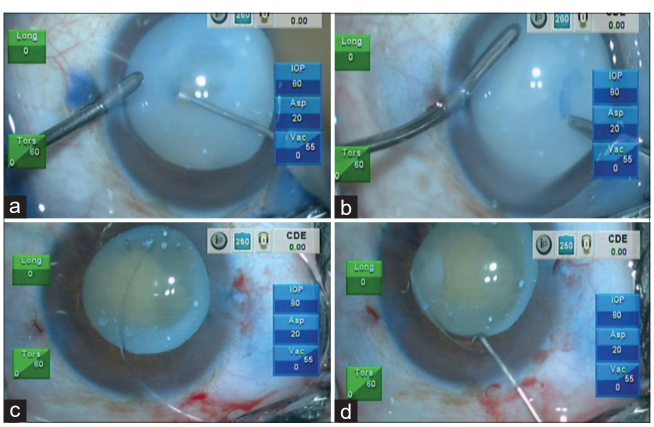

Figure 1: Images showing (a) Puncture made in anterior lens capsule (ALC) with cystotome, (b) Edge of ALC flap grasped with micro-rhexis forceps and capsulorhexis performed, (c) Capsular tension ring (CTR) inserted through the main incision with forceps, (d) Sinskey’s hook used to hook and dial the trailing end of the CTR

Results

We have performed phacoemulsification in morgagnian cataract using capsular tension ring (CTR) in 11 eyes of 11 patients during the study period. Table 1 shows the baseline details of the patients. The mean age was 72.73 ± 5.46 years. CTR insertion was uneventful and without any intra-operative complication in all the cases. Phacoemulsification with intraocular lens (IOL) implantation in the capsular bag was performed successfully in all the cases. No intraoperative complications like as posterior capsule rupture (PCR), zonular dialysis (ZD), or iris trauma were noted. In none of the cases, the capsular bag was sucked into the phaco tip intra-operatively.

The mean corrected distance visual acquity (CDVA) improved from 2.62 ± 0.25 Log MAR to 0.35 ± 0.28 Log MAR at 3 months postoperatively ($P = 0.00008$ by Mann Whitney U test). Except for 2 patients, who were having non-proliferative diabetic retinopathy with diabetic macular edema (NPDR with DME), remaining nine patients gained CDVA of 20/40 or better than it at three months postoperatively [Table 2]. Mild corneal edema was noted in two eyes at the early postoperative period which resolved subsequently within a week. The mean intraocular pressure was 14.24 + 1.13 mm Hg at three months

Table 1: Baseline details of the patients

Parameters	Value
No of patients	11
Age (Mean±SD)	72.73±5.46 Years
CDVA (Mean±SD)	2.62±0.25 LogMAR
ECD (Mean±SD)	2352.73±244.07 cu/mm^2
IOP (Mean±SD)	14.24±1.13 mmHg

CDVA=corrected distance visual acuity, IOP=Intra ocular pressure, ECD=endothelial cell density

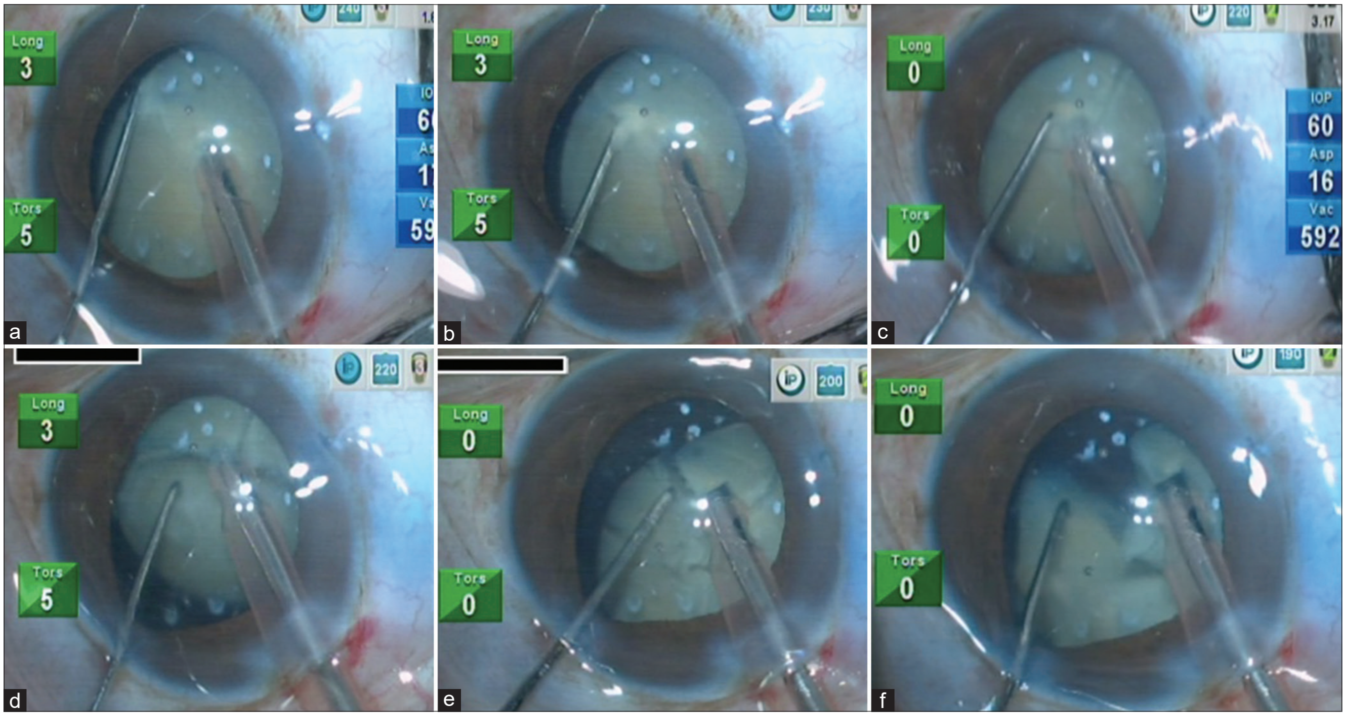

Figure 2: Images showing that the nucleus is being held with phaco probe and either (a) horizontal chopping or (b) vertical chopping is being performed to divide the nucleus into two halves, and (c-f) the nucleus is chopped into smaller fragments using either vertical or horizontal chopping method

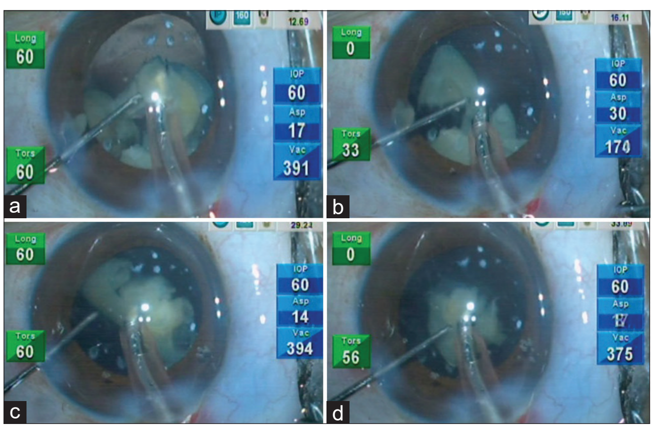

Figure 3: Images (a-d) showing all nuclear fragments including the last piece being emulsified at a deeper plane within the capsular bag

after surgery. The mean endothelial cell density at three months post-operative visit was 2203.91 ± 259.63 cells/mm^2 with mean cell loss of 148.82 ± 41.52 cells/mm^2. Other postoperative complications like retinal detachment, cystoid macular edema and pseudophakic bullous keratopathy were not noted till the last short-term follow-up of 3 months.

Discussion

Morgagnian cataract is a special form of cortico-nuclear cataract. It is assumed that the process of fiber dissolution that is encountered in cortical cataract, in general, is speeded up and occurs en masse in morgagnian cataract.[11] Histopathologically, cortical cataracts consist of eosinophilic fluid accumulation between the lens cells. This displaces and causes degeneration of the adjacent lens cells. These degenerated cells then release protein globules or droplets called the morgagnian globules. These globules accumulate and eventually substitute the entire cortex resulting in a morgagnian cataract. The nucleus then gets displaced to the bottom of the capsular bag near the lens equator due to gravity.[12]

Phacoemulsification in a morgagnian cataract presents difficulties to the surgeon at various steps starting right from the capsulorhexis. The anterior capsule fluctuates due to lack of pressure in the capsular bag due to underlying milky cortex which, therefore, prevents the creation of a continuous curvilinear capsulorhexis (CCC).[13] Also, the lack of epinuclear or cortical support below the nucleus increases the risk of PCR during phacoemulsification. The high machine parameters used in emulsifying the hard nucleus can also lead to rupture of the floppy posterior capsule.[14] Holding on to a hard dense nucleus during phaco in an empty capsular bag is a challenging thing to do. The zonular weakness of these morgagnian cataracts adds to the difficulties for the surgeon. The weak zonules and the vitreous syneresis make the bag more floppy.[3,6]

Two different approaches have been described previously to overcome the intra-operative difficulties of morgagnian cataract. In IOL scaffold technique described by Parkash *et al.*, two out of four or more nuclear fragments created after initial vertical chopping are first emulsified and aspirated within the capsular bag.[3] The remaining nuclear fragments are prolapsed into the AC above the iris plane by the phaco probe using high vacuum. In the case of a smaller nucleus or a fragile posterior capsule, the entire nucleus or all nuclear fragments respectively are lifted in the anterior chamber. IOL is then placed inside the bag in all three situations described

Table 2: Summary of all the cases

Age	Sex	Cataract Grade	CDVA	CTR	Pre op ECD	ECD 3 months post op	CDVA 3 post op
69	M	HMC	PL+	Yes	2300	2198	20/40
71	F	HMC	PL+	Yes	2398	2201	20/32
73	F	HMC	HM+	Yes	2709	2567	20/32
81	M	HMC	HM+	Yes	2466	2344	20/40
77	F	HMC	PL+	Yes	2400	1905	20/125
75	F	HMC	HM+	Yes	2100	1987	20/32
72	F	HMC	HM+	Yes	2104	2078	20/32
67	M	HMC	PL+	Yes	2198	2078	20/200
79	M	HMC	PL+	Yes	2760	2652	20/32
62	F	HMC	PL+	Yes	1999	1800	20/40
74	F	HMC	PL+	Yes	2406	2278	20/32

CDVA=corrected distance visual acuity, HMC=hyper mature morgagnian cataract. CTR=capsular tension ring, ECD=endothelial cell density, HM=Hand movements, PL=Perception of light

and phacoemulsification is continued above the IOL. This technique although uses dispersive OVD, it cannot, however, ensure full endothelial protection as emulsification is done at a plane closer to the endothelium. It, therefore, makes the endothelial cells more vulnerable to damage compared to in the bag emulsification.[15] Secondly, the IOL inside the fragile capsular bag makes it heavy and this may give away in case of high turbulence produced during phacoemulsification of the remaining fragments. In our technique, the weakness of the capsular bag is taken care of by the CTR, thereby, providing a very stable bag. Also, emulsification is done throughout in a deeper plane in the bag under dispersive OVD that ensures maximum endothelial protection.

In the visco-shell technique, Sato *et al.*, had used healon (2.3% sodium hyaluronate) to act as an OVD shell for safe phacoemulsification in a morgagnian cataract.[6] Healon is injected into the bag below the nucleus and the capsular bag is inflated. The nucleus is then slightly prolapsed anteriorly out of the bag and healon again injected between the cornea and nucleus. Phacoemulsification in this technique is, therefore, performed at a slightly anterior plane (supracapsular) and theoretically can cause endothelial damage despite protection by healon.[15] Also, healon cannot ensure permanent protection to the PC during the procedure as it acts only as a temporary barrier. It may get aspirated during phaco, thereby, endangering the PC. Healon works as a visco-cohesive at low flow rates and pseudodispersive at higher flow rates. Optimal flow parameters are to be maintained throughout the phaco in this technique which can be a drawback in certain situations specially if the nucleus is very hard. However, healon does not have any role in stabilization of the capsular bag, which we believe is the ultimate deciding factor in the management of phacoemulsification in morgagnian cataract.

The capsular tension ring (CTR) was first described in 1991 by Hara *et al.* and they named it as "equator ring". Its design ensured the maintenance of the round contour of the capsular bag after lens removal during cataract surgery.[16] Originally, indications for CTR were capsule stabilization in eyes with zonular weakness or dehiscence, intraocular lens (IOL) subluxation, pseudoexfoliation syndrome, and high myopes not receiving a posterior chamber intraocular lens (PCIOL).[8,17-21] CTRs were approved by the U. S. Food and Drug Administration in 2003. It has since then become an invaluable tool for the management of compromised zonular fibers during cataract surgery. The CTR creates an equally distributed centrifugal force to the equator of the bag. In doing so, the CTR recruits tension from the stronger zonules to buttress areas of weak or absent zonules, stabilizing the entire complex.[22] Studies have shown that they provide long-standing support to the capsular bag unless there is progressive zonular damage as in Marfan's syndrome and pseudoexfoliation.[23] In our technique, though there is no obvious subluxation of the lens, we use the CTR to stabilize the capsular bag during surgery to facilitate uneventful surgery. Our technique, therefore, describes a newer indication for use of CTR.

During our previous experience with phacoemulsification of morgagnian cataract, we encountered situations wherein the entire capsular bag was aspirated into the phaco probe during phacoemulsification. This necessitated the implantation of a scleral fixated, iris fixated or anterior chamber IOL. However, we have not experienced any such incident in our current series of 11 cases. With our technique, the entire process of phacoemulsification including the last nuclear fragment can be emulsified within the capsular bag due to enhanced stability provided by the CTR.

Conclusion

Our novel technique, therefore, helps to overcome the shortcomings of the visco shell technique as well as the IOL scaffold technique. Endothelial damage is minimal in our technique theoretically as phaco is performed in the bag and dispersive OVD is used to coat the endothelium. Also, our technique ensures maximum stability to the zonules and therefore prevents PCR. A comparative study of the different techniques is, however, needed to establish the superiority of the technique over the other two in terms of prevention of endothelial cell loss and PCR. The main culprit for intraoperative complications during phacoemulsification in a morgagnian cataract is the vulnerable capsular bag. Following insertion of a CTR after capsulorhexis, the bag becomes stable and the subsequent steps of the surgery become uneventful, thereby, preventing any further complications.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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