Performing cataract extraction in patients with zonular weakness presents many challenges and increases the risk of intra- and postoperative complications. Capsular tension rings (CTRs) and other endocapsular support devices have been important management options for patients with significant zonulopathy. Hara et al and Nagamato and Bissen-Miyajima introduced the first endocapsular devices, but they were popularized and further developed by U.F.C. Legler and B.M. Witschel. The standard CTR is an open polymethyl methacrylate (PMMA) ring with rounded eyelets on both free ends.

The CTR may serve a dual purpose, providing intraoperative support during cataract extraction and serving as an implant for long-term IOL stabilization. The diameter of the CTR is larger than that of the capsular bag, allowing the centrifugal forces inherent in the ring to expand the capsular equator, buttress the weak areas, and provide equal distribution of support over the remaining zonules. The CTR also recruits tension from existing zonules and redistributes the forces to the remaining weaker zonules to stabilize the entire zonular apparatus, and it tautens the posterior capsule during surgery to prevent capsular shrivelling so that Nd:YAG laser capsulotomy may be performed after phacoemulsification.

There is also a decreased prevalence of posterior capsular opacification in patients with CTRs.

**IMPLANTATION TIME**

A CTR can be implanted at any step after capsulorrhexis and hydro- and viscodissection. An intact capsulorrhexis is necessary for implantation. Convention has been to place the CTR at the earliest concern of zonular weakness prior to lens extraction. This provides the advantage of capsular support intraoperatively. Additionally, early placement is commonly believed to allow capsular distention, which may prevent damage to the bag during the most crucial steps of phacoemulsification and cortical aspiration. Bayraktar et al reported reduced zonular separation and increased capsular IOL fixation in cases with pseudoxfoliation syndrome when a CTR was implanted before phacoemulsification compared with a control group for whom no CTRs were implanted.

Nevertheless, with the widespread use of CTRs in cataract extractions, a number of complications have been reported, including anterior capsular tears during implantation, posterior dislocation of the ring, and intraoperative dislocation after early placement. These reported complications have raised concerns regarding the safety of early CTR implantation prior to lens extraction. Inserting and rotating a CTR in the capsular bag with an intact crystalline lens is challenging and results in significant zonular stress, increasing the risk for iatrogenic damage to existing zonules and further capsular bag decentration. In this scenario, the capsular bag can be lost before phacoemulsification is performed. Zonular dehiscence also increases the risk of long-term instability, pseudophacodonesis, and even late subluxation.

**EARLY VERSUS LATE PLACEMENT**

Using Miyake-Apple video analysis, Ahmed et al studied the effects of early (after hydro- and viscodissec-
tion) versus late (after phacoemulsification) placement of CTRs in cadaver eyes. Compared with late CTR placement, early implantation was associated with markedly increased capsular bag displacement, increased capsular bag torque, and zonular elongation during implantation. There was also an increased tendency for the leading CTR eyelet to be entrapped within the capsular fornix, and cortical removal was also more challenging and tedious in the early placement group. In the case of complete zonular dehiscence or posterior capsular tear during lens extraction, the early-placed CTR can dislocate posteriorly into the vitreous cavity. This would necessitate vitrectomy and CTR removal.

Video analysis demonstrated that implantation of the CTR after lens extraction resulted in minimal capsular bag displacement and zonular stress.

To address the lack of zonular support during lens extraction and avoid complications of early CTR placement, the surgeon can use multiple iris/capsular retractors at the capsulorrhexis edge to stabilize the capsular bag during phacoemulsification and cortical aspiration. It must be noted that, during in- and outflow in phacoemulsification and particularly with a hard lens and/or substantial zonular weakness, focal pressure on the anterior capsule may cause a capsular tear. In some cases, the iris retractors can be dislodged. After lens extraction, a CTR can be safely implanted prior to IOL insertion, and the retractors can then be removed.

A CTR may be safely implanted early and, as mentioned earlier, does afford some protection from intraoperative capsular collapse. The use of a cohesive ophthalmic viscosurgical device (OVD) to perform viscodissection and thus create adequate space for implantation and to cleave cortex from the capsular fornix is helpful if this is done.

In addition to the zonular stress created by early implantation of a CTR, it is our clinical impression that manual implantation can also result in more stress than in implantation using an injector. The tip of the injector can be placed in the capsular bag, thereby removing the tension on the capsulorrhexis that occurs during manual implantation. Furthermore, the surgeon can use a backing-out technique to reduce capsular entrapment caused by the leading eyelet of the CTR. Tactile feedback is reduced with injector use, but capsular entanglement can be avoided by carefully observing capsule dynamics during injection.

**MODIFIED CTR AND CTS**

In cases of severe zonulopathy, a standard CTR does not provide adequate intraoperative support and capsular bag centration. The modified CTR (m-CTR; Morcher GmbH, Stuttgart, Germany) has a single or double eyelet that allows the surgeon to anchor the capsule to the sclera. One challenge to the use of m-CTRs is that they must be dialed in, making placement before phacoemulsification difficult. Most surgeons therefore place the ring after lens extraction. Furthermore, to provide intraoperative support and maintain some degree of centration during phacoemulsification, temporary iris hooks can be placed at the capsulorrhexis edge. However, this technique runs the risk of anterior capsular tear, dislodgement, and lack of expansion of the capsular equator.

The Capsular Tension Segment (CTS; Morcher GmbH) is intended for patients with significant zonular weakness. Because the CTS is smaller than standard CTRs and m-CTRs, it can be placed prior to phacoemulsification without a dialing technique. Much less force is transmitted to the already weakened zonular apparatus. The device is designed to slide into the capsular bag with minimal trauma. It can therefore be used in cases of discontinuous capsulorrhexis, anterior capsular tear, or posterior capsular rent. It is inserted into the capsular bag after capsulorrhexis and placed over the area of zonular weakness.

When full circumferential support is required, a CTS can be implanted in conjunction with a CTR. For example, a CTS can be used as an intraoperative device to avoid possible entrapment of a CTR eyelet in the capsular fornix. It is much easier to strip cortex around the partial segment compared with the full ring structure of the CTR. The surgeon can use the CTS to provide support intraoperatively and remove it once the lens is extracted. Alternatively, it can be permanently sutured to the sclera to provide long-term support and centration.

**CONCLUSION**

The use of endocapsular support devices in cataract surgery reduces intra- and postoperative complications in patients with zonular weakness and provides intraoperative support and long-term IOL centration. Because early implantation of CTRs may cause iatrogenic capsular and zonular trauma in patients with an already weakened zonular apparatus, surgeons may wish to avoid implanting CTRs prior to phacoemulsifi-

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**TAKE-HOME MESSAGE**

- A CTR can be implanted at any step after capsulorrhexis and hydro- and viscodissection.
- Early implantation of a CTR provides protection from capsular collapse; however, it is also associated with increased capsular bag displacement, capsular bag torque, and zonular elongation during placement.
- Late implantation reduces zonular stress intraoperatively and increases the likelihood of IOL support and centration.
cation. There have been no large-scale studies assessing the optimal timing for CTR implantation, but our clinical impression is that late implantation reduces zonular stress intraoperatively and increases the likelihood for IOL support and centration. Iris retractors and CTS devices increase intraocular support and can also reduce the risks associated with early implantation of CTRs.

Iqbal Ike K. Ahmed, MD, FRCSC, is an Assistant Professor of Ophthalmology in the Department of Ophthalmology at the University of Toronto. Dr. Ahmed states that he has no financial interest in the products or companies mentioned. He may be reached at tel: +1 905 820 3937; e-mail: ike.ahmed@utoronto.ca.

Khalid Hasanee, MD, FRCSC, is an Assistant Clinical Professor of Ophthalmology, Department of Ophthalmology, McMaster University, Hamilton, Ontario. Mr. Hasanee states that he has no financial interest in the products or companies mentioned.

Mikel Mikhail is a doctoral (MD) candidate in the Michael G. DeGroote School of Medicine, McMaster University, Hamilton, Ontario. Mr. Mikhail states that he has no financial interest in the products or companies mentioned. He may be reached at e-mail: mikel.mikhail@medportal.ca.


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