In modern cataract surgery, a variety of forces are applied to the capsular bag and to the zonules during lens extraction, nucleus rotation, and IOL implantation. The condition of the zonular apparatus determines how efficient phacoemulsification will be, and therefore patients with general zonular weakness and/or zonular dialysis present significant challenges for the cataract surgeon. Zonular problems are most often seen in cases of trauma, pseudoexfoliation (PXF) syndrome, glaucoma, high myopia, and hereditary systemic diseases such as Marfan and Weill-Marchesani syndromes and homocystinuria. In these patients—because there is an increased risk for capsular tears, vitreous prolapse, IOL instability, and postoperative IOL-capsular bag complex decentration—I typically use a capsular tension ring (CTR) to stabilize the crystalline lens during cataract surgery. This ancillary device reduces the likelihood of intraoperative complications.

CTRs have three general functions: (1) to stretch the capsular bag to maintain the circular contour of the capsule during surgery and to prevent its collapse and aspiration, (2) to distribute forces equally over the zonules, and (3) to prevent vitreous prolapse into the anterior chamber. A conventional CTR counters progressive contractile centripetal forces and resists capsulorrhexis shrinkage as the capsular bag contracts after surgery. This is a likely scenario in PXF syndrome, in which the entire capsular bag can dislocate years after the initial surgery. To some extent, a CTR can also retard posterior capsular opacification by mechanically blocking lens epithelial cell migration.

**BENEFITS AND DRAWBACKS**

CTRs are manufactured in different sizes, making them useful in a variety of situations, including cataract surgery in children, in patients with hyperopia and emmetropia, and in eyes with a large capsular bag diameter. When selecting the size of the ring, the surgeon must consider the patient’s age, the size of the eye, the elasticity of the capsule, and the amount of existing zonular support. The CTR may be inserted with an injector or using two forceps to maneuver the device into the eye. The former is preferable, but the latter is used to implant modified CTRs (described below) and devices specially designed for suture fixation. It is necessary to emphasize that CTR implantation is absolutely contraindicated in cases of anterior and/or posterior capsular tears.

CTR insertion can, however, complicate irrigation and
aspiration because the ring can trap cortical material at the capsular bag equator. To avoid this, consider delaying CTR insertion until after the cortex has been removed. In cases in which early implantation of the CTR is justified, consider using tangential stripping and bimanual I/A to increase the efficiency of cortex removal.

CONVENTIONAL AND MODIFIED CTRs

Current indications for conventional CTRs include zonular instability, zonular rupture, and inherent or acquired zonular weakness. Standard CTRs are unlikely to provide sufficient capsular support in progressive or advanced zonulopathy, nor can they prevent progressive zonular loss and capsular decentration. There is a high risk that the IOL will be dislocated postoperatively if conventional CTRs are used in these conditions. Today’s surgeons can use modified CTRs to safely address moderate or profound zonular weakness.

The first modified CTR, designed by Robert J. Cionni, MD, of Salt Lake City, Utah, incorporated a fixation eyelet on the central ring.6 This eyelet allows the ring to be sutured to the sclera and provides intraoperative support during phacoemulsification (Figure 1). The Cionni CTR (Morcher GmbH, Stuttgart, Germany) can be used in patients with zonular dialysis of greater than 3 clock hours. However, because the segment of the ring attached to the fixation element does not allow the device to be fully retracted inside the injector tube (Figure 2), most surgeons use forceps to manually implant this modified CTR through a relatively large incision (approximately 3 mm).7

OTHER DEVICES

Many other devices are designed to facilitate cataract surgery in patients with zonular dialysis. For instance, flexible iris retractors not only enlarge the pupil but also support the capsular bag in the presence of extremely loose zonules.8 However, they have short and flexible hooked ends that tend to slip, in some cases tearing the anterior capsulorrhexis. Specially designed titanium or plastic capsular retractors such as the Cataract Support System (Duckworth & Kent Ltd, Hertfordshire, England) and the MST Capsule Retractors (MicroSurgical Technology, Redmond, Washington) have
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Cover Story

Elongated hooked ends that support the peripheral capsular fornix but do not compromise the capsulorrhexis. These devices function like artificial zonules, fixing the entire capsular bag to the limbus. They stabilize the bag during phacoemulsification and do not complicate cortical clean-up.

The principal advantage of devices such as the Ahmed Capsular Tension Segment (Morcher GmbH), the Assia Anchor (Hanita Lenses, Kibbutz Hanita, Israel), and the Yaguchi Capsular Expander (designed by Shigeo Yaguchi, MD, PhD, of Japan) is minimizing surgical trauma to the already compromised existing zonules caused by dialing in and positioning the CTR inside the capsular bag. Although these devices can support the capsular bag during surgery and prevent its dislocation postoperatively (Figure 3), their main disadvantage is that they offer only focal support and do not restore the shape of the capsular bag equator. In many cases, combination of these devices with conventional or modified CTRs is called for.

MALYUGIN MODIFIED CTR

The Malýugin CTR (Morcher GmbH; Figure 4) is a modified version of the Cionni CTR. Developed to address the difficulties of microincision cataract surgery (MICS) in patients with extensive zonular dialysis or zonular weakness, the device centers the subluxated lens capsule and allows it to be secured to the scleral wall.

The basic idea was to move the fixation element to the tip of the ring, thus allowing the CTR to be completely retracted into the injector tube and thereby facilitating injection through a microincision (2.2 mm). The curved portion of the Malýugin CTR slides along the capsular bag equator during...
injection, eliminating the risk of perforating the capsular fornix with the tip of the CTR.10

SURGICAL TECHNIQUE
My surgical technique in a patient with traumatic cataract, zonular dehiscence, and iridodialysis (Figure 5) is described below. A video of the procedure can be viewed at http://eyetube.net/?v=pejuf.

After a clear corneal incision is made, capsulotomy is initiated with a bent needle (Figure 6), and MST microcapsulorhexis forceps (MicroSurgical Technology) are used to grasp the flap and tear the capsule in a circular manner (Figure 7). In many cases, capsular folds and lens instability can be observed during the capsulorrhexis creation, providing additional evidence of significant zonular pathology.

The Malyugin CTR is retracted into the injector cartridge, and a needle is passed through the eyelet to allow the device to be fixated with a 9-0 polypropylene suture. The injector is positioned in the center of the anterior chamber, and the ring is slowly inserted into the capsular bag until it is securely positioned under the anterior capsule (Figure 8). The ring should be injected in the direction of the zonular defect to prevent damaging the residual zonules. The CTR’s curved fixation element safely slides along the capsular bag equator without any risk of damaging it, and the trailing end of the device is then guided under the fixation element and released from the plunger. Using a Sinskey hook, the ring is rotated until the fixation element is positioned in the center of the zonular defect.

A conjunctival flap is created with scissors, and gentle cautery of the episcleral vessels is performed. The needle is then passed through the ciliary sulcus using an ab interno approach (Figure 9), and the fixation element is guided through the capsulorrhexis opening with a reverse Sinskey...
hook and positioned on the anterior surface of the sclera (Figure 10). The needle is externalized, fixated to the superficial scleral layers in a zig-zag fashion with four to five bites, and a double knot is tied. If iridodialysis is present, as it was in this case, the iris root can be sutured to the sclera with a 10-0 polypropylene suture at two points (Figure 11). The conjunctiva is closed with two or three 8-0 silk interrupted sutures placed in the limbus.

Multiple-quadrant hydrodissection is carefully performed and followed by quick-chop phacoemulsification with the Stellaris system (Bausch + Lomb, Rochester, New York) using linear ultrasound. The dual-linear footpedal helps to stabilize the anterior chamber and increases the safety of the procedure (Figure 12). After the last fragment of nucleus is removed, cortical material is aspirated from the capsular bag with bimanual I/A (Figure 13), and a foldable acrylic IOL (Micry AY; PhysIOL, Liege, Belgium) is injected into the capsular bag (Figure 14). The leading haptic goes directly into the bag, and the trailing haptics is, in most cases, inserted bimanually by gently holding the capsulorrhexis edge with a microhook and using a second instrument to advance the haptic inside the bag. At the end of the case, the capsular bag and the IOL should both be stable.

If the pupil is atonic, the Siepser sliding-knot technique is used to place two to four interrupted sutures (10-0 polypropylene). This is necessary not only to achieve good cosmetic appearance but also to eliminate glare and other unwanted visual phenomena (Figure 15).

**CLINICAL STUDY**

We investigated the safety, visual function, pupil cosmesis, and final IOL position in 32 eyes (29 patients) that underwent phacoemulsification with the Malyugin CTR and in-the-bag IOL fixation. Localized or generalized zonular deficiencies were due to conditions such as Marfan syndrome (n=15), traumatic cataract (n=8), PXF (n=5), and glaucoma (n=4).

Mean age of the patients was 51.2 ±12.5 years, preoperative BCVA varied from 0.4 to counting fingers, and the extent of the zonular defect according to ultrasound biomicroscopy (UBM) varied between 60° and 210° (mean, 97°). Mean follow-up was 19 ±6.1 months. Mean BCVA improved to 0.7 after the surgery, and no major complications were observed during surgery. Posterior capsular opacification was the most frequent finding after surgery, occurring in five eyes, three of which required Nd:YAG capsulotomy.

Capsular bag and IOL position were
verified with UBM (Figure 16). In all patients, both bag and IOL were positioned centrally; mean shift in the direction of the traction suture was 0.26 ± 0.19 mm, and mean lens tilt was 4.7 ± 3.5º. Intraocular pressure was within the normal range in all cases (Figure 17).

CONCLUSION

Reducing incision size is a natural trend that can be observed through the long history of cataract surgery. Today, we perform MICS on a regular basis; however, zonular compromise still presents a significant challenge and raises the risk of intra- and postoperative complications, such as long-term instability of the IOL.

Conventional and modified CTRs provide numerous benefits to surgeons and allow us to manage challenging cataracts with weak zonules. The ongoing development of endocapsular devices allows cataract removal in cases with weak or absent zonules and facilitates fixation of the capsular bag to the sclera. In this study, the combination of the Malyugin CTR and clear corneal phacoemulsification provided favorable functional and anatomical results in eyes with compromised zonules. We now have clinical evidence that MICS techniques can be safely used in patients with severely damaged zonules.

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