Capsular tension rings and related devices: current concepts
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**Purpose of review**
To discuss current designs, indications, contraindications and controversies pertaining to capsular tension devices.

**Recent findings**
Capsular tension rings and other newer endocapsular support devices have become increasingly important in the management of zonular weakness during cataract extraction. They have been found to improve both intraoperative support during phacoemulsification and postoperative intraocular lens centration. Since the introduction of the original capsular tension rings in 1991, there has been a progressive evolution of this device to help deal with profound zonular weakness. These newer devices, which permit scleral-suture fixation, include the modified capsular tension ring and the capsular tension segment.

**Summary**
Continual advances in capsular tension device technology have allowed for increased safety and efficacy in performing cataract surgery in patients with zonular weakness with newer devices being evolved to manage more profound cases.

**Keywords**
capsular tension ring, endocapsular support device, zonular dialysis

**Introduction**
The use of capsular tension rings (CTRs) and other endocapsular support devices has found an important niche in the management of zonular weakness in complicated cataract surgery. Performing cataract extraction in patients with significant zonulopathy presents many challenges with increased risks of intraoperative and postoperative complications.

Numerous options exist in the management of compromised zonules. It is helpful to categorize these approaches into two broad categories: methods of cataract extraction and intraocular lens (IOL) fixation.

With regards to cataract removal, several options exist including phacoemulsification, extracapsular and intra capsular approaches. In severe cases, a posterior approach with pars plana lensectomy and vitrectomy may be entertained. Of course, the ability to maintain the benefits of small-incision surgery with phacoemulsification is the preferred choice.

IOL implantation options include a sulcus posterior-chamber IOL (PCIOL), an anterior-chamber IOL (ACIOL), iris-fixated IOL, or in-the-bag PCIOL with CTR. The use of the CTR with PCIOL implantation is the preferred course of action, however, due to the numerous advantages that are reviewed in this paper.

**Understanding zonular weakness**
To understand zonulopathy, it is helpful to categorize it according to both the extent of zonular dialysis (number of clock hours) and the severity of generalized zonular instability \[1–3,4••\]. This distinction is very important as specific zonular cases each have their own underlying pathogenesis or a combination of causes. For example, a traumatic cataract with segmental zonular lysis (with remaining strong zonules) may need to be handled differently from a case of pseudoexfoliation with generalized zonular weakness. The choice of cataract extraction and endocapsular support device relies greatly on this distinction.

**Mechanics of the capsular tension ring**
The mechanics of the CTR are detailed in Table 1. A CTR may serve a dual purpose, both as a tool providing intraoperative support during cataract removal and as an implant for long-term IOL stabilization. As the diameter of the CTR is larger than that of the capsule bag, the
centrifugal forces inherent to the ring expand the capsular equator and buttress the weak areas, providing equal distribution of support over the remaining zonules [5]. The CTR re-expands the capsular bag, provides counter-traction and tautens the posterior capsule during surgery. After surgery, it offers the advantage of preventing capsule shriveling and allows for Nd:YAG capsulotomy after phaco [6**]. As the capsular bag’s circular contour is maintained, enhanced zonular support is produced [7]. The CTR also recruits tension from existing zonules and redistributes the forces to the remaining weaker zonules thereby stabilizing the entire zonular apparatus. This added support of the CTR may also help to recenter a mildly subluxed capsular bag to avoid decentration and dislocation [1]. Other advantages of the CTR include decreased prevalence of posterior capsule opacification (PCO) [8], enhanced safety and efficiency during phacoemulsification and possibly reduced incidence of capsular contraction syndrome. Standard CTRs however, do not recenter a severely subluxed capsular bag nor prevent progressive zonular loss. To deal with these problems, scleral-fixated devices such as the modified CTR (M-CTR) or the capsular tension segment (CTS) must be used.

**Indications and contraindications to capsular tension rings**

The most frequent causes of zonular insufficiency that benefit from CTR implantation include pseudoexfoliation, traumatic lens displacement, iatrogenic zonular damage, Marfan’s syndrome [9], homocystinuria, hypermature cataracts, and post-vitrectomy and filtration patients [6**]. Other less-frequent situations include aniridia, retinitis pigmentosa [10], intraocular neoplasms, Weil–Marchesani syndrome and microspherophakia [6**]. CTR implantation has also been successfully performed in cases of congenital lens coloboma; however, there have been no long-term studies [11].

Clinical situations where a standard CTR would be indicated (authors’ preferences) include the following: (a) evidence of mild zonular instability based on either localization of zonulysis (less than 4 clock hours); or (b) degree of generalized zonular weakness, for example, mild pseudoexfoliation characterized with a ‘floppy capsular bag’. Certain clinical signs that may indicate ‘mild’ generalized weakness including slight lens movement on capsulorhexis, mild rhexis ovalization but without bag collapse or overt decentration [1–3,4**]. If these criteria are not met, the degree of zonulopathy is likely to be moderate (Fig. 1) to advanced and a standard CTR is considered to be insufficient.

There are certain situations where CTR implantation is absolutely contraindicated. Anterior radial or posterior tears in the capsule are situations where CTR insertion can be detrimental [12,13]. In cases of noncontinuous capsulorhexis, the centrifugal forces generated by the CTR may provoke further extension of the capsular tear towards the posterior direction. In cases such as these, the CTR is at risk of falling into the posterior segment [12–14].

**Current endocapsular devices**

In this section we describe current endocapsular devices.

**Standard capsular tension ring**

In 1991, Hara et al. [15] and Nagamoto and Bissenn-Miyajima [16] introduced the first endocapsular devices. This was later popularized and further developed by U.F.C. Legler and B.M. Witschel (The capsular ring: a new device for complicated cataract surgery. Presented at American Society of Cataract and Refractive Surgery [ASCRS] Symposium on Cataract, IOL, and Refractive Surgery, May 1993; Seattle, Washington). Known as the standard CTR, this open-ring structure (Fig. 2) is made of polymethylmethacrylate (PMMA) material and has an oval-shaped cross section with eyelets at both free ends.
It is a compressible circular ring with two smooth-edged end terminals. The ‘ski tip’ design of the end terminals aid in avoiding entrapment of the capsular equator on insertion and also allows for the placement of secondary instrumentation.

The CTR is manufactured by both Morcher GmbH (Stuttgart, Germany) and Ophtec (Groningen, The Netherlands), and are US Food and Drug Administration (FDA) approved. The Morcher ring, also known as the Reform ring, comes in three different sizes based on an uncompressed diameter: 12.3 mm (compresses to 10.0 mm), 13.0 mm (compresses to 11.0 mm) and 14.5 mm (compresses to 12.0 mm). The Ophtec ring (which is marketed as StabilEyes in the United States by Advanced Medical Optics, Irvine, California) is available in a 13-mm ring (compresses to 11 mm) and a 12.0-mm ring (compresses to 10.0 mm). The CTR may be inserted manually with forceps or with injectors (authors’ preference), which are less traumatic. Both Ophtec and Geuder (Heidelberg, Germany) manufacture injectors that may be used to implant the Morcher and Ophtec CTRs. It is important to note that the Ophtec CTRs are not compatible with the Geuder injector. Both the Morcher and Ophtec CTRs, however, may be used with Ophtec injector.

Currently, few studies exist examining the safety and efficacy of CTRs. In a prospective study of 21 eyes, Jacob et al. [1] evaluated the safety and efficacy of the CTR in patients with less than 150˚ of zonular dialysis. The mean follow-up time was 242.33 days. They found that phacoemulsification with in-the-bag PCIOL and CTR implantation had a 90.47% success rate. Capsular collapse did not occur in any eye, but two eyes developed intraoperative extension of dialysis. Fifteen eyes (71.42%) had a final visual acuity of 20/40 or better. All patients with successful implantation remained well centered at 6 months.

Bayraktar et al. [2] examined the effect of an endocapsular tension ring in preventing zonular complication during phacoemulsification in patients with pseudo-exfoliation without overt zonular weakness. This was a prospective randomized study of 78 eyes with pseudo-exfoliation cataracts that were randomly divided into two groups. CTRs were implanted in 39 eyes and the remaining 39 served as controls. Five eyes (12.8%) in the control group and no eyes in the CTR group developed intraoperative zonular separation. The posterior capsule rupture rate was 7.7% in the control and 5.2% in the CTR groups. Capsular IOL fixation was 94.9% and 74.3% in the CTR and control groups respectively.

In their retrospective series of 14 cases with loose or broken zonules managed with capsular tension rings, Gimbel et al. [3] concluded that CTRs help to avoid capsular bag collapse and vitreous presentation during surgery. No observable IOL decentration occurred in their group.

With regards to the issue of IOL tilt and decentration, Lee et al. [17] reported their findings on 40 eyes of 20 patients who were followed for 2 months. Each patient had an IOL in one eye and an IOL with a CTR in the fellow eye. Comparatively, the IOL-CTR group had a statistically lower rate of IOL decentration compared with the IOL-only group using Scheimpflug image analysis. The mean decentration in the IOL-CTR group was 0.42 ± 0.17 mm, whereas in the IOL-only group it was 0.57 ± 0.16 mm. The amount of IOL tilt at 60 days was also significantly less in the IOL-CTR group (IOL-CTR 2.47 ± 0.40˚, IOL-only 3.06 ± 0.56˚).

Selection of capsular tension ring size

The selection of CTR size is based on capsular bag dimensions. A larger capsular bag usually requires a larger ring. Many surgeons prefer to choose a slightly larger implant, with 13 mm being most common. At minimum, overlap of the end terminals is needed to provide complete circumferential support. Vass et al. have shown that the size of the capsular bag positively correlates with the globe’s axial length [18]. The corneal diameter is also an indicator of capsular bag size [18]. On the basis of this information, white-to-white corneal measurement and axial measurements can be used as a guide to CTR sizing, although many surgeons advocate routinely using...
larger sizes (authors’ preference) to ensure adequate overlap of end terminals. Furthermore, it would be appropriate to use a larger CTR in cataract surgery involving highly myopic eyes [18].

Modified capsular tension ring

Prior to the advent of the M-CTR, management of profound lens subluxation required more invasive and complicated surgery as the standard CTR is unable to provide adequate intraoperative support and center the capsule bag in these cases. Some surgeons sutured the standard CTR through the capsule bag with or without a peripheral capsulorhexis and then lassoed the CTR along with the peripheral capsule [19]. To avoid the risk of creating capsular tears with this technique, Cionni developed the M-CTR (Morcher GmbH) in 1998 (Fig. 3, Table 2). This implant provides a solution to extensive and/or progressive zonular damage by allowing the surgeon to anchor the capsule bag to the eye wall. It is an open-ring design with one (model 1-L or 1-R) or two (model 2-L) fixation eyelets attached to the central ring. The eyelets, which allow the ring to be sutured to the sclera, protrude 0.25 mm forward from the body of the CTR and thus sit anterior to the anterior capsule, thereby conserving the capsule bag’s integrity on suturing [6].

Moreover, an adequately sized capsulorhexis (that is, 5.5 mm) is of utmost importance when working with the M-CTR. In cases of a small capsulorhexis margin, the hook may drag on the capsulorhexis edge and result in iris chafing and related pigment dispersion and chronic uveitis.

Cionni et al. [20] studied the effect of the M-CTR in 90 eyes with congenital loss of zonular support. In 94% of cases, the M-CTR provided good centration of the capsular bag and PCIOL. In 80% of eyes, the best-corrected visual acuity was 20/40 or better. The suture breakage incidence was 10%. Hence, recommendations were made to use 9–0 rather than 10–0 sutures to address this concern.

Ahmed et al. [21] reported their series of 68 consecutive patients with profound zonulopathy due to a variety of causes in which the M-CTR was scleral-fixated. The double-eyelet M-CTR was implanted in 10 cases with the remainder receiving the single-eyelet M-CTR. Varying causes for zonular weakness included Marfan’s syndrome (22 cases), trauma (19 cases), ectopia lentis (10 cases), pseudoexfoliation (six cases) and other (12 cases). The average follow-up time was 12.4 months with all cases achieving adequate centration. Complications included elevated intraocular pressure (six cases), mild PCO tilt (five cases), pigment dispersion (two cases), mild iritis (five cases) and cystoid macular edema (four cases). These results demonstrated the wide range of clinical situations where a M-CTR may be utilized. One of the major findings of these studies is that the need for vitrectomy, which would have been routinely required with many of these cases, is often obviated with the use of capsular tension devices.

Table 2 Key points about the CTR

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<thead>
<tr>
<th>When to use a CTR</th>
<th>When not to use a CTR</th>
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<tr>
<td>Mild zonular weakness:</td>
<td>Anterior capsule tear.</td>
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<tr>
<td>less than 4 clock hours of dialysis;</td>
<td>Posterior capsule rent.</td>
</tr>
<tr>
<td>mild generalized instability.</td>
<td>Incomplete rhexis.</td>
</tr>
<tr>
<td>All pseudoexfoliation patients (debated): does improve centration and tilt.</td>
<td>Severely subluxed capsular bag.</td>
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</table>

Figure 3 Cionni M-CTR for suture scleral fixation
In their case series of seven eyes (five patients), Moreno-Montanes et al. [22] demonstrated that M-CTR implantation was an acceptable procedure to correct limited lens subluxation, with preservation of the capsular bag and relatively few complications.

Capsular tension segment

The CTS, designed by Ahmed in 2002 (Figs 4a–d) and manufactured by Morcher GmbH, is also intended for patients with profound zonular insufficiency. It is designed for cases requiring optimal intraoperative support (Figs 4b, 4c) for significant zonular weakness, or for patients in need of long-term postoperative centration of an IOL within the capsular bag. This partial PMMA ring segment (Fig. 5) is 120° with a radius of 5 mm and, like the M-CTR, the CTS also possesses an anteriorly positioned fixation eyelet.

Placing a CTR into an eye with a dense cataract or significant zonular weakness prior to phacoemulsification

Figure 4a CTS

Figure 4b CTS with iris retractor through eyelet for intraoperative stabilization

Figure 4c Phacoemulsification with CTS and iris retractor in place

Figure 4d Sutured CTS in place after surgery with well centered IOL
can be challenging and may create further zonular damage [23••]. As the CTS can be implanted without a dialing technique and thus with much less force transmitted to the zonular apparatus, it has a distinct advantage over the CTR and M-CTR in these situations. The CTS is designed to slide into the capsule bag with minimal trauma, and thus may be used in cases of a discontinuous capsulorhexis or anterior capsule tear, or a posterior capsule rent. It is inserted into the capsule bag after capsulorhexis and placed over the area of zonular weakness. The main body of the device sits inside the capsule bag supporting and extending the capsule equator. The central eyelet remains anterior to the capsule. When used for intraoperative support, an inverted iris retractor, via a paracentesis, is placed through the eyelet acting as a coat hanger to support the capsule in the area of zonular weakness (Figs 4b, 4c). For global weakness, multiple CTS devices may be used in a similar fashion [24••] (Fig. 6). Unlike other endocapsular devices, the CTS may be used only as an intraoperative device and can be easily removed once lens extraction is complete or, as most surgeons do, it can be permanently suture-fixated to the sclera, much like the M-CTR for long-term capsular bag support and centration. It should be distinguished that the CTS provides support in the transverse plane when sutured to the scleral wall. When circumferential support is also required, a CTR may be implanted in conjunction with an already positioned CTS (authors’ preference).
The CTS is available in three different radii of curvature: 4.5 mm (model 6E), 5.0 mm (model 6D) and 5.5 mm (model 6C).

In a consecutive series of 35 patients in which a CTS was implanted with or without another support device, IOL centration was achieved in all cases with no significant IOL tilt [25]. Several combinations of devices were used including the following: one CTS (nine patients), two CTSs (eight patients), CTS + CTR (nine patients), CTS + Iris coloboma ring (one patient) and CTS + Iris diaphragm rings (four patients). Two patients developed an intraoperative anterior capsule tear and one patient develop a posterior capsule rent, but the CTS was still successfully implanted in these cases. Three patients developed PCO. Initial outcomes have demonstrated the versatility of the CTS both as an intraoperative tool and implant support device.

Closed foldable capsular folding ring
Dick [26] has recently introduced a new device, the closed foldable capsular ring (CFCR), which is a foldable capsular tension and bending ring system with a sharp-edged design. The CFCR has eight hydrophobic and eight hydrophilic ring segments. The minimum overall diameter is 9.2 mm. This implant device can be inserted either manually with forceps and a two-folded technique or through an injector cartridge system. In their series of 104 eyes, this implant was inserted through a small incision (1.6–3.2 mm) with no significant complications over 6-months follow-up. PCO was minimal or absent in all cases.

Current issues concerning capsular tension rings
In this section we describe current issues concerning CTR.

What device to use
A comparison of CTR, M-CTR and CTS is given in Table 3. Some surgeons feel that the choice of endocapsular support devices depends mainly on the nature of zonular weakness (nonprogressive compared with progressive) [24••]. It would perhaps be more useful to also take into consideration the degree of zonular loss and/or extent of generalized zonular instability.

Nonprogressive zonulopathy such as traumatic or iatrogenic zonular dialysis or zonular coloboma are well suited for standard CTRs as the remaining zonular fibers are usually quite strong and, with redistribution of these forces with the CTR, can support the capsular bag [24••]. In progressive cases such as advanced pseudoxfoliation syndrome or Marfan’s syndrome, however, a suturable M-CTR or CTS may be of optimal value as it can be secured to the sclera. Further support can be achieved as necessary by combining devices depending on the amount of scleral-fixation needed. Moreover, endocapsular ring implantation does not eliminate the underlying cause of zonular weakness and in severe cases of progressive dialysis it may be unavoidable with a conventional CTR to prevent pseudophacodinesis, further luxation or dislocation of the capsular bag complex into the vitreous [4••].

CTRs are indicated in cases of mild, generalized zonular weakness or small, localized zonular dialysis (less than 3–4 clock hours). In cases of profound zonular insufficiency, a standard CTR may not supply enough intraoperative and postoperative support to maintain the desired orientation of the capsular bag.

In more advanced or progressive cases of zonular instability, the Cionni M-CTR or the CTS(s) is indicated. A 9.0 Prolene suture with double-armed CTC-6 needles (Ethicon Inc, Somerville, New Jersey) is passed through the eyelet of the fixation hook of the CTS or MCTR prior to implantation and fixated to sclera [27]. An ab-externo approach through a scleral groove to suture the CTS or MCTR has been proposed, which can be performed under topical anesthesia [28].

When to place the capsular tension ring
Issues concerning the timing of insertion are given in Table 4. The CTR can be inserted into the capsule

<table>
<thead>
<tr>
<th>Table 3 Comparison of CTR, M-CTR and CTS</th>
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<tr>
<td><strong>CTR</strong></td>
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<tr>
<td>Requires continuous curvilinear capsulorhexis</td>
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<tr>
<td>May be placed prior to lens removal</td>
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<tr>
<td>Use with anterior capsule tear</td>
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<tr>
<td>Use with posterior capsule rent</td>
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<tr>
<td>Use with large zonular dialysis (more than 4 clock hours)</td>
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<tr>
<td>Use in progressive zonulysis</td>
</tr>
<tr>
<td>Allows for suture fixation to sclera</td>
</tr>
<tr>
<td>May be easily removed from eye if needed</td>
</tr>
<tr>
<td>Cortical removal difficulty</td>
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bag at any time following capsulorhexis, viscodissection and hydrodissection. There has been debate as to the optimal timing of CTR insertion. CTR implantation after capsulorhexis and hydrodissection, but before nucleus extraction (early implantation) has been hailed as a safe alternative in cases of pseudoexfoliation. By using this early implantation technique, reduced intraoperative complications caused by zonular separation have been reported [2]. During phacoemulsification and cortical aspiration, the distended capsular orientation decreases the risk of it being aspirated by the phaco or irrigation/aspiration tips [3,29].

There are drawbacks to CTR implantation prior to nuclear extraction. Entrapment of cortical material by the CTR against the capsular bag may hinder removal [12]. Placing the CTS as an intraoperative device during phaco and cortex removal, however, helps solve this problem as it is much easier to strip cortex around the partial segment as opposed to the full ring structure.

CTR implantation prior to cataract removal may result in further iatrogenic zonular damage. Ahmed et al. [23**] using Miyake-Apple video analysis, have demonstrated that early CTR implantation in cases with moderate zonulysis results in significant zonular elongation and capsular displacement of up to 4 mm compared with later CTR implantation. Furthermore, if a capsular tear ensues there is risk of CTR subluxation into the vitreous body [12,14]. It is therefore recommended (authors’ preference) that the optimal timing of CTR or M-CTR insertion into the capsular bag be as late as safely possible (CTS may be implanted early due to its atraumatic entry). For cases of serious zonular weakness, the CTS may be used in conjunction with an iris retractor for intraoperative support as described earlier. Alternatively, iris retractors or modified capsule retractors (Mackool Cataract Support System, Duckworth and Kent Ltd, Hertfordshire, UK) placed on the capsulorhexis (Fig. 7) may provide support, but risk capsular tear or dislodgement, which is less likely with the CTS. Performing phaco in profound zonular instability without the support of CTS or iris/capsular retractors risks capsule bag dislocation and lens subluxation, even if a CTR has been implanted.

**Pseudoexfoliation and capsular tension devices**

Patients with pseudoexfoliation are excellent candidates for CTR implantation, due to associated progressive zonular deterioration [2]. There is a debate, however, as to whether all pseudoexfoliation patients should receive CTRs. These patients are at an increased risk for intraoperative complications, as well as postoperative IOL dislocation especially from superior zonular dialysis [30,31]. Postoperative capsular phimosis is also an impending risk in pseudoexfoliation syndrome. Moreno-Montanes and Rodriguez-Conde [32] have recommended that CTR placement should be mandatory when operating on all patients with pseudoexfoliation. There is currently no evidence, however, demonstrating that pseudoexfoliation patients without any zonulopathy require an insertion of a CTR prophylactically. Furthermore, even with CTR implantation, certain progressive cases may still dislocate years later [4**].

**Capsule phimosis**

Due to weakened zonules exerting decreased centrifugal forces, the contractile forces of an anterior fibrosing capsule may be overwhelming, thereby leading to capsular phimosis. Capsular contraction forces may be symmetric or asymmetric. Asymmetric forces cause the IOL to shift to one side (usually the stronger side), whereas symmetric contraction is less likely to result in lens decentration.

### Table 4 Timing of CTR insertion

<table>
<thead>
<tr>
<th>When to place a CTR&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Prior to phaco</th>
<th>After phaco/cortical removal</th>
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<tbody>
<tr>
<td>- Offers better nuclear stability for phacoemulsification</td>
<td>- Offers better nuclear stability for phacoemulsification</td>
<td>- Offers better nuclear stability for phacoemulsification</td>
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<tr>
<td>- More difficult with dense lens (higher risk of iatrogenic zonular damage)</td>
<td>- More difficult with dense lens (higher risk of iatrogenic zonular damage)</td>
<td>- More difficult with dense lens (higher risk of iatrogenic zonular damage)</td>
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<tr>
<td>- Difficult to remove cortex</td>
<td>- Difficult to remove cortex</td>
<td>- Difficult to remove cortex</td>
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<sup>a</sup>CTS may be inserted at any time due to atraumatic entry.
Tehrani et al. [33] showed a positive correlation between capsular bag shrinkage and axial length in their study with the capsule measuring ring (HumanOptics, Erlangen, Germany). Utilizing preoperative biometric data, a regression formula of moderate validity was determined to predict the amount of capsular bag shrinkage.

Although it was initially felt that anterior capsule contraction following cataract surgery with CTR placement might be prevented [3,34], more recent reports have indicated that capsular phimosis is still a postoperative concern despite CTR implantation [29]. Capsular contraction to the point of complete capsulorhexis opening occlusion has also been reported despite CTR use [34, 35]. Capsular contraction has occurred following CTR implantation with IOLs made from silicone, PMMA and acrylic materials [34]. CTRs are still beneficial in these situations, however, as the capsular contraction is typically symmetrical as opposed to asymmetrical without the use of a CTR, thus reducing the risk of IOL decentration.

Methods to further reduce the risk of capsule contraction syndrome include creating a capsulorhexis opening of 5.5–6.0 mm, use of an acrylic IOL [36–39], aspiration of lens epithelial cells (LECs) on the undersurface of the anterior capsule to reduce LEC proliferation and metaplasia [40]. LEC metaplasia and fibrosis may also be reduced by the presence of an endocapsular ring by decreasing contact between the optic and anterior capsule [41]. Anterior capsule relaxing incisions either during surgery with microscissors or after surgery with a Nd:YAG anterior capsulotomy is a critical step to prevent decentration (Fig. 8).

Kurz and Dick [42] demonstrated that the spring constant of a CTR is a suitable mechanical characteristic to facilitate the choice of CTR model. They found that CTRs with lower spring constants were more advantageous for the management of zonular dialysis, whereas higher spring constant CTRs were ideal for the prevention of capsular bag shrinkage.

**How to manage capsular tension ring dislocation**

Postoperative CTR subluxation or dislocation is a risk for patients with severe or progressive zonulysis. In a retrospective interventional case-series of 11 patients, Ahmed et al. [4••] demonstrated that CTR decenterations, including into posterior vitreous, may be effectively managed with scleral-suture fixation of the CTR through the fibrotic capsular bag, or with the placement of a CTS under the anterior capsule to reposition the displaced apparatus.

In cases where a CTR displaced into the vitreous cavity cannot be repositioned, several techniques of retrieval have been reported. Lang et al. [14] have reported the successful removal of an intact ring through a sclerotomy site. Another possible approach is to cut the fallen ring into two halves and remove each half by using two forceps utilizing a bimanual technique [43]. A third technique proposed by Ma et al. [44] appears to be the most viable and safest option. This approach encompasses the use of a CTR injector to withdraw the ring in one piece through the initial phaco incision.

**Posterior capsule opacification**

Although the incidence of PCO is reduced with the use of CTRs [8], PCO has still been reported after surgery [24••]. To minimize the risk of PCO, Nishi et al.’s [41] capsular bending ring (CBR) may be utilized, with the added feature of a square edge. This model has been shown to significantly reduce the risk of posterior capsule epithelial growth [41]. In additional, Dick et al. [45] reported that combining a viscoadaptive viscoelastic agent and a CBR not only enhances the safety of primary and secondary PCIOL implantation and IOL exchange in pediatric cases, but also reduces PCO. A square-edged IOL design used in conjunction with a CTR may also decrease the incidence of PCO [38].

PCO was reported to be of particular concern when using the Cionni M-CTR [22]. With the fixation hook protruding anterior to the capsulorhexis margin, it has been suggested that the anterior capsule may be slightly lifted away from the optic and this may facilitate LEC migration in this zone [22].

**Conclusion**

Endocapsular devices offer numerous advantages in situations of zonular insufficiency including reestablish-
ment of the capsular bag contour, decreased risk of PCO, decreased capsular bag collapse and risk of aspiration, limited late IOL decentration due to asymmetric capsule contraction, decreased irrigation fluid passing behind the capsule, decreased risk of vitreous herniation, decreased IOL decentration, closure of the capsule and extension of zonular dialysis [46].

Over the past decade, there have been dramatic advances in the management of zonular weakness. From the advent of the capsular tension ring to the more recent CTS, each device has served to play a specific role in the management of weak zonules in cataract surgery.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

* of special interest
** of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 105).


This paper demonstrates that the M-CTR can be used in a variety of clinical situations.


This paper demonstrates that optimal CTR insertion timing should be delayed to be as safe as possible.


This paper provides a brief review on Capsular Tension Devices.


Capsular tension rings and related devices Hasanee et al. 41