In recent years devices and techniques were developed to preserve the capsular bag and maintain the capsular diaphragm between the anterior and posterior segments of the eye. Small zonular defects (up to 3 clock hours) can be treated using a capsular tension ring (CTR), however large defects require suture fixation of the capsular bag to the scleral wall. Modified endocapsular rings were developed, such as Cionni’s ring (modified capsular tension ring, MCTR), Malyugin-Cionni ring and Ahmed’s Segment (capsular tension segment, CTS) (both manufactured by Morcher GmbH, Stuttgart, Germany). The modified rings support the entire (MCTR) or a part (CTS) of the capsular equator and are sutured to the scleral wall through an extension of the ring passing through the anterior capsulorhexis. In this article we discuss intraoperative clinical findings and strategies for managing compromised zonules during the early steps of cataract surgery, including capsulorhexis and hydrodissection, explaining the application of capsular tension rings and capsule retractors, devices that are especially helpful in weak zonule cases.

**Pearls for Anterior Capsulorhexis**

The lack of zonular circumferential traction due to diffuse zonular weakness will create difficulty incising the anterior capsule, as though the cystotome were dull. If the cystotome tip depresses rather than incises the central anterior capsule, a halo-shaped light reflex may be noted. Finally, there may be significant phacoemulsification as the cystotome first perforates and tears the anterior capsule. Weak zonules significantly increase the risk of a radial anterior capsular tear because of this pseudoelasticity. Because the zonules do not adequately immobilize the anterior capsule, the peripheral capsule moves along with the flap as it is being torn. While a large diameter capsulorhexis would be helpful for phaco, making a smaller opening reduces the risk of a peripheral extension if one is struggling to control the tear.

Capsular retractors or a capsular tension ring (CTR) require a continuous curvilinear capsulotomy, the overriding importance of achieving an intact capsulorhexis dictates erring on the side of a smaller diameter that can be secondarily enlarged after the IOL has been implanted. The capsule tear-out rescue technique may be helpful for controlling a tear that wants to run radially because of weak zonules and pseudoelasticity.

**Pearls for Hydrodissection**

When there is diffuse zonular laxity, the nucleus is more difficult to rotate because of deficient capsular rotational stability and counter fixation. One should therefore suspect significant circumferential zonular weakness if, despite proper and gentle hydrodissection technique (Figure 2), the nucleus does not rotate easily. Overly forceful efforts to rotate...
the nucleus may shear already weakened zonules. This may potentially create a large zonular dialysis or dislocate the crystalline lens even prior to insertion of the phaco tip.

One alternative is to use two instruments to bimanually rotate the nucleus. In this situation, the second instrument tip, rather than the capsular bag, becomes the counter fixating fulcrum around which to rotate the nucleus. However, when severe zonular laxity is diagnosed during the capsulotomy step and the nucleus cannot be easily rotated following hydrodisssection, the safest strategy is to insert capsule retractors. By fixating the capsular bag to the eye wall, capsule retractors will facilitate nuclear rotation and avoid creation of a zonular dialysis in the process.

**Pearls for Capsular tension rings (CTRs)**

There are some signals that must be cautiously evaluated during the slit lamp pre-op examination. While frank subluxation of the crystalline lens or extensive zonular dehiscence are easily evidenced, other aspects such as subtle iridodonesis or phacodonesis, deep anterior chamber, vitreous in the anterior chamber, increased retro-iridal space, and the presence of pseudo-exfoliative material at the papillary rim can be overlooked. These signals are frequently found in the following diseases: previous ocular trauma, Marfan syndrome, high myopia, and previous intraocular surgery. These are situations where the implantation of capsular rings may be advisable (Figure 3).

In cases of mild zonular dialysis with little or no decentration of the crystalline, CTRs are enough to provide adequate stabilization of the capsular bag. They maintain the equator of the capsular bag fully distended in 360 degrees, ensuing better conditions for the phacoemulsification and for the centration of the intraocular lens in the bag. The choice of the diameter of the CTR — in correlation to the size of the eye globe and or its dioptic power is not very important, as the implantation of a ring with a diameter bigger than that of the equator of the bag will only have the consequence of the overlapping of the extremities of the ring. On the other hand, choosing one with a diameter smaller than the diameter of the capsular bag will leave part of the capsular equator floppy.

The Cionni ring (CR) is the option when the dialysis is bigger than four clock hours and the subluxation of the crystalline is easily noticed through the well-dilated pupil. In the severe cases, one may choose the CR with two fixating eyelets instead of the model with one eyelet. As these eyes require additional delicate maneuvers at the ciliary body level and the surgery is lengthier than usual, topical anesthesia is not a good choice. In cases where a posterior capsular rupture is evidenced, both the CTR and the CR should not be implanted, as well as in cases of posterior polar cataract due to the higher risk of defective posterior capsule.

CTRs have two important disadvantages. Significant compression is required to implant the ring into the capsular bag because of its larger size. This may stretch the capsulorhexis and potentially shear zonules by ovalizing or decentering the bag. Because of this compressive rebound force, CTRs should never be inserted in the presence of an anterior or posterior capsule tear. Secondly, the ring may impede cortical aspiration by pinning and trapping cortex in the capsular fornix. Surgeons can delay CTR insertion by instead using capsule retractors to stabilize the bag during phaco. The capsule retractors should be left in place during CTR insertion to reduce zonular trauma.

CTRs compensate for weakened zonules in several ways. With a focal zonular weakness or dehiscence, the ring redistributes mechanical forces (e.g., from nuclear sculpting or IOL insertion) to areas of stronger zonular support. However, if the entire circumference of zonules is uniformly weak, this benefit is lost. A second advantage is that centrifugal pressure applied by the ring makes the flaccid capsular bag taut. This reduces redundant capsule folds, forward trampolining of the posterior capsule, and inward collapsing of the capsular fornices toward the aspirating instrument tip. The final benefit of a CTR is to counter progressive contractile capsular forces post-op. Severe capsulophimosis is always a result of deficient zonular counter traction and is a likely factor in spontaneous late dislocation of the entire capsular bag in pseudoexfoliation.

**Pearls for Using Capsular Anchor**

Ehud Assia, MD has developed “Capsular Anchor” an alternative device to fixate the intact lens capsule to the scleral wall (Figure 4). The Capsular Anchor (Hanita lenses, Kibbutz Hanita, Israel) is a poly methyl methacrylate (PMMA) intraocular, uni-planer implant, inserted into the capsular bag after capsulorhexis is performed. The Anchor clips the anterior...
capsule, and supports a localized segment of the lens equator. The two lateral arms of the device are inserted behind the anterior lens capsule whereas the central rod is placed in front of the capsule. A 10-0, or preferably 9-0, prolene suture is used to fixate the Anchor to the scleral wall. After lens removal by phacoemulsification a conventional PC-IOL is inserted into the capsular bag. The capsular Anchor recently gained the CE mark and permit for use in Europe and is in use in several countries.

**Pearls for Inserting Capsule retractors**

In addition to enlarging a small pupil, flexible iris retractors can be used to support the capsular bag in the presence of extremely loose zonules. However, because the hooked ends are very short and flexible, iris retractors may tend to slip off of the anterior capsular edge during phaco and will not support the equator of the capsular bag. Richard Mackool, M.D., designed capsular hooks that are elongated enough to support the peripheral capsular fornix and not just the capsulorhexis edge. In this way, the retractors function as artificial zonules to stabilize the entire bag during phaco and cortical cleanup. Unlike capsular tension rings, capsule retractors provide much better support in the anterior-posterior direction and do not trap the cortex. The disposable nylon capsular retractors from MicroSurgical Technology (Redmond, WA, USA) are a newer alternative to the Mackool Capsule Support System. Packaged three to a container, the former feature a double-barreled design that creates a loop at the tip, which is less likely to puncture the equatorial capsule.

Capsule retractors can be inserted through limbal stab incisions at any stage including midway through the capsulorhexis step. By anchoring the bag to the eye wall, the additional antero-posterior support and rotational stability facilitate hydrodissection and nuclear rotation. The self-retaining capsule retractors are also strong enough to center and immobilize a capsular bag that is partially subluxated due to a severe zonular dialysis. Finally, they restrain the peripheral anterior and equatorial capsule from being aspirated and dehisced by the phaco or I/A tip. As a single strategy for severe zonular deficiency, capsule retractors are significantly more effective than capsular tension rings at preventing posterior capsule rupture. Because CTRs can only redistribute instrument and mechanical forces to the remaining intact zonules, the greater the zonular defect or deficiency, the less effective a CTR is at stabilizing the bag. However, a CTR can be used in conjunction with capsule retractors, particularly if there is a sizable zonular dialysis. If after first inserting retractors the unsupported equatorial regions of the capsular bag tend to collapse inward toward the phaco tip, a CTR can be inserted to distend the equator of the bag to its proper anatomic configuration.

Although the tip of the capsule retractor is dull, it is possible for the hooks to tear the capsulorhexis margin during surgery. There is a tendency to over tighten the capsular retractors because the tension is initially adjusted with a soft eye. Inserting the phaco tip with irrigation suddenly displaces the nucleus and capsular bag posteriorly, which effectively further tightens the retractors. After inserting the phaco tip, it is therefore important to momentarily assess whether the capsule retractors have become so taut that they tent the capsulorhexis edge. If so, they should be loosened slightly so that the capsular rim does not tear during phacoemulsification. This is particularly important if the capsulorhexis diameter is on the small side.

**Pearls for Nuclear emulsification in Compromized Zonules**

Fragile zonules are very prone to further damage during nuclear emulsification, and poor capsular bag stability heightens the risk of capsular rupture. Forceful sculpting or rotation of the nucleus may shear zonules in the oppositely located quadrants. Care should be taken to avoid causing excessive nuclear movement with sculpting, chopping, or rotation. Phaco chop significantly reduces the stress placed on the zonules and capsule by replacing sculpting and cracking motions with the manual forces of one instrument pushing inward against another. Because of the centrally directed instrument forces, horizontal chopping is particularly effective at avoiding nuclear tilt or displacement, and it is this author’s preference for weak zonule cases. The supracapsular flip technique prolapses and flips the endonucleus out of the capsular bag prior to emulsification. If accomplished, this prevents the capsular bag from bearing any of the phaco instrumentation forces. The ease with which this flipping maneuver can be accomplished varies depending upon the size of the endonucleus relative to the
cases may not be safe with a lax posterior capsule that is setting that usually avoids post-occlusion surge with routine /g68/g86/g83/g76/g85/g68/g87/g76/g82/g81/g3/g193/g82/g90/g3/g85/g68/g87/g72/g3/g76/g86/g3/g68/g71/g89/g76/g86/g68/g69/g79/g72/g17/g3/g36/g3/g83/g85/g72/g16/g83/g85/g82/g74/g85/g68/g80/g80/g72/g71/g3/g89/g68/g70/g88/g88/g80/g3 inadvertent aspirating the peripheral or posterior capsule. smaller-diameter, 20-gauge tip greatly reduces the risk of is removed. Compared to a standard 19-gauge phaco tip, a situation, one must be vigilant as increasingly more nucleus removed. Because the nuclear bulk will initially mask this as the last nuclear fragments, epinucleus, and cortex are inadvertently aspirating the more pliant anterior capsule may cause a by a capsule polisher. While removing cortex, inadvertently aspirating the more pliant anterior capsule may cause a zonular dialysis. Effective hydrodissection is crucial because the more easily lens material separates from a floppy capsule, the less likely it is for the capsular folds to be aspirated.

Pearls for Cortical cleanup

As adherent cortex is aspirated, the usual centrifugal capsular counter fixation afforded by stronger zonules is deficient. Lacking circumferential zonular tension, a lax posterior capsule tends to cling to epinucleus and cortex that is being aspirated, and redundant capsular folds can be easily ensnared by the aspirating instrument or snagged by a capsule polisher. With removing cortex, inadvertently aspirating the more pliant anterior capsule may cause a.

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