

Loose Lens Surgical Management

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Abstract

The loose lens has numerous etiologies, of which trauma and pseudoexfoliation syndrome are the most common. In addition to history, numerous signs observed at the slit-lamp should be recognized and evaluated. Proper identification and surgical planning can help avoid complications during cataract extraction. The surgical indications for lens extraction, surgical techniques to improve stability throughout the entire case, and reported results of these measures will be discussed. With an appropriate approach and settings, phacoemulsification can successfully be performed with a loose lens. Specific adjunctive measures discussed include capsular tension rings and capsule hooks. Through a thorough evaluation and knowledge of various surgical techniques to stabilize the lens, the postoperative outcomes for phacoemulsification of the loose lens can be significantly improved.

Keywords

Loose lens, zonular dialysis, zonular laxity, phacodonesis, ectopia lentis, capsular tension ring, capsule hooks

Disclosure: The authors have no conflicts of interest to declare.

Received: July 29, 2012 **Accepted:** April 12, 2013 **Citation:** *US Ophthalmic Review*, 2013;6(2):105–8 DOI: 10.17925/USOR.2013.06.02.105

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Causes of the Loose Lens

Trauma has historically been the most common cause of a loose lens. Here the term loose lens is used broadly to mean zonular dialysis (weakness). Although common use of terms will vary, one early paper defines partial dislocation, or subluxation, as when the lens is still “partially in the hyaloid fossa but is displaced to one side of the optical axis”.¹ Luxation (complete dislocation) is complete displacement of the lens outside the hyaloid fossa associated with complete zonular dialysis. Ectopia lentis describes a congenitally dislocated lens.² In a series of 166 patients, trauma accounted for 53 % of cases.³ After appropriate and thorough evaluation for associated ocular injuries, other causes may be considered. Isolated lens subluxation or essential ectopia lentis can spontaneously occur in adulthood.^{4,5} There are numerous other causes and associations including ocular diseases such as pseudoexfoliation (which in more recent studies is most common),⁶ myopia, or aniridia. Systemic diseases that have been reported to be associated with ectopia lentis include Marfan’s,⁷ Ehlers-Danlos,⁸ Weill-Marchesani,⁹ sulfite oxidase deficiency,¹⁰ hyperlysinemia,¹¹ homocystinuria,¹² and syphilis.³

Evaluation of the Loose Lens

The three major complications of the loose lens include dislocation into the anterior chamber (AC), which can damage the cornea or cause acute angle closure glaucoma. Subluxation alone causes significant refractive error with astigmatism. Finally, dislocation into the posterior segment can lead to uveitis or retinal detachment. An exam should include external

examination for the signs of the systemic diseases discussed above. One of the main goals is to determine the range of dialysis as this determines which options will be most appropriate. After a careful refraction, the slit-lamp exam must include evaluation for phacodonesis (this may best be seen before dilation with low power while having the patient switch gazes or by tapping on the examination table), iridodonesis, iris transillumination defects, vitreous in the anterior chamber, and changes in the anterior chamber depth. More subtle signs of the loose lens include an uneven depth between the iris and the anterior capsule, and visualizing the lens equator on eccentric gazes, which can appear flattened without the outward force of normal zonules.¹³ Gonioscopy should be performed to evaluate for synechia, which can also influence the decision of placing an anterior chamber lens. Ultrasound biomicroscopy has been used to demonstrate the region of dialysis and can also demonstrate local rounding of the lens.¹⁴ Interestingly, although clearly instrumental for surgical planning, the number of clock hours of dialysis was not found to be associated with final postoperative visual acuity in at least one study.¹⁵ One definite and large confounder would be the presence of ocular comorbidities, especially in cases of trauma.

Proposed indications for surgical intervention include complete dislocation, mature cataractous changes, phacolytic uveitis, and decreased vision despite optimal refraction.⁴ In terms of preoperative identification of risk factors, a national registry that identified risk factors for a capsular or zonular tear found that trauma had the highest odds

ratio at 14, followed by synechia (7), phacodonesis (6), brunescence (4), and miosis (3).¹⁶

Intraoperative signs of the loose lens include direct visualization of the zonular dialysis, sudden increase in the anterior chamber depth and later flattening of the chamber as irrigation fluid passes through the dialysis and accumulates posterior to the bag, vitreous loss, and changes in position of the lens, such as the entire lens moving the direction of sculpting.⁵ During capsulorrhexis, if radial folds are seen they may point to the region of dehiscence. Abnormal rotation is another sign.

Loose Lens Surgical Management Surgical Planning

Techniques to deal with the loose lens begin preoperatively. Zonular dialysis has been well-described as increasing the rate of complications.¹⁷ If the surgeon is already planning on an extended surgery with suturing, topical anesthesia may be insufficient.⁵ If peri- or retro-orbital anesthesia is used, the surgeon can consider using a Honan balloon to disperse the volume. Intracapsular extraction (ICCE) is an option followed by either a posterior scleral sutured lens or an anterior chamber intraocular lens (ACIOL).¹⁸ Other techniques used include pars plana lensectomy with vitrectomy.¹⁹ Newer techniques have successfully been applied to phacoemulsification and will be described in detail. One proposed algorithm states that for less than 3 clock hours of dialysis, low-settings phacoemulsification may be sufficient.²⁰ For 3 to 5 clock hours, inserting a polymethylmethacrylate capsular tension ring (CTR), may be appropriate. Finally, for 5 to 7 clock hours, a scleral-sutured CTR can be used. If, instead, the bag is deemed to be too unsteady, ICCE or lensectomy should be carried out instead of phacoemulsification. Additional surgical support is not always needed: after reviewing over 9,500 consecutive cataract extractions, one study reported inserting a CTR in only 0.7 % of cases.²¹

If feasible, the main wound should be made directly across from the region of subluxation. If this cannot be achieved as with a temporal dialysis, then the second best location is 90° away. The incision should be small to limit wound leak with subsequent anterior chamber shallowing. If planning on transcleral sutures (discussed in detail below), the scleral window over the region of dialysis should be performed before the eye is entered and becomes softer. If vitreous has already bypassed the zonules and entered the anterior chamber, an anterior vitrectomy should be performed. Next, a barrier of retentive viscoelastic should be placed over the dialysis to tamponade the vitreous.

Capsulorrhexis should be started away from the region of dialysis. If the weakness is diffuse, and the lens is already subluxated, an incision near the area of subluxation will best protect the weakest zonules. If using a scleral-sutured CTR, consideration must be made of where the ring will be inserted and where the eyelet will be. The capsulorrhexis center needs to be adjusted away from the anatomic center of the lens because the final location of the bag will be displaced in the direction of the suture. Staining of the capsule may be necessary to improve visualization. The weakened zonular attachments will allow the capsule to be more flexible and resist tearing. The uneven distribution of forces will also affect the normal centripetal forces expected during the capsulorrhexis. This may necessitate either starting the capsulorrhexis with a 15° sharp-tip blade or using forceps to apply traction while a second instrument

creates the tear.²² This also provides the benefit of avoiding excess force applied posteriorly, stretching the zonules further. The size should be larger than normal (about 6 mm)²² for a number of reasons: the option of phacoemulsification in the iris-plane should be left open, as well as the option for a larger than normal haptic size. Also, zonular laxity allows for more capsular phimosis, especially with pseudoexfoliation. As the capsulorrhexis is extended toward the region, tension should always be directed toward the region of laxity rather than away. Once the capsulorrhexis is complete, the CTR or iris hooks can be inserted.

Again, to avoid overfilling the anterior chamber, it is beneficial to allow some fluid out of the main wound prior to hydrodissection. During hydrodissection the cannula is directed toward the region of laxity. If the nucleus can be completely dissected off the capsule and into the anterior chamber, then supracapsular phacoemulsification can be performed with a marked reduction of pressure on the zonules.

Phacoemulsification

Phacoemulsification should be performed with minimal pressure exerted on the zonules. Whichever technique is chosen, lowering all of the settings is advisable. This is carried out to avoid exerting undue pressure on the capsule and zonules. Besides the direct hydrostatic forces on the capsule and zonules, the zonular laxity allows for transudation of the fluid into the vitreous, with resultant vitreous hydration causing increased positive posterior pressure with possible vitreous loss. A technique described by Osher as 'slow motion phacoemulsification,' uses a bottle height between 35–50 cm, aspiration rate around 12 cc per minute, vacuum below 30 mmHg, and low ultrasound power.²³ This was shown to produce only very minor intraocular pressure fluctuations during phacoemulsification, protecting against AC shallowing.²⁴

Using mostly aspiration would be optimal, and chopping is another excellent option. A second instrument can be used to stabilize the lens during manipulations. If grooving is performed, then attention must be directed at not pushing on the lens such as from using inadequate ultrasound power. Forceful cracking should be avoided since it depends on exerting force against the bag, as should flipping techniques that depend on more forceful interactions with the capsule. Viscoelastic can be used to attempt to dissect the nuclear pieces from the bag so that rotating and manipulation can be carried out with less outward force applied to the bag.²⁵

Cortex Removal

A definitive hydrodissection is vital to completing cortex removal without worsening the dialysis. Irrigation and aspiration should be performed with movements made tangential to the region of dialysis. No movements should be made radial (perpendicular) to the region as this will enlarge the dialysis. For the cortex nearest the region, the cortex should be pulled tangentially and toward the region. A CTR can still be inserted at this point, either just before or after cortex removal. Other options to reduce the amount of applied traction include using viscoelastic to separate the cortex from the bag, inserting the lens earlier so it can serve as a barrier to protect the bag, or using manual irrigation and aspiration. A Simcoe cannula has been used dry to remove remaining cortex while an assistant continuously injects viscoelastic to keep the chamber and bag formed.²⁵ The Simcoe cannula or just a 27 gauge cannula can also be used at the end of the case to remove remaining viscoelastic while it is replaced with

balanced salt solution (BSS). Any vitreous loss should be dealt with in a similar way to a posterior capsular tear, by an anterior vitrectomy.

Lens Implantation

If the bag is judged to have enough support, placing a lens in the bag is the most-efficient technique. The lens may also be placed in the sulcus. Using a larger lens (over 6 mm) can help in case of further zonular dialysis with lens subluxation as a larger haptic will have a greater area of unimpaired vision. Using an inserter and unloading the lens deep and centrally can help avoid needing to make large forceful movements to rotate the trailing haptic into the bag. If the lens cannot be inserted easily into the bag, as can occur if the wound is not across from the region of dialysis, then the lens can be inserted in the anterior chamber and then manipulated into the bag one-half at a time.²² Placing the haptics perpendicular to the region of dialysis would help decrease the phimosis expected to occur around the region, though some place the haptics at the same axis as the dialysis.²⁶

Specific Surgical Techniques

Capsular Tension Ring

A CTR can be placed at any stage past capsulorrhexis when it is clear that the lens is otherwise too unstable to proceed. The CTR can be placed in the bag or sutured in place using a modified CTR (MCTR). One sizing technique uses either an 11 or 12 mm ring for standard cases, and, since axial length was shown to be proportional to bag diameter,²⁷ a 13 mm ring if the axial length was greater than 25 mm.^{26,28} More than one CTR can be inserted.²⁹ Injecting viscoelastic at the anterior capsule rim has the advantage of dissecting away cortex as well as providing adequate space to insert the CTR. The CTR is inserted either with forceps or an inserter. A second instrument with a hook can be used in conjunction with an inserter to lead the free end and guide the ring so that it is placed at the equator, covering the region of dialysis. CTRs create an even distribution of forces, thereby reinforcing the tenuous grip any weakened zonules have on the bag. It also keeps the bag in the region of the dialysis from freely coming toward the phaco tip. Inserting the ring after capsulorrhexis as opposed to after lens removal offers more protection and stability at the cost of making certain subsequent steps more challenging, such as trying to aspirate cortex trapped between the ring and the capsule (this can be addressed by pulling the cortex tangentially rather than radially). Also, computerized video analysis in cadaver eyes revealed that early implantation required more torque, which led to five times more displacement of the bag.³⁰ A CTR should not be used in case of an unstable bag, such as if there is a posterior tear or if a continuous capsulorrhexis could not be completed. This has led to extension of the tear and loss of the CTR into the vitreous.³¹

In cases with extensive dialysis or where the underlying process can be expected to progress (thus threatening the stability of the entire bag with the lens and CTR inside), a Cionni modified CTR with an eyelet that can be sutured to the sclera is the better option.³² One suturing technique reported by Ahmed and Crandall used a conjunctival peritomy carried out over the region of dialysis to insert a 13 mm 27 gauge needle 1 mm posterior to the limbus, then maneuvered anterior to the lens. Double-armed 10-0 polypropylene suture on a straight needle was passed one arm at a time through a paracentesis 180° away, guided across the chamber, and into the 27 gauge needle so the 27 gauge needle with the suture could

be pulled out through the peritomy site. Both suture ends are pulled until the loop is visible in the chamber and withdrawn out of the eye with a hook then cut. One end was guided through the eyelet then tied to the other cut end. The knot was pulled out so the ring could be inserted into the capsule, and rotated until the eyelet was in the region of dialysis. Altering just one step, passing the 10-0 in through the ciliary sulcus rather than a paracentesis, leaves four cut ends that allows for suturing two eyelets when necessary. The eyelet can also be threaded first, before going through the stab incision.¹⁵ The use of a 27 gauge needle is not required—a scleral flap can be made in that same position—and the needles can be directly passed into the paracentesis, across the anterior chamber, and out through the scleral flap.³³ The same double-armed 10-0 polypropylene sutures have also been passed through a scleral tunnel and then passed one over and under a standard CTR, and finally tied externally.³⁴ Also available is a poly(methyl methacrylate) (PMMA) ring with an eyelet resembling a MCTR described as a capsular tension segment that is considerably smaller at 4.75–5.5 mm.³⁵ The smaller size could make it easier to insert and offer less interference during cortical aspiration.

The main complication of using a CTR is worsening the integrity of the bag during insertion and manipulation of the ring. The dialysis can be enlarged or the anterior or posterior capsule may be torn by the ring or guiding instruments. In one study, the dialysis was enlarged in 9.5 % of cases.²⁶ Another surgeon reported that after implanting over 500 CTRs, there were zero intraoperative complications related directly to the CTR.²⁹

CTRs can almost half pseudophakic astigmatism,³⁶ which may be caused by IOL tilt or decentration,³⁷ and should be considered for toric lens implantation.

Results

One prospective series using a CTR for cases with less than 150° of dialysis successfully placed a lens in the bag in all but one of 21 eyes, and the IOL was still centered in all eyes 6 months later.²⁶ A multicenter prospective trial examined 255 cases with less than 4 clock hours of dialysis.⁶ Of the 255 eyes, there were only 15 intraoperative complications reported: four violated capsules, three lenses that had to be sutured in place, six vitrectomies, one worsened dialysis, and in one case the AC collapsed. An IOL was placed in the bag in 98 % of cases and at 12 months 98 % of the lenses were still centered. By 1 year, 9 % of cases required a posterior capsulotomy for posterior capsular opacity, while 9 % had capsular phimosis with only two cases requiring intervention.

A randomized control trial consisting of 78 patients with pseudoexfoliation syndrome undergoing cataract extraction randomized half of the patients to receive a CTR.²⁸ A lens was able to be placed in the bag in 95 % of CTR cases versus only 80 % of the controls. Vitreous loss occurred in 21 % of the controls versus only 5 % of the CTR cases. Best corrected visual acuity was statistically similar in the two groups.

MCTR has also shown favorable results in cases with up to 9 clock hours of dialysis.³⁸ A prospective series of 46 eyes noted postoperative decentration in only three cases (7 %), two of which required resuturing.¹⁵

Iris Hooks

Iris hooks have been used to fixate and support the anterior capsule following capsulorrhexis.^{39,40} Also available are hooks designed specifically

for the capsule. As is the case for iris retraction, four equidistant stab incisions are made for insertion of the hooks. The hooks engage the edge of the capsulorrhexis and are carefully retracted to provide evenly distributed support to the capsule. Hydrodissection and the remaining steps are performed as described above, and the hooks are removed after the lens is inserted.

One proposed benefit of the iris hooks compared with a CTR is that the hooks offer protection against anteroposterior movement, since with a CTR the whole bag can still move along with the zonules.³⁹ They also do not trap cortex beneath them as can occur with a CTR inserted early in the case. Hooks can also be combined with CTR in cases of dialysis from 3 to 6 clock hours.¹⁹ Given the smaller profile of the hooks, one possibility is inserting the hooks just after completing capsulorrhexis so that the CTR does not have to be inserted with the nucleus still in place.

Long-term Management

Complications following cataract extraction with a loose lens include further subluxation or complete dislocation, and increased capsular phimosis.²⁰ Using silicone lenses can lead to increased phimosis compared with acrylic lenses. Three-piece lenses with their more rigid

haptics can also reduce phimosis by exerting more centrifugal force. Posterior capsule opacity (PCO) following CTR use has been reported to occur as frequently as in 34 % after an average follow up of 4 years,¹⁵ and in higher percentages in smaller studies, especially involving younger patients.⁴¹ Early rabbit studies had shown that CTRs decreased the rate of PCO formation, as cells could not migrate posteriorly past the CTR.⁴² At this time it is still unclear if CTR affects the rate of PCO. In a study of MCTR outcomes with less than 3 years of follow up, 10 % of the 10-0 polypropylene stitches degraded with two-thirds of those cases requiring resuturing.³³ This lead Cionni to suggest using 9-0 polypropylene or 8-0 polytetrafluoroethylene suture for all MCTRs. For cases with a dislocated bag following CTR placement, one study reported successful recentering of the lens in nine of nine cases by scleral fixation of the ring as described above.⁴³

Conclusion

Zonular dialysis has numerous causes. The main surgical methods for overcoming the surgical difficulties include altered phacoemulsification technique and settings, CTRs, and capsular hooks. Through careful surgical planning, satisfactory outcomes can be achieved in a large portion of patients. ■

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