Femtosecond laser capsulotomy

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This guest editorial is one of a series looking back at landmark articles published in the JCRS. This special series commemorates the 25th anniversary of the joint Journal of Cataract & Refractive Surgery. This issue: Femtosecond laser capsulotomy. J Cataract Refract Surg 2011;37: 1189–1198.1

Friedman et al. presented an important article that examined femtosecond laser capsulotomy.1 The article presented a combined 3D optical coherence tomography (OCT) system and femtosecond laser for cataract surgery. Femtosecond lasers were well established in refractive surgery for creating a laser in situ keratomileusis flap. The introduction of OCT to guide the femtosecond laser for the first time enabled the creation of a 3D model of the anterior segment in real time. Landmarks from the OCT image were then used by the surgeon to apply the femtosecond laser through the cornea onto the lens capsule and nucleus. The OCT visualization allowed the laser to avoid the posterior capsule and other eye landmarks irrespective of the eye’s dimensions.

The femtosecond laser (Catalys Precision Laser System, OptiMedica Corp.) presented in the study used a liquid interface to limit the rise in intraocular pressure to 15 mm Hg, allowing for a more comfortable experience than that in laser in situ keratomileusis surgery. It also avoided creating folds in the cornea, thereby avoiding distortion to the laser beam path. A capsulotomy as opposed to a capsulorhexis was created. The capsulotomy took only 2.5 seconds, which was considerably faster than a capsulorhexis. Laser pulses were applied in a spiral pattern from posterior to anterior pattern, starting from anterior lens material and ending in the anterior chamber.

The article clearly demonstrated the geometric superiority of the capsulotomy when compared with the manual capsulorhexis (Figure 1). The capsulotomy took less time to perform and showed a 12-time improvement in precision in sizing. The accuracy in achieving a circular shape by 3 times was also noted. Furthermore, the central positioning of the capsulotomy to its intended location was very precise, resulting in a uniform and consistent overlap of the capsule over the intraocular lens (IOL) edge at all time points. Femtosecond lasers enabled the surgeon to choose the capsulotomy size for IOLs of different design.

The article also examined the capsulotomy edge strength in cadaveric porcine eyes and the experiments were conducted in vitro, unaffected by the variables that affect clinical use, such as eye movements.

This early publication coincided with the launch of 4 femtosecond cataract laser platforms from 4 different companies. Generally, the sense of precision associated with the term laser seemed to imply that femtosecond laser–assisted cataract surgery would always be precise, safe, and better than manual cataract surgery. The only concerns left to answer were the economic burden of the new technology and its implication for ophthalmic training. Indeed, a number of early adopters had low complication rates, with anterior capsular tears of 0.31%. 2 Others, however, reported laser-associated anterior capsular tears of 1.87% compared with 0.12% with manual capsulorhexis at their site.3 The femtosecond laser platforms used differed in the interface type: the former had direct contact and the latter used fluid in the interface.

This raised concerns regarding the claim of 2-fold increase in capsular strength of the laser capsulotomy vs manual capsulorhexis. An electron microscopy study examining capsulotomies generated by the different laser platforms suggested that the capsulotomy edge was improving with each generation of improvement in laser, irrespective of patient interface and tending to become as smooth as the capsulorhexis edge (Figure 2). However, laser platforms using noncontact patient interfaces were associated with anomalous misdirected laser pulses in 40% of the clinical capsulotomy samples (Figure 3). It was conceivable that if force was applied to these regions of the capsulotomy during cataract surgery, it would result in an anterior capsular tear, explaining some of the safety concerns reported by some surgeons. The cause for these pulses to be generated in 2.5 seconds was unclear. It may be that the low increase in intraocular pressure during docking using some platforms allowed for some small freedom to move. Of interest, the laser systems using contact interface did not experience this problem; they initially, however, had more tissue bridges. For the latter group, the direct contact likely resulted in indentation of the cornea, which in turn altered the laser beam path, preventing the laser pulse from perforating the capsule. These platforms were able to overcome the corneal indentation with the introduction of a contact lens.4

The clinical and morphological electron microscopy findings seemed to be at odds with the increased capsular strength reported with laser capsulotomy. Studies performed on unpaired cadaveric porcine eyes often

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suggested greater capsular strength after laser capsulotomy.\textsuperscript{6,7} Only 1 study on porcine eyes showed inferiority when capsules with aberrant pulses were specifically studied.\textsuperscript{8} In humans, there was no difference between femtosecond capsulotomy and manual capsulorhexis.\textsuperscript{9,10} This is in keeping with the concept that a smooth capsular edge is a strong capsular edge, irrespective of manual or laser. Although these studies highlighted the need for more nuanced study of laser platforms, no specific solution was made available for the aberrant pulses associated with noncontact laser platforms.

A large number of patients have undergone and continue to undergo uneventful laser cataract surgery. The gradual improvement in technology has resulted in capsulotomy edges approximating manual capsulorhexis smoothness.\textsuperscript{4} Laser capsulotomy has proven to be useful in complicated trauma cases, in cases of zonular weakness, and in white cataracts. Unlike the dispute over capsular strength, there has been no dispute to the claim that laser capsulotomy position and shape are very precise. The ability to control the capsular size and position precisely has raised the possibility of more complicated IOL designs, such as the capsule-fixated IOL where the capsulotomy is positioned in a groove at the edge of the optic.\textsuperscript{11} Other possibilities remain, such as the ability to center the IOL to induce...
prism to help strabismus patients. The future may also include the possibility of sectoral capsulotomy through which to remove the cataract and replace with a flexible IOL. This could allow the surgeon to maintain capsular continuity to transmit ciliary body strength through a largely intact anterior and posterior capsule. This may recover accommodation, an enticing prospect for the future, which can only be considered because of laser capsulotomy.

REFERENCES


Disclosures: None reported.

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