Review Article :

FEMTOSECOND LASER ASSISTED CATARACT SURGERY (FLACS)-A PARADIGM SHIFT IN CATARACT SURGERY

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1. INTRODUCTION

The role of femtosecond lasers in cataract surgery is to assist or replace several aspects of the manual cataract surgery. These include the creation of the initial surgical incisions in the cornea, the creation of the capsulotomy, and the initial fragmentation of the lens. The femtosecond laser may also produce incisions within the peripheral cornea to aid the correction of pre-existing astigmatism. Femtosecond lasers have been used successfully in ophthalmic surgery since 2001. The technology has been applied widely in LASIK. In FemtoLASIK the laser replaces the mechanical device (microkeratome) to create a precise corneal flap to prepare the eye for the secondary laser ablation. There are several benefits; Femtosecond lasers have been noted to be more precise than microkeratomes, with fewer likely collateral tissue effects. This has contributed to more precise, reproducible and safe LASIK outcomes.

In applications of the femtosecond lasers to dissection of a corneal flap for refractive surgery, the intrastromal cutting is performed at predetermined depth relative to the corneal surface applanated against a contact lens. In cataract surgery though cutting is performed inside and on the surface of the crystalline lens. Since lens position and orientation differs from eye to eye, precise 3-dimensional imaging is required to define location of the lens capsule in order to properly apply the laser cutting patterns. Image-guided laser cataract surgery was first conceptualized by D. Palanker and M. Blumenkranz in 2005. The Femtosecond laser procedure was first used clinically in cataract surgery by Professor Zoltan Nagy in Budapest, Hungary (Europe) in 2008. This was followed by Dr Steven Slade in the USA (2010) and Dr. Harvey Uy in Asia (2009) and Dr Michael Lawless in Australia (2011).

The more common acronyms include ReLACS (refractive laser–assisted cataract surgery), FLACS (femtosecond laser–assisted cataract surgery), and FALCS (femtosecond–assisted laser cataract surgery).

II. PRINCIPLE

The FSL causes tissue disruption with its near-infrared scanning pulse focused to 3 ìm with an accuracy of 1 ìm. Photodisruption is essentially induced by vaporization of target tissues, which occurs through the following steps: the focused laser energy increases to a level where a plasma is generated; the plasma expands and causes a shock wave, cavitation, and bubble formation; and then the bubble expands and collapses, leading to separation of the tissue. Because FSLs function nearly at an infrared wavelength, they are not absorbed by optically clear tissues. This makes FSL-assisted surgery amenable to anterior chamber targeting at various depths, as the anterior chamber provides an optically clear tissue space. The near-infrared wavelength is not absorbed by the cornea, and the waves are known to dissipate approximately 100 ìm from the lens tissue target.

Currently, 4 femtosecond laser technology platforms are commercially available for cataract surgery: Catalys (Optimedica), Lensx (Alcon Laboratories, Inc.), Lensar (Lensar, Inc.), Victus (Technolas).

III. PROCEDURE

Although the steps for each laser platform vary, they all require pupillary dilatation and topical anesthesia, followed by applanation of the cornea with a docking system that involves a contact lens with a circumferential suction skirt distributing pressure evenly on the cornea. The docking system minimally distorts anatomy while increasing intraocular pressure (IOP), although reportedly less IOP increase than seen in FSL refractive surgery. Once docking is complete, anterior segment imaging is then performed. LenSx and OptiMedica utilize Fourier-domain optical coherence tomography (FD-OCT), while LensAR utilizes Scheimpflug imaging technology. This step is required to find anatomical landmarks for laser pattern mapping. It is also crucial that specific boundaries are mapped, including the iris and the posterior surface of the lens. The posterior surface of the lens must be identified in order to avoid puncture of the posterior capsule. Preprogrammed corneal incisions for temporal wound, paracentesis, and any optional limbal-relaxing incisions (LRIs) can be adjusted at this point to surgeon preference. The pattern is then centered and the laser is activated.

Using the OptiMedica and LenSx systems, laser-assisted capsulotomy is performed, followed by lens fragmentation. This sequence is justified because lens fragmentation causes release of gas bubbles, which can distort the anatomy and affect capsulotomy planning. If a corneal incision is created, it is the last step before the patient is moved to the operating room. The integrity of the anterior chamber is not disturbed before the patient is sterile, as this initial incision does not penetrate the posterior corneal surface. Once in the sterile field, any partial-thickness corneal incisions are then completed with a microsurgical blade. Patients then undergo removal of the anterior capsulotomy, followed by standard phacoemulsification.

The capsulorhexis is performed first and takes 1.5 to18.0 seconds (depending on the laser platform), followed by lens fragmentation and ultimately corneal wound creation. If suction is lost during the procedure, the suction ring can be reapplied and the procedure completed (unless anterior chamber gas bubbles prevent imaging). However, if suction is lost during the capsulorhexis, the capsulorhexis must be completed manually. Lens fragmentation is then performed based on the segmentation pattern selected by the surgeon. For higher degrees of lens softening, the length of laser time may be significantly increased, from 30 to 60 seconds. Finally, the arcuate incisions, paracentesis, and clear corneal wound are created. Relaxing incisions can be made on the surface or created in an intrastromal location (by some platforms). The arcuate incisions are generally set at a default depth of 80% at the peripheral limbus, but depth, optical zone size, and placement can be customized. Some surgeons choose to open the incisions at the time of surgery; however, many open the incisions either partially or fully during the postoperative period (up to 1 month after surgery), depending on the patient's vision, refraction, and topography. Nomograms to gauge the effects of these incisions better are being developed, but it is hypothesized that intrastromal incisions will yield greater precision and better postoperative comfort.

Once the laser treatment has been completed, the suction is released, the patient interface is removed, and the patient is slowly undocked from the laser. Depending on whether the laser is located in the operating room or in another location, the surgeon can proceed with phacoemulsification immediately or wait up to 2 to 3 hours between the 2 stages of the procedure. Some systems use an integrated bed, which is advantageous for head positioning and stabilization during image acquisition and treatment. However, this necessitates moving the patient to a different bed to be transported to and from the room. The laser-created wounds have been found to be stable and watertight with minimal anterior chamber reaction for up to a few hours after the procedure, although the pupil becomes progressively more miotic with increased time between laser and phacoemulsification. Due to progressive pupillary miosis, it is recommended that phacoemulsification occur within 30 to 40 minutes of the femtosecond laser procedure.

FEMTOSECOND LASER

IV. ADVANTAGES OF FEMTOSECOND CATARACT SURGERY

1. Less time than standard phaco surgery.

2. Less corneal complications than standard phaco surgery due to reduction in power or U/S power.

3. Femtosecond laser can be used to create a perfectly centered, shaped and sized refractive capsulotomy with no radial tears.

4. Water tight main corneal incision and improved and consistant peripheral corneal relaxing incisions.

5. Good IOL centration and improve outcomes of premium IOL implantation and accommodative IOL insertion because these

IOLs need a continuous central capsulotomy to hold them in place.

V. CONCLUSION

There is no doubt that this technology has added costs and ultimately it is the patients who will pay for this addition to the procedure. With premium IOLs, we have seen that patients are willing to pay out of pocket for new technology if they view it as being safer or offering better results. Similarly, patients will likely be willing to pay extra if they perceive that they will achieve better results with laser assisted cataract surgery. The average laser costs between $400 000 and $550 000 to acquire, excluding the service cost after the first year, which traditionally ranges from $40 000 to $50 000 per year. Disposable interface costs range from $300 to $450 per eye. Additional costs are associated with incorporating this technology, which may include office or surgery center construction and hiring of new personnel. Therefore, as Uy et al mentions in a recent article, individual practices must assess surgical volume, surgical pricing structure, patients' willingness to pay, and the cost of space and personnel to develop a business plan that demonstrates a positive return on their investment before investing in this technology. Recently, companies have begun to mobilize these platforms and bring the laser to the individual surgeon.

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