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Review

Femtosecond Laser Assisted Cataract Surgery (FLACS): An overview

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ABSTRACT: Age-related cataract is one of the most important causes of visual impairment, and cataract surgery is one of the commonest surgeries performed worldwide. Femtosecond laser assisted cataract surgery (FLACS) is a new and promising technology in the arena of cataract operations. Femtosecond lasers (FSL) are used in cataract surgery for performing anterior capsulotomy, fragmentation of the lens, corneal incisions and limbal relaxing incisions. Results in most cases have been quite promising. FSL-created capsulotomies are more accurate in size, centration and circularity, and are reproducible. Positioning of the intraocular lens is also better. FSL systems also reduce the ultrasonic energy utilization for all grades of cataract. Better corneal incisions and limbal relaxing incisions (for astigmatism correction) may be added benefits. Femtosecond laser assisted cataract surgery may prove to be one of most important developments in the modern era of cataract surgery. However, FLACS has been around for a relatively short time. More long-term data may better prove its efficacy in the years to come.

KEY WORDS: ***Cataract; Femtosecond laser; Capsulotomy; Corneal incisions; Lens fragmentation; Phacoemulsification***

INTRODUCTION

Throughout the world, the most important cause of visual impairment is age-related cataract.[1,2] Surgery for cataract was first introduced by Sushruta in India and consisted of a simple procedure called 'couching' in which a curved needle was used to push the lens into the rear of the eye and out of the field of vision. The eye would then be soaked with warm clarified butter and bandaged. He had cautioned that this procedure was to be performed only when absolutely necessary.[3] Needless to say, this procedure was fraught with complications and was later replaced by cataract extraction. The first successful cataract extraction is attributed to the French ophthalmologist Jacques Daviel, who performed the procedure in 1747 and it heralded the start of the modern era in cataract surgery.[4]

Today, one of the most common operative procedures performed worldwide is surgery for cataract.[5] Cataract operation today is a quick outpatient procedure with rapid recovery of visual function and almost negligible surgical morbidity.[6]

The surgical procedure of choice at present is phacoemulsification because of its excellent safety record and visual outcome.[7-9] It uses ultrasonic vibrations to shatter and break up a cataractous lens, allowing it to be removed through a small sutureless incision.[10] The main steps in the procedure involve creating manual corneal incisions and anterior capsulotomy, followed by phacoemulsification and insertion of a synthetic intraocular lens. However, this procedure is not without complications and may result in damage to the cornea, iris or lens capsules, lens subluxation and vitreous loss. Results of this manual procedure also depend to an extent on the skill of the surgeon.[11]

The advent of Femtosecond Laser Assisted Cataract Surgery (FLACS) may prove to be one of the most important developments in the modern era of cataract surgery. With advances in multifocal and accommodating intraocular lenses, FLACS may pave the way for more accuracy and precision in cataract surgery with better visual outcomes for patients.

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LASERS IN CATARACT SURGERY

For more than five decades, a variety of lasers have been used in the treatment of several ocular disorders. Lasers have been investigated for use in cataract surgery since the 1970s. Krasnov reported a laser modality for phacopuncture in 1975.[12] The neodymium: yttrium aluminium garnet (Nd:YAG) laser was used by Aron-Rosa and Aron to perform anterior capsulotomies.[13] Peyman and Katoh in 1987 used an Erbium:YAG laser for inducing photoablation on the lens nucleus.[14] However, these pioneering procedures did not gain popularity due to complications and preference for conventional phacoemulsification.[15] Presently, the Nd:YAG laser is widely used for treating posterior capsular opacification in pseudophakic patients.[16]

In 2001, femtosecond laser (FSL) was introduced for the creation of corneal flaps in laser in situ keratomileusis (LASIK).[17] These flaps were markedly superior to those made by manual keratomes in terms of reproducibility, uniformity and safety. In addition, they were closer to their intended thickness and centration. The use of femtosecond laser in cataract surgery has the potential for similar benefits.[15]

Femtosecond lasers work by cutting tissues with a process of photodisruption, unlike argon (photocoagulation) and excimer (photoablation) lasers.[16] FSL use a shorter pulse time of 10^{-15} s. The shorter pulse time decreases the energy output for a given effect and this helps in preservation of ocular structures, leading to better visual outcomes.[15] The wavelength of FSL is 1053nm, which is in the near-infrared spectrum. It is not absorbed by optically clear tissues and not affected by corneal magnification. Therefore, it can be focused at different depths within the anterior chamber with great precision.[15,16]

At present, four femtosecond laser systems are commercially available for cataract surgery. These are: LenSx (Alcon LenSx, Ft Worth, Texas, USA), Catalys precision laser system (Optimedica, Santa Clara, California, USA), VICTUS (Technolas GMBH Munich, Germany) and LensAR (LensAR Inc. Orlando, Florida, USA). The platforms have slight variations in their specifics, but the overall procedure performed is essentially similar.[16]

FEMTOSECOND LASER: USES IN CATARACT SURGERY

Femtosecond lasers are used in cataract surgery for performing anterior capsulotomy, fragmentation of the lens, corneal incisions and limbal relaxing incisions.[15]

Anterior capsulotomy (capsulorrhexis)

A continuous curvilinear capsulotomy is a crucial step in cataract surgery. Manual construction of the capsulorrhexis is one of the most challenging aspects of cataract surgery to master.[18] Femtosecond laser provides a distinct advantage in this step as it can create capsulotomies which are more accurate in size, centration and circularity, and are reproducible. FSL also produces better intraocular lens (IOL) overlap by the anterior capsule leading to better positioning of the IOL. IOL decentration and tilt are also less as compared to manual capsulorrhexis.[11,19-21] An optimal capsulotomy may result in more widespread use of the newer accommodative IOLs, with better post-operative visual outcome for patients.

Lens fragmentation

The use of excessive ultrasound energy during the phacoemulsification process can cause damage to the corneal endothelium and thermal injury to the cornea at the probe insertion site.[22]

Femtosecond laser systems pre-treat the lens by using fragmentation patterns to segment the nucleus and soften hard cataracts, which can reduce the amount of ultrasonic energy from the phacoemulsification probe. This decreases the number of intraocular instruments used, lens manipulation and intraocular movements.[15,16]

FSL systems have been shown to reduce the ultrasonic energy utilization for all grades of cataract.[11,19,23] However, more studies are required to ascertain if laser lens fragmentation significantly improves the safety profile and outcomes of cataract surgery.[16]

Corneal incisions

For most cataract surgeons, the preferred method to access the anterior chamber is the self-sealing clear corneal incision, with its faster recovery and good visual outcomes.[24,25] The problems encountered are detachment of the Descemet's membrane, gaping at the internal aspect of the corneal wound and a risk of endophthalmitis.[26,27]

Creation of the corneal incision is another aspect of cataract surgery which may potentially benefit from the FSL system. A cadaver eye study has shown more stability and reproducibility of FSL-guided corneal incisions.[28] Another study showed the creation of a self-sealing incision with the FSL system which was resistant to leakage under normal intraocular pressure. Also, a multiplanar geometrical wound structure was more easily achieved.[11] This, along with the decreased mechanical stress on the eye during the femtosecond laser surgery procedure, may result in faster healing and fewer incision-related complications. However, more data are required in this regard.[16]

Limbal relaxing incisions

Limbal relaxing incisions can correct a significant amount of pre-existing astigmatism. However, due

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to the technical demands of the manual incision and inconsistencies in the results, only a small percentage of patients who could potentially benefit are being treated.[15,16]

Femtosecond lasers can produce very accurate corneal relaxing incisions.[29,30] This in turn may help in the treatment of pre-existing astigmatism and counteract surgery-induced astigmatism in a more reliable way.[31]

CONCLUSION

Ophthalmology has always been at the forefront of embracing new technologies and innovations. FLACS may herald a new era of precision, accuracy and reproducibility of some of the steps in cataract surgery. At present, it is mainly used in the construction of the corneal incision, anterior capsulotomy and fragmentation of the lens, and results have been very promising in most studies.[11,20,32-34] However, financial implications have to be taken into consideration as investments have to be made for equipment, staff training, workflow adjustments and patient education.[35] Femtosecond laser technology has been around for a few years only and more studies may be warranted to better judge its superiority over conventional phacoemulsification. As FLACS becomes more widespread, the coming years will better prove its benefits and long term efficacy.

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