Research Article

Femtosecond laser Cataract Surgery…… Advantages and Financial Considerations.

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Abstract
The use of femtosecond lasers is considered an evolution in modern corneal and cataract refractive surgery. With accuracy, safety, and repeatability. In recent years, the new concept of refractive cataract surgery has been outlined, whereas the quality as well as the quantity of sight is considered. In fact, digital surgery represents, the last technological step to the highest precision and quality thanks to the application of femtosecond technology in cataract surgery..
Keywords: Femtosecond Laser, cataract surgery, phacoemulsification, advantages, financial considerations.

Introduction
Femtosecond-laser-assisted cataract surgery (FLACS) is a new technology in the field of ophthalmology. The first implementation of femtosecond laser cataract surgery was performed in 2008 in Europe by Nagy et al.,[1] Today's cataract surgery patients expect not only improved vision after cataract extraction, but also excellent visual quality and spectacle independency, and pressure on ophthalmic surgeons is ever increasing. The use of this new technology may help health providers to improve their results.[2] This review paper presents the most important advances and the disadvantages of femto cataract surgery.

Cataract and femtosecond laser surgery:
Cataract is responsible for half of the global burden from vision impairment. In the western world, phacoemulsification is the surgical procedure of choice routinely providing excellent visual and safety outcome. Approximately 18 million cataract procedures are performed globally every year, rising up to 24 million soon due to demographic changes, aging population, and changes in indication for crystalline lens surgery.[3]

Nevertheless, it is not a perfect procedure and room for improvement exists. Complications such as endophthalmitis, cystoid macular edema, endothelial cell damage, vitreous loss and retinal detachment remain sight threatening concerns.[4]

The femtosecond laser is now commercially available to perform three key steps in small incision cataract surgery: capsulotomy, lens fragmentation and wound construction.[5]

Femtosecond lasers work on the principle of photodisruption brought about by a tightly focused beam of ultrashort pulsed light energy with enough peak power to create plasma. The focused femtosecond pulses induce optical breakdown with significantly less pulse energy, thereby minimizing collateral damage.[6]

Main steps in Femtosecond laser cataract surgery:
- **Incisions and Capsulorrhexis**

When the patient is under the operating microscope, the paracentesis and primary incision can be created or opened (if laser created) and an ophthalmic viscosurgical device (OVD) should be injected, as usual, into the anterior chamber. As the OVD enters the anterior chamber, close attention should be paid to the movement of the anterior capsule. A Utrata forceps or microforceps can be used in a circular (continuous curvilinear) motion to remove

the anterior capsule if the laser capsulorr-hexis is incomplete or a radial tear has formed. Alternatively, a cystotome can be used to pull the tissue centrally, preventing extension of radial tears that may be present. Fortunately, as software has improved, radial tears have become less common, but they may occur.[7]

Figure 1: Liberation of adhesions in the main incision with a spatula[7]

- **Changes in Hydrodissection**

The air bubbles should be gently decompressed from behind the lens before more aggressive hydrodissection is perfor-med Generally, by tapping gently on the anterior surface of the lens (tilting the lens slightly) with the hydrodissection cannula and gently injecting balanced salt solution beneath the anterior capsule during hydrodissection, the bubbles come forward into the anterior chamber. If performed too aggressively, rapid hydrodissection could lead to a posterior capsule rupture.[8]

Figure 2: Air bubbles by the action of femtosecond laser[8]

- Divide-and-Conquer Versus Chopping

With any technique, it is best to remove the superficial cortex first. This allows clear visualization of the segmentation and softening pattern of the nucleus below. At this time, the standard divide-and-conquer technique can be used; however, creating the grooves will expend additional US energy. The grooves made by the laser will crack easily and then less energy will be used to remove the softened nuclear material. Standard chopping or stop-and-chop may also be very effective. Since the grooves created by the laser are extremely narrow, the second instrument selected should be very narrow, such as an Akahoshi chopper (Katena Products, Inc.), a Nagahara chopper (Storz Ophthalmics), a Cionni chopper (Duckworth & Kent), or a Neuhann chopper (Geuder AG).[9]

- Changes in Cortical Removal

Once the nuclear material has been removed, the surgeon may find that the removal of cortical material is slightly more challenging than with traditional phacoemulsification. When the laser creates the capsulorrhexis, it also cuts a circular disk of cortex, which exactly matches the diameter of the capsulorrhexis. At times, it may be difficult to visualize the edge of the cortex because the edge may correspond to the edge of the capsulorrhexis. Although this perfect safety zone ideally protects the capsule, it may be more difficult to extract the residual cortical material from the bag, the most challenging area being the subincisional cortex. The ease of cortical removal improves during the learning curve and appears to be an insignificant issue for experienced users. Bimanual techniques can be useful when faced with subincisional cortex or with cortex that is thicker than usual and is flush with the underlying capsule.[10]

Efficacy and safety of FLACS

The number of studies of FLACS in human subjects is steadily increasing. So far, good visual outcomes, low complication rates and no significant safety concerns have been reported.

Refractive Outcomes

Femtolaser created anterior capsulotomy eyes showed better quality of vision and significantly less induced internal aberrations as compared to traditional manual capsulorrhexis.

Studies revealed that the femtolaser capsulotomy induced significantly less internal aberrations as measured by the Nidek optical path difference scan aberrometer (Nidek Inc).[11]

There was no statistically significant difference found regarding postoperative refraction, uncorrected, and best spectacle-corrected distant visual acuity. The femtosecond-treated eyes, however, showed significantly better quality of vision postoperatively.

The femtosecond-treated eyes had lower values of intraocular vertical tilt (Z1-1) and coma aberrations (Z3-1), higher Strehl ratios, and higher modulation transfer function (MTF) values.[10]

Further studies have shown that predictability of IOL power calculation is significantly better in FLACS compared with conventional cataract surgery. [11]

FLACS allowed more surgeons to choose premium IOLs for their patients. In a study on LenSx system and implantation of accommodating IOLs, each eye achieved BCVA of 20/30 or better at 1 week postoperatively.[12] This study correlated with earlier reports in terms of the accuracy and reproducibility of FSL-corneal incisions. It also demonstrated reduced variation in ELP.

Corneal wounds with perfect structure and dimension are of great importance to prevent postoperative infection and minimize surgically induced astigmatism (SIA).

The Alcon-LenSx femtosecond laser uses an image-guided capability, which is able to control the corneal thickness measurements, the shape, placement, incision length, width, and depth (percentage of

corneal thickness). The procedure is computer controlled, predictable, and precise.[13] The surgeon can immediately open the incision after femtolaser pretreatment or can wait until the next postoperative day.

Using this, the surgeon can take into consideration the SIA and can topographically control how deep he or she should open the premade corneal incisions at the slit lamp in the office. So, the effect of femtolaser-created arcuate corneal incisions can be titrated in order to reach the optimal effect as regards the preoperative corneal astigmatism.

Effect on the corneal endothelium

The effect of femtolaser treatment on corneal thickness, corneal volume stress index, and endothelial density was found significantly better in the early postoperative period in comparison with conventional phaco.[14]

The presumed reason behind this is the shorter phacoemulsification time with less CDE.

Effect on the macula

Subclinical macular edema is a common complication of conventional phacoemulsification. It is thought that this macular thickening is related to inflammation mediated by prostaglandins and triggered by manipulation of the anterior segment, particularly the iris.[15]

Macular thickness and volume were assessed by OCT (Zeiss GmbH) 1 week and 1 month postoperatively and studied.[15] Regarding safety issues, femtosecond laser–assisted cataract eyes do not differ regarding macular thickness compared to traditional ultrasound phacoemulsification; on the other hand, results are somewhat better regarding the thickness of the inner retinal layer during the first week following surgery.

This difference between the FLACS and control groups reduced after 1 month and no longer attained statistical significance, but the authors suggested that reduced subclinical edema in the early postoperative phase could be beneficial for patients at risk of developing clinically significant cystoid macular edema later on.

Little is known about the effects of FLACS on age-related macular degeneration (ARMD), although one could infer that a reduced inflammatory response in the eye may decrease the risk of ARMD progression.[16]

Economics and financial considerations

Despite its perceived benefits, FLACS is not yet widespread, even in high-volume refractive centres. This is largely due to the significant financial costs involved in its implementation. Although costs are likely to reduce with competition and more entrants to the market, it is probable that the initial cost of the FLACS platform itself will be between US$400,000 and $500,000. Furthermore, a usage fee is likely to be $150 to $400 per eye and maintenance costs are estimated to be around $40–50,000 per year.[17]

If surgeons are confident in their own microsurgical skills and outcomes, it could be difficult to justify the additional expense, except perhaps in a very high-volume refractive cataract practice. In a state-funded healthcare system, without the use of premium intraocular lenses, the use of FLACS will no doubt be questioned.[18]

The benefit of doing a capsulotomy using a $500,000 laser compared with a needle costing a few pence must correlate with the proportional benefit in outcome. At the present time, outside of toric and accommodative IOL use, this does not exist and consequently there is, so far, no reimbursement scheme from either private medical insurance or national health systems.[19]

However, with time and marketing, it is likely that the public perception will change. As awareness of femtosecond technology increases, we will start to experience more and more patients asking about or demanding FLACS. This may necessitate a change in the state-funded healthcare system to allow top-up care,

where patients are given the option of paying extra for the premium IOL and laser technology.[19]

A system of 'co-payments' such as this is already permitted in some countries. Another method of improving economic viability may be through 'bundled discounts', whereby companies reduce the cost of their laser machines in return for a supply contract for other surgical instruments and IOLs.[20]

From a practical viewpoint, to increase the number of patients interested in FLACS, the consent process which is often conducted by senior nurse practitioners in high-volume units, may need to be replaced, at least in the early stages, by a detailed discussion by the operating surgeon.

It has been suggested that surgery should not be conducted on the same day as preoperative assessment. Operating theatre space would have to be created to fit the laser, with extra space required to allow transfer of either the patient or the phacoemulsification machine to permit the second stage of the operation. It is thought that there is a window of opportunity lasting 2–3h after femtosecond capsulotomy, before leaking lens proteins elicit an anterior chamber inflammatory reaction. Therefore, to improve efficiency, two or three patients could be pretreated with the FLACS system before lens removal and IOL implantation in the operating theatre.[21]

One model has been proposed, whereby a single laser suite, operated by one surgeon, feeds into several operating theatres with other surgeons completing the manual parts of the procedure. [22]

A situation could result where cataract surgery is no longer performed in smaller hospitals or outreach theatres, with it instead becoming centralized using a 'carousel' model in larger units with access to femtosecond technology. If superior efficacy and safety profile can be demonstrated conclusively, it is conceivable that FLACS may eventually have a role in the management of complex cataracts within the public sector. [22]

In conclusion, at present, FLACS is considered as a great advancement in cataract surgery over standard cataract surgery with many studies have shown better reproducibility in terms of capsulorrhexis diameter and centration, corneal wound construction, and decreased ultrasound energy and decreased endothelial cell loss. However, economics and financial aspects should be considered.

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