Femtosecond laser-assisted cataract surgery

The real contribution of femtosecond laser-assisted techniques in cataract surgery (FLACS) is currently under some debate. In view of the well-known requirements of lens surgery, two basic questions should be addressed: 1) what aspects of surgery can be performed more safely with femtosecond laser (FSL) and 2) what aspects can be improved in the future. Issues associated with the costs of this technology should be separated from scientific discussion, or reserved for platforms in which the financial aspects of healthcare processes are analyzed. Let us attempt to respond to the following FSL issues: 1. Can FSL reproduce all the characteristics we want for an incision or capsulorhexis? 2. Can it break down the lens nucleus to an extent that it only has to be aspirated? 3. Is it as safe for the endothelium and anterior and posterior capsule as current phacoemulsification procedures? 4. Are the chances of success in the treatment of complex cases any greater? 5. Will it more precisely address the challenges of cataract surgery in the near future?

First of all, we should emphasize that, with FSL, corneal incisions and capsulorhexis can now be made more accurately than by even the very best surgeon, and, perhaps more importantly, they can be reproduced regardless of their skill. Nevertheless, the surgeon will continue to play the key role in the process; it will be they who will apply clinical criteria, make the diagnosis, take surgical decisions and carry them out, and it will be they who will be responsible for solving any complications that might arise. However, the surgeon must also bear in mind that the technology now available allows him or her to operate in a safer and more reproducible manner.

The “ideal” incision should be one that is easy to perform and reproducible; its architecture should follow accepted standards, it should facilitate all the standard phacoemulsification maneuvers without compromising visualization, allow implantation of the selected intraocular lens, provide safety on closure, be self-sealing, anastigmatic, heal rapidly and ensure rapid refractive stabilization. The deciding factor for achieving these objectives is to establish the appropriate relationship between the length and width of the wound. As with pre-calibrated knives, FSL allows the real width of the incision to be pre-defined and executed with the desired angulation and the ideal length-to-width ratio, features which cannot be achieved with the same accuracy manually. Using the imaging systems integrated in most commercialized FSLs, the epithelial and endothelial access zone is located and the architecture of the incision (number of planes, length and angulation) is designed in an extremely precise manner. Incisions are reproducible (with the only limitation imposed being that of corneal transparency), regardless of the quality of the cutting instrumentation, pressure applied to the eye or the skill of the surgeon. They do, however, depend on the surgeon’s knowledge of the ideal length-width ratio of the incision, the most appropriate angle of attack and the ideal location for a given case. Nowadays, the accepted standards for an incision include a length/width ratio (L/WR) of between 0.66 and 0.70 and an angulation at around 36°-49° with respect to the tangent in the incision zone. To date, no reports have been published comparing the architecture of incisions created by FSL with those made manually in humans. Masket et al. in a study performed on cadaver eyes, found greater stability and reproducibility with incisions created using FSL, although they suggested that the significance of these findings should be determined in future studies analyzing the morphology and incisional architecture of the FSL technique, compared to the manual method.
No-one today doubts the advantages of capsulorhexis: 1) emulsification can be carried out within the capsular bag, thus increasing the safety of the process and reducing endothelial damage; 2) by maintaining the integrity of the capsular bag, any type of intraocular lens can be implanted; 3) it prevents post-surgical contact between the iris and any structure that is not the anterior capsule; and 4) it ensures the final positioning of the lens better than any other type of capsulotomy. With FSL, capsulorhexis now no longer depends on external factors (eye size, external compression of the eye, anterior chamber depth, and pupil dilation) that determine its diameter, symmetry and even its centration with respect to certain anatomical references within the eye. FSL allows a capsulorhexis diameter of the desired size to be made, case after case, correctly centered with respect to the desired anatomical reference (limbus, pupil, lens curvature or visual axis), the only limitation being pupil diameter at the time of the surgery. We can confirm that FLACS offers the possibility of performing a more circular, symmetric capsulorhexis, with the possibility of overlapping the lens to the desired extent, thus ensuring correct positioning of the intraocular lens and reducing the risk of opacification or contraction of the anterior and posterior capsules. We intuitively think that, in this way, the lens may remain better centered and more stable in its final position with respect to the desired position. Capsulorhexis with FSL has recently been compared with manual capsulorhexis. These studies already indicate that capsulorhexis performed with FSL is more regular in terms of shape, provides better overlap of the lens edges and improves lens centration. Whether the refractive consequences of achieving this are relevant or not may be a secondary issue. The refractive result of lens surgery is multifactorial and depends on preoperative measurements, knowledge of calculation formulae, the real power of the intraocular lens, its final position and the long-term stability of the factors involved, something which is unlikely in a biological system subject to changes related with inflammation (in the short-term) and aging (in the long-term).

In addition, FSL should allow perfect capsulorhexis to be performed in situations that are currently critical (absence of fundus reflex, capsular pseudoexfoliation, narrow anterior chambers, capsular fibrosis and childhood cataracts, etc.) and permit centration of the capsulorhexis with respect to the pupil or limbus or decentration to any other location as necessary.

In the context of lens nucleus fragmentation, the energy required for phacoemulsification generates mechanical energy leading to loss and morphological alteration of endothelial cells, and heat energy that causes burns around the incision. Endothelial loss is also multifactorial and depends on the preoperative condition of the endothelium, the types of viscoelastics and irrigation solutions used, the phacoemulsification technique, the instrumental manipulation required, and, once again, the experience of the surgeon. With FSL, less manipulation of the fragments and lower phacoemulsification power are required for pre-fragmentation of the nucleus, all of which should improve endothelial protection. There are currently very few studies published that validate the assumption that less energy for fragmentation and phacoemulsification of the nucleus is required with FSL. To date, Palanker et al. claim to have observed a 39% reduction in the cumulative dispersed energy, while Nagy et al. report a reduction in the effective ultrasound power required and a shorter phacoemulsification time. Opinion is still divided with respect to fragmentation patterns. Intense fragmentation of the lens requires more FSL energy, more gas bubbles are released, structures are poorly visualized, it is more difficult to use chop techniques and, in general, there will be free particles in the anterior and posterior chambers which may be projected onto the endothelium, requiring more time and greater use of fluids. Conversely, less fragmentation of the lens will have the opposite advantages and disadvantages. Only time will reveal the best strategy for each type of lens.
FLACS already offers advantages over manual techniques in performing incisions and capsulorhexis. It also facilitates lens fragmentation, and in addition, it allows a more satisfactory approach to complex situations. Moreover, knowing the importance of the correct positioning of the lens, particularly for complex optics (aspherical, diffractive, toric, etc.), it is easy to assume that a perfect capsulorhexis is the first step towards achieving this. Nowadays, the FLACS technique is aimed at responding to the current challenges of lens surgery; it cannot be said that this procedure is less safe than the conventional technique. Its use in the future lies in whatever applications we can imagine for this technology.

REFERENCES


Javier Mendicute
Consultant at Ophthalmology Department. Hospital Universitario Donostia