Editorial

Femtosecond Laser versus Manual Technique in Ophthalmic Surgery

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Femtosecond laser (FS) in ophthalmic surgery has been in use for almost twenty years. First approved by the U.S. Food and Drug Administration in 2001 for creating corneal flaps in laser – assisted in situ keratomileusis (LASIK), the applications for FS has been expanded to other ophthalmic procedures including astigmatic keratotomy, intrastromal corneal ring segments, corneal pockets for presbyopia-addressing inlays, small incision lenticule extraction, keratoplasty, and most recently, FS laser-assisted cataract surgery (FLACS)[1].

It is the increasing use of the latter that has raised the question: Are FS lasers truly advantageous over traditional manual techniques? The implications are profound as an estimated 19 million cataract surgeries were performed in 2011 and is expected to reach 30 million worldwide by 2020[2]. In theory, ultrashort laser pulse lasers that operate in the infrared range (wavelength: 1,053 nm) to create precise cleavage planes with minimal collateral damage sounds ideal. But the questions that have to be addressed, as with any new technologies, are: Do they result in superior refractive outcomes? Are they safer in that complication rates are reduced?

This editorial puts into perspective lessons learned from over 15 years of femtosecond laser use in keratorefractive surgery and also summarizes to date, the evidence from literature, FLACS versus manual phacoemulsification to see whether it is truly advantageous.

The superior accuracy of FS over microkeratomes in LASIK flap creation is well-established[3,4]. However, whether greater accuracy translates into clinical benefit is questionable. A meta-analysis of seven prospective randomized controlled trials of 577 eyes concluded that FS LASIK did not have an advantage in efficacy, accuracy, and safety over mechanical microkeratomes, although it might induce fewer aberrations[5]. It is difficult to compare complication rates because associated complications are rare and different. FS LASIK flap complications are from an inflammatory etiology of the laser such as diffuse lamellar keratitis and transient light-sensitivity syndrome, whereas complications with the microkeratome are associated with mechanical complications such as epithelial defects and flap dislocations[6]. There appears to be no difference in long-term visual function and keratocyte density five years postoperatively; a recent randomized clinical paired – eye study found that keratocyte density in the LASIK flap decreased by 20% the first year after LASIK and remained low through 5 years, and higher-order aberrations increased and uncorrected visual acuity improved immediately after surgery. Interestingly, there were no differences in any of the variables between the microkeratome versus femtosecond treatments[7].

For the other aforementioned keratorefractive procedures such as astigmatic keratotomy (AK), channel creation for intrastromal corneal ring segments (ICRS), pockets for inlays, and small incision lenticule extraction (SMILE), or various partial to full – thickness keratoplasties, there have been less long-term experience and hence, little published data on head-to-head comparisons of FS versus mechanical techniques. There are many case reports and small series on the effectiveness of reducing corneal astigmatism with limbal relaxing incisions, however the challenge is that there are various nomograms for manual, femtosecond, and more recently, intrastromal FS (FISK) incisions to address corneal steepening and thus, standardization for comparative studies is difficult.

Since being approved for cataract surgery by the US FDA in 2010, to date, more than 1.2 million eyes in the US and 2 million eyes globally have undergone FLACS. (Marketscope, LLC. St. Louis, MO)There are currently 5 femtosecond platforms for FLACS: LenSX (Alcon, Aliso Viejo, CA, USA), Lens AR (LENSAR, Inc., Winter Park, Fl, USA), Catalys (Abbott Medical

Optics Inc., Santa Ana, CA, USA), VICTUS (Bausch and Lomb Inc., Dornach, Germany), and FEMTO LDV Z (Ziemer Ophthalmic Systems, Port, Switzerland). Proponents have touted the accuracy and precision of the FS laser over manual steps including construction of clear corneal incisions, capsulotomy, and lens fragmentation. The accuracy and reproducibility of the FS have been reported previously, but comparative meta-analysis of FLACS versus manual cataract surgery (MCS) with regards to refractive outcomes and reduced complication rates are now available.

A meta – analysis of 2802 screened articles comprising of 14,567 eyes from 15 randomized controlled trials and 22 observational cohort studies concluded that there were no statistically significant differences between FLACS and MCS with regard to visual and refractive outcomes and complications.[8] Theoretically, precise capsulotomies would ensure capsule overlap of the intraocular lens, reducing the risk of myopic shift or astigmatism from anterior shift or tilt of the IOL. However, the meta-analysis revealed that there were no difference in UDVA, CDVA, and mean absolute error (MAE). The investigators do state that this lack of difference may be attributable to numerous sources of error in refractive predictability, including choice of IOL formula, and methods of prediction error assessment. Safety analysis revealed no difference between FLACS and MCS for capsular, pupillary, and corneal complications. However, with FLACS, there was a greater incidence of posterior capsular tears- which is associated with increase risk for cystoid macular edema, endophthalmitis, and retinal detachment. Furthermore, FLACS was associated with a significantly greater concentration of prostaglandin relative to MCS. In favor of FLACS was a statistically significant difference in effective phacoemulsification time, absolute mean deviation from intended capsule diameter, horizontal IOL centration, and post-operative central corneal thickness. The investigators of this meta-analysis note that "it is important to consider the clinical significance of the measured differences when interpreting these findings" and that "there will be continued head-to-head comparisons between these 2 techniques…[it is important to] await this evidence and recommend that a subsequent re-evaluation be performed after a significant number of well – designed randomized trials are introduced into the literature."

This need is reiterated by a recent Cochrane Database Systematic Review of FLACS versus MCS, whereby risk of bias was also taken into consideration[9]. From the screening of search results by two independent investigators, 16 randomized controlled trials (RCTs) conducted internationally enrolled a total of 1638 eyes of 1245 participants. However, in 11 of the 16 studies, the authors reported financial interests with the laser platform evaluated in their studies. Even then, the Cochrane authors conclude that their review "could not determine the equivalence or superiority of laser-assisted cataract surgery compared to standard manual phacoemulsification for their chosen outcomes (intraoperative complications, UDVA, CDVA, refractive outcomes, quality of vision, postoperative complications, cost – effectiveness) due to the low to very low certainty of the evidence available from these studies."

If FS laser adoption in the keratorefractive market is an indicator, FS penetration into FLACS will continue to grow. Despite a clear lack of benefit and a tenfold greater investment required for FS lasers over mechanical microkeratomes, FS lasers for LASIK experienced a 15% growth from 2000 to 2015. (Marketscope, LLC. St. Louis, MO) The growth chart for FS in FLACS appears even more aggressive. FLACS penetration rate increased from 0.6% in 2011 to 9.0% in 2016 in the US and from 0.1% to 2.5% globally during the same time period. (Marketscope, LLC. St Louis, MO) But to say that new technology is better because it is being rapidly adopted is not based on evidence. Good data from adequately powered, well – designed, independent RCTs will benefit all parties. If no clear advantage is evident, it validates those who are waiting until FS technology improves, or advances until it confers a true benefit. Conversely, if FLACS proves to be superior over MCS, it will stimulate more competition into the market, improving the technology while decreasing the costs, both which will benefit patients.

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