Use of the Femtosecond Laser for Cataract Surgery with Intraocular Lens Implantation

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Abstract

Femtosecond laser technology offers a promising approach to minimally invasive corneal surgery. Recently, femtosecond laser-assisted cataract surgery has been approved by the FDA. Femtosecond laser systems can create more precise and reproducible surgical incisions under computer control than with the conventional manual technique. Femtosecond laser-assisted cataract surgery may become a standard procedure for cataract surgery with intraocular lens implantation.

Cataract is one of the major causes of preventable blindness in both developing and industrialized countries. Today most cataracts can be treated safely by modern surgical techniques involving phacoemulsification of the lens and intraocular lens (IOL) implantation. The management of cataract has changed considerably over the last few years with various improvements in surgical techniques, especially adoption of the femtosecond laser. This laser was first introduced for flap creation during laser in-situ keratomileusis (LASIK) [1-6]. Since then, the femtosecond laser has been used in a variety of procedures for corneal surgery, including predissection of corneal grafts for penetrating keratoplasty [7], anterior and posterior lamellar keratoplasty [8-12], and Descemet’s stripping automated endothelial keratoplasty. It has also been used for refractive surgery [13], including LASIK, limbal relaxing incisions, intrastromal ring segment implantation [14], and correction of presbyopia. Most recently, use of the femtosecond laser has been expanded to include cataract surgery [15].

The name femtosecond laser indicates the short duration of its laser pulses (1 femtosecond (fs) = 1 × 10−15 seconds). Other lasers used for ocular surgery, such as the argon (photocoagulation), excimer (photoablation), and ND: YAG (photo disruption) lasers have a longer pulse time of 10−9 seconds. Several companies have developed femtosecond laser units for cataract surgery. These include the LenSx (Alcon, Fort Worth, TX), Optimedica Catalyst (Optimedica Corporation, Sant Clara, CA, USA), Technolas Workstation and IntraCor (Technolas Perfect Vision GmbH, Munich, Germany), and LensAR Laser System (LensAR Inc., Winter Park, FL). The femtosecond laser first received FDA approval for use in lamellar corneal surgery and additional approval for femtosecond laser-assisted cataract surgery was granted in 2010.

Femtosecond laser systems can create precise and reproducible surgical incisions under computer control. The chief benefit of using a femtosecond laser for cataract surgery is that it replaces manual incision with a dedicated knife or forceps for creation of the initial corneal incisions, capsulotomy, and initial lens fragmentation. Successful intraocular use of the femtosecond laser for lens fiber disruption [16], treatment of presbyopia [17], and accommodation surgery [18] has been achieved in animal models. The first surgeon to report the performance of femtosecond laser-assisted cataract surgery in humans was Nagy in 2009 [19]. Since this initial report, many further reports and reviews of femtosecond laser-assisted cataract surgery have been published [20-41]. The first advantage of femtosecond-assisted cataract surgery is more precise capsulorrhesis and phacoemulsification at a lower power than with the conventional manual technique [19,41]. For accurate centration and fixation of advanced IOLs, including toric, multifocal, and accommodating IOLs, use of the femtosecond laser to achieve accurate capsulorrhesis may be an effective option. A second advantage is that the femtosecond laser creates precise corneal incisions. Three-dimensional computer control of the corneal incision using a femtosecond laser may reduce the risk of endophthalmitis associated with manual self-sealing clear corneal incisions. The third advantage is that the femtosecond laser allows precise placement of limbal relaxing incisions, which are effective for reducing astigmatism after cataract surgery. The fourth advantage is that femtosecond laser light is not absorbed by the surrounding tissues, including the cornea, resulting in no risk of corneal damage.

Despite all these positive aspects, the laser units are still relatively large and under development. Additionally, femtosecond laser machines equipped with a rotating Scheimpflug camera or optical coherence tomography incur additional costs for spare parts and annual maintenance, and are considerably more expensive compared with the current standard method of cataract surgery. Further investigation of postoperative complications such as endophthalmitis is also necessary. If these issues can be solved, femtosecond laser-assisted cataract surgery may become a standard procedure for treating cataract in the near future. Development of a femtosecond laser combined with a phacoemulsification unit is also expected.

References


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