Techniques and uses of femtosecond laser in ophthalmological practice

Essay
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CONTENTS

LIST OF ABBREVIATIONS

AC	Anterior chamber
AK	Astigmatic keratotomy
ALK	Anterior Lamellar keratoplasty
BCVA	Best corrected visual acuity
CXL	Collagen cross-linking
D	Diopter
DALK	Deep Anterior Lamellar keratoplasty
DLEK	Deep lamellar endothelial keratoplasty
DSEK	Descemet's stripping endothelial keratoplasty
Er:YAG	Erbium- doped yttrium aluminium garnet
FALK	Femtosecond laser-assisted lamellar keratoplasty
FDA	Food and drug administration
FLK	Femtosecond laser keratomileusis
FS	Femtosecond
FSL	Femtosecond laser
FS LTA	Femtosecond laser trabecular ablation
ICRS	Intrastromal corneal ring segment
KHz	Kilohertz
LASIK	Laser assisted in situ keratomileusis
LK	Lamellar keratoplasty
mm	Millimeter
Nd:YAG	Neodynium-doped yttrium aluminium garnet
Nd:YLF	Neodynium-doped yttrium lithium fluoride
nm	Nanometer

NPDS	Non penetrating deep sclerectomy
ns	Nanosecond
OBL	Opaque bubble layer
PKP	Penetrating keratoplasty
PLD	Posterior lamellar disc
PLK	Posterior Lamellar keratoplasty
PMCD	Pellucid marginal corneal degeneration
PRK	Photorefrsctive keratectomy
ps	Picosecond
SD	Standard deviation
SE	Spherical equivalent
TH PKP	Top hat penetrating keratoplasty
TLSS	Transient light sensitivity syndrome
UCVA	Uncorrected visual acuity
µJ	Micro joules
µm	Micrometer
UVA	Ultra-violet A

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INTRODUCTION

The femtosecond (FS) laser is an infrared laser that works at a wavelength of 1052 nanometer (nm). It emits ultrashort laser pulses with a diameter of 0.001 millimeter (mm) at one-billionth of a second (10^{-15} sec). With the laser, tissue can be cut very precisely and with practically no heat development. (1)

At present, corneal flap creation in Laser assisted in situ keratomileusis (LASIK) surgery is the most common application of the FS laser. The major advantages of FS laser flap creation over the mechanical microkeratome are: 1) increased precision with improved flap safety and thickness predictability; 2) reduced incidence of flap complications, such as buttonholes, epithelial abrasions, short flaps, free caps, blade marks, and irregular cuts; 3) greater surgeon choice of flap diameter, thickness, side cut angle, hinge position, length, spot size, separation, and firing patterns (spiral or raster); and 4) capability of cutting thinner flaps (90 µm or even less). (2)

The FS laser may be used to cut a flap then a lenticule of central corneal stroma using intrastromal photodisruption for correction of myopia (all–FS laser treatment of myopia). (2)

Intracorneal ring segments are implants used for intrastromal insertion in the midperipheral cornea for correction of up to - 3.50 diopters of myopia and for milder cases of

keratoconus without central scarring. The FS laser may be programmed to create arcuate tunnels for implant placement at approximately 70% corneal depth. The tunnel creation with the laser is not only easier and less awkward than with the traditional mechanical spreader method, but also is more precise, more predictable, and less likely to perforate the cornea. [(3)]

Collagen cross-linking utilizing ultra violet A (UVA) irradiation and riboflavin solution instillation through a femtosecond laser–generated pocket has been applied clinically for the treatment of corneal ectasia and keratoconus. [(4)]

The FS laser (FSL) is capable of creating straight trephination cuts or complex-pattern trephination cuts for enhanced wound integrity of the graft-host junction. The latter includes the "top-hat" (with a larger diameter cut posteriorly) and the zig-zag patterns. The choice of shapes and diameters in FS laser–assisted keratoplasty is dependent on individualized clinical requirements. [(2)]

FSL can be precisely used to perform lamellar keratoplasty. Femtosecond laser–assisted lamellar keratoplasty shows promise as a safe and effective surgical choice in the treatment of various corneal pathologies. [(5)]

FSL is used to perform corneal biopsies in patients with keratitis. The technique allows us to obtain corneal tissue in a quick, accurate and minimally invasive way. [6]

The FSL is used for corneal tattooing. The advantages of the FS laser–assisted corneal tattooing include a customized design, speed, decreased pain, reduced risk of perforation, and good wound healing. This procedure provides improvements over current corneal tattooing techniques. [7]

Various studies have been conducted to study the different uses of FSL in glaucoma, including its use in glaucoma surgeries as well as laser trabeculoplasty. [8]

FSL-assisted astigmatic keratotomy is simple and efficient for managing irregular astigmatism in post-keratoplasty patients and may overcome the limitations of earlier techniques. [9]

There are four FSL systems available in the market: the IntraLase FS (AMO, Irvine, CA, USA), the Femtec (20/10 Perfect Vision AG, Heidelberg, Germany), the Femto LDV (Zeimer Ophthalmic Systems Group, Port, Switzerland), and the VisuMax femtosecond laser system (Carl Zeiss Meditec, Inc., Dublin, CA).[10]

AIM OF THE WORK

The aim is to clarify techniques, different uses of femtosecond laser in ophthalmological practice and differences between different types of femtosecond laser systems.