Femtosecond Laser in Refractive Eye Surgery

Protocol for Essay
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Abstract

The history of science in general and medicine in particular is full of those great moments when an important new discovery precipitates a flood of solutions to old problems. In 1916 and 1917 Albert Einstein continued his study of the physics of light. Among other things, Einstein showed that molecules that had been suitably energized would emit light of a single color, or monochromatic light. He calculated that when an excited molecule is hit by an electromagnetic particle (photon), the molecule will fall to a lower energy level and emit an identical photon moving in the same direction. The net result is two photons, where one existed before, amplifying the signal After World War II, in 1951, Charles Townes wanted to produce stronger microwaves. He soon built the first device that produced ***microwave amplification by stimulated emission of radiation*** ; he named this the "MASER" after the initials of the process. Arthur Schawlow proposed using this method for amplification of light in 1958, eventually developing ***light amplification by stimulated emission of radiation***, or the "LASER"

Key Word

review and display the uses of femtosecond laser in refractive surgery and to mention its advantages

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Contents

List of abbreviations

ALK	Automated lamellar keratoplasty
CPA	Chirped pulse amplification
D	Diopters
DLK	Diffuse lamellar keratitis
FS	Femtosecond
kHz	Kilo hertz
Laser	**Light amplification by stimulated emission of radiation**
YAG	Yttrium-aluminum- garnet
Nd	Neodymium
LASEK	Laser-assisted subepithelial keratomileusis
Lasik	Laser-assisted in-situ keratomileusis
LIOB	Laser induced optical breakdown
MM	Mechanical microkeratome
mW	Milli watt
NA	Numerical aperture
nm	Nanometers
OBL	Opacified bubble layer
PRK	Photorefractive keratectomy
RK	Radial keratotomy
SE	Spherical equivalent
µm	Micrometers
µJ	Micro joules

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Chapter 1:

Introduction and Aim of Work

Introduction

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After World War II, in 1951, Charles Townes wanted to produce stronger microwaves. He soon built the first device that produced ***microwave amplification by stimulated emission of radiation*** ; he named this the "MASER" after the initials of the process. Arthur Schawlow proposed using this method for amplification of light in 1958, eventually developing ***light amplification by stimulated emission of radiation***, or the "LASER" **(Maiman, 1960).**

In 1960 T.H. Maiman discovered the ruby laser. Although this laser was used on limited basis because of technical factors (instability of the beam and inconvenient pulse duration), subsequent generations of new lasers, such as the argon, krypton and neodymium (Nd):YAG (yttrium-aluminum- garnet) lasers, have made it possible to treat effectively four of the commonest causes of blindness, which are: diabetic retinopathy, age-related macular degeneration, glaucoma and cataract. Other lasers, such as the carbon dioxide, tunable dye and excimer lasers currently enjoy more applications **(Maiman, 1960).**

When molecules undergo chemical reactions their atoms move so fast that we cannot see them. But imagine that we could film the process with a high-speed camera and play it back in “slow motion”. It is possible to follow atoms and molecules in “slow motion” during a chemical reaction in which chemical bonds are broken and new ones created **(A.H. Zewail, 1990).**

Professor Zewail used a technique that may be described as the world’s fastest camera. This uses laser flashes of such short duration that is down to the time scale on which the reactions actually happen – ***femtoseconds***. One femtosecond (fs) is 10^{-15} seconds, that is; 0,000000000000001seconds, which is to a second as a second is to 32 million years! This area of physical chemistry has been named ***femtochemistry*** **(Jain, 1995).**

Femtosecond technology has lately been incorporated in laser machines to create LASIK flaps, which is regarded by many ophthalmologists as an improvement over traditional LASIK because of a greater accuracy in flap size, shape, and thickness **(Durrie and Kezerian , 2005).**

The technology of the femtosecond laser brings a new level of safety and guarantees better results to refractive surgery. It provides an all-laser approach for optimal precision. A computer-assisted laser creates a corneal LASIK flap with a preset diameter and a precise thickness **(Touboul et al, 2005).**

Aim of Work:

The aim of this essay is to review and display the uses of femtosecond laser in refractive surgery and to mention its advantages and disadvantages.

Chapter 2:

Review of Literature

1- Evolution of FS Laser

Today, laser refractive surgery is quickly gaining popularity. Laser surgery is only the latest in a long line of vision correction aids dating back many centuries. Glasses have a history of about 500 years, rigid contact lenses 60 years, gas-permeable lenses 30 years, and disposable lenses ten years **(McDonnell, 2000).**

In concert with contact lens development is the fast-evolving field of refractive surgery. Radial keratotomy has been around for about three decades, photorefractive keratectomy (PRK) for two decades, and laser-assisted in-situ keratomileusis (LASIK), the last decade. Most recently, wavefront technology, Femtosecond LASIK (IntraLASIK) and phakic intraocular lenses offer more precise and higher myopic correction **(Vogt, 2003).**

RADIAL KERATOTOMY:

Sato, Fyodorov and Durnev, as well as other groups of ophthalmologists, introduced anterior cuts to the cornea. Radial keratotomy (RK) was the name given to this incisional procedure. With the release of the Prospective Evaluation of Radial Keratotomy (PERK) results, and the development of nomograms by Assil, Casebeer, Lindstrom and others, the procedure has been greatly modified to a staged approach, with two or more incisions performed, depending on the age of the patient and the degree of myopia to be corrected (**Bashour, 2004**).

RK, while a relatively effective procedure to correct myopia, has seen its share of adherents decline over the years as newer technologies appeared on the scene. The ten-year PERK study, a randomised controlled trial of 793 eyes operated by RK, showed that 85% of the follow-up patients had uncorrected visual acuity of 20/40 or better, and 60% were within one dioptre of emmetropia.The safety level of RK, where less than 3% of patients experience loss of best-corrected visual acuity, has set the standard for other eye correction techniques. Even though RK has its advantages, there are a number of complications which have contributed to the decline in popularity of this breakthrough procedure **(Waring et al, 1994).**

PHOTOREFRACTIVE KERATECTOMY (PRK)

The excimer (“excited dimer”) laser is the invention with the greatest impact on refractive surgery in recent times. Today, it can be seen in two major modalities of corrective operations: PRK and laser keratomileusis. The great attraction of laser is the precision of its cuts and the minimal damage it causes to the surrounding tissue. As early as 1983, Trokel et al performed the first argon fluoride (ArF) excimer laser incision on bovine cornea **(Trokel et al, 1983).**

At this time, this process of shaping the anterior corneal contour with the ArF laser was called ***photoablative decomposition*** (**Linsker et al, 1984**).

Seiler et al in Germany, and L'Esperance et al in the United States were the first to use the excimer laser for therapeutic purposes. Since then, this technique has been used to remove corneal opacities, as well as to create a new curvature for refractive errors, with the latter being termed PRK **(L'Esperance et al, 1988) (Seiler et al, 1988).**

"Excited dimer" is a misnomer for the rare gas-halide mixture that provides the substrate for laser emission. The excimer laser used for corneal surgery is an ultraviolet beam with a wavelength of 193 nm and contains sufficient energy to break intermolecular bonds and eject the remnants at supersonic speed. This laser-tissue interaction is the basis for the smooth cuts evidenced in laser incision. With computer manipulation, the beam can be coaxed and shaped to perform a variety of functions. For myopia, the laser is centred on the optical zone to remove a specific volume of tissue so as to flatten the cornea and normalize the refractive error of the eye. The same goal as RK is reached without incision and its attendant