

# Characteristics of laser eye surgery biology essay

[Science](#), [Biology](#)



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## **Lasers in biology/surgery**

### **Abstract**

There are several different types of lasers used in biological reconstruction. Some, most effectively used in laser eye surgery. This is a type of refractory surgery which corrects the impaired enamel in a biological living eye. In order to reshape and manipulate the eye, the material wavelength, frequency, and refractive index all play into account to provide optimal cooperation and reconstruction. There are two common types of laser eye surgery; Lasik (laser-assisted in-situ keratomileusis) (Figure 1) and PRK (Photorefractive Keratectomy). These two types have a different approach in which lasers are used. They vary by frequency, amplitude, and or wavelength depending on the area and skin depth of reconstruction.

### **History**

The ability to reconstruct biologically with lasers was introduced in 1968 when the carbon dioxide laser was developed. This was the beginning of the excimer laser [3]. By 1980 the excimer laser was found to be in the ultraviolet range and in this range it could etch living tissue. Theoretical reconstructions of incisions were made from 193 nm excimer laser of ultraviolet light radiation. It was discovered that it also would flatten the cornea. The angle and degree of central corneal flattening were directly correlated to the energy of the laser provided. Laser eye surgery was finally made practical in 1989[1].

## **Laser eye surgery and its motivation for other eye reconstructions**

After making laser eye surgery practical, the possibility for reconstruction of other living tissue also became practical. The introduction of other lasers, with their own set of properties, was developed in order to be used efficiently on the affected area. For example, different pulsing lasers are used for different kind of laser eye surgery. In Lasik, the laser is comprised of an ultraviolet radiation in which the excimer molecule follows a unique excited state. The molecule also has a disassociated ground state. When the material is induced by an electrical discharge, which produces high energy pulses, the laser can form temporary agglomeration or coagulation. This causes the material to give up its excess energy resulting in a strongly repulsive ground state, which can allow for the pulses to be on the order of nanoseconds. The wavelength for Lasik surgery is on the order of 193 nm and is typically an argon fluoride (ArF) laser. This particular wavelength is used as it eliminates the risk of burning or laceration of the living tissue. The excimer laser adds enough energy to alter the bonds of the living surface tissue, which then disintegrates into the air causing ablation. The excimer laser also removes fine layers independent of temperature. Temperature must remain independent and constant due to the possible effects of an increase or decrease in degrees. An increase in 10-20 degrees centigrade would cause the tissue to coagulation or agglomeration the targeted tissue [4]. If the temperature was to raise a minuscule amount in laser eye surgery it would reflect on the wavelength and cause the procedure to go from a soft tissue procedure to a hard tissue procedure. This would cause a negative affect and the skin depth equation would also then be altered which relates <https://assignbuster.com/characteristics-of-laser-eye-surgery-biology-essay/>

to the wavelength and dioptric value. Equation 1 is an example of the ablation profile for the correction of myopic Lasik where;  $R$  and  $R_m$  are the initial and final radii of curvature,  $n$  is the refractive index of the cornea,  $S$  is the optical zone diameter and  $T_m$  is the depth of tissue removal (skin depth). When there is an intended change in the refraction Equation 2 is used. This equation is supportive for both Lasik and PRK reconstruction surgeries. Equation Also, Equation Where  $D$  is the dioptric value and  $n$  is the refractive index. The dioptric value is positive for convex lenses and therefore negative for concave lenses. It is important for the variation of skin depths. As for the Excimer laser used (Table 1) there are several options depending on the necessary power intended for the treatment needed based from equation 1 and 2. All materials wavelengths are in the necessary ultraviolet range. The pulse rate can range from 100 Hz to 8 kHz with a duration range from 10 to 30 nanoseconds. PRK[2] and Lasik depend predominantly on skin depth and pulse lasers (Table 1).

## **Characteristics of laser eye surgery**

The argon fluoride Laser is typically the laser of choice for laser eye surgery. The pulses that break up the carbon-carbon bonds on the surface of the eye typically can only break up 0.3 microns per pulse; this in turn would take hundreds of pulses. Similarly the retina has a surface area of roughly 6 mm diameter which will also need hundreds if not thousands of laser spots. However, this can be compromised by the frequency which can run between 100Hz to 400Hz allowing for the process to be efficient. The frequency can be related to equation 2 where  $\omega$  is the frequency in Hertz,  $V$  is the velocity of the laser and  $\lambda$  is the wavelength of the material. Equation

## Other biological laser uses

Since other living tissue has stronger interconnecting bonds different lasers are used rather than the basic argon fluoride Laser used for laser eye surgery. For example, the retina and surface skin is much softer than fingernails, which are much softer than dental enamel. Mohs's hardness scale relates skin to being very soft with a hardness of 1. Fingernails have the same hardness as pure gold and a hardness of 2.5 whereas dental enamel is relatively as strong as apatite, which ranks a 5 on Mohs's hardness scale [5]. Hard tissue surgical lasers are dominated by erbium-doped yttrium aluminum garnet (Er: YAG) lasers operating at high wavelengths on the order of 2940 nanometers (table 1). This high wavelength can also be used for cauterization of blood vessels and lymphatic. The higher wavelength is needed in order to penetrate throughout the biological tissue and reconstruct the affected area. The relationship between wavelength energy and frequency can be expressed as: Equation Where  $h$  is Planck's constant and  $E$  is the energy of the light. This can be related to equation (3) and then derived into equation (5) we can then determine an inverse relationship between wavelength and photonic energy. Therefore the wavelength plays an important role in both the energy and how it is delivered to the operative site, and its effect on the actual biological tissue. Equation Another characteristic that has to be taken into account is the relative external and internal refractive indices. This will vary from soft tissue (retina, to skin) to hard tissue (tooth enamel). To calculate the refractive index in soft tissue such as the cornea, equation (6) determines the power of the cornea from its radius where;  $P$  is the power,  $n$  is the keratometric index, and  $r$  is the radius

in meters. This equation is used by keratometers for keratometry (K) readings. This allows us to determine the D value (equation 2) and the skin depth of the specific tissue that is being examined. This allows for accurate readings as the refractive index will vary from either person to person or different sets of tissue being analyzed.

## **Equation**

### **Pros and cons of using lasers in biological reconstructions**

Using sterile objects in surgery can be deceiving and never truly sterile. A laser is a safer approach, if possible, because it is naturally sterile. It evaporates bacteria and fungi, which in turn reduces the possibility of local infections. This can also lead to a decrease in post-operative pain by sealing nerve endings. However, even though soft tissue laser reconstruction is typically in the ultraviolet range there is potential for x-ray exposure.

## **Conclusion**

The relations between skin depth, wavelength, frequency and energy all play an important role in biological tissue reconstruction. For laser eye surgery it is imperative for the energy and power to be as precise as possible in order to create a positive effect. The power can then be derived into refractive index which then can be derived into the Dioptric value and skin depth which is necessary for the variants in either tissue hardness or different biological tissue. From equation 3 the frequency of the ArF excimer laser and the Er: YAG laser are inversely proportional to the wavelength. This is visually shown by the wavelength versus frequency in figure 2 and represented by equation 3 and table 1. Figure . Laser beam reshaping the cornea during LASIK

procedure. Figure . Excimer laser vs. Er: YAG wavelength. Table . Laser materials for biological tissue surgery[6]. LaserWavelength(nm)Relative Power (mW)Frequency (Hz)

### **Ar2**

126n/a2. 37e15

### **Kr2**

146n/a2. 05e15

### **Xe2**

175n/a1. 71e15

### **ArF**

193601. 55e15

### **KrF**

2481001. 21e15

### **XeBr**

282n/a1. 06e15

### **XeCl**

308509. 73e14

### **XeF**

351458. 54e14

### **KrCl**

222251. 35e15Er: YAG294010001. 01e14

## **Excimer\***