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Laser Photocoagulation: Literature Review

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Abstract

The increasing role in the use of lasers for medicinal purposes has had an impact on advances in medicine. Laser photocoagulation is a therapy that is widely used for retinal diseases. The invention of lasers revolutionized retinal therapy by facilitating more precise, reliable applications and minimal pain. Based on single wavelength selection, the laser also reduces the amount of damage to adjacent tissue. In the field of medicine other than as curative therapy, laser photocoagulation is also carried out as a preventive measure, preventing the occurrence of more serious complications in these patients. At present, laser photocoagulation as a preventive therapy uses argon laser as its main ingredient. Argon lasers are lasers with green light. The purpose of this burning is to repair diseased or damaged eye tissue so that it can prevent complications that will be caused by persistent diseased or damaged tissue.

Keywords. laser, photocoagulation, literature review

Introduction

One of the laser techniques that is often used in the field of ophthalmology is photocoagulation. Photocoagulation is a retinal therapy technique in which the laser used is a strong wave to clot the tissue. Light energy is absorbed by the target tissue and converted into thermal energy. When the temperature of the tissue rises above 65^{o}C, there will be protein denaturation and tissue coagulation necrosis.[1]

The increasing role in the use of lasers for medicinal purposes has had an impact on advances in medicine. Laser photocoagulation is a therapy that is widely used for retinal diseases. The invention of lasers revolutionized retinal therapy by facilitating more precise, reliable applications and minimal pain. Based on single wavelength selection, the laser also reduces the amount of damage to adjacent tissue. Laser light is used routinely for blood coagulation and blocking veins. Argon laser is a laser that is often used for photocoagulation.[2,3]

Most surgeons use photocoagulation with laser beams whose wavelengths are 400-700 nm and use infrared. The posterior segment lasers used today include green, red, yellow and infrared light. Light delivery system is carried out through the pupil with the application of a slit lamp, indirect ophthalmoscope, endo-photocoagulation or by application of contact *probes* via *transscleral*.

Laser is an abbreviation of the word *Light Amplification Stimulated Emission Radiation*. This theory of light was first introduced by physicist Albert Einstein in 1920 and only 40 years later the theory was practiced by the German doctor Mainamm who was finally judged successful for the first time directing the beam in a sphere of lines using rubies. Therefore, the first laser was called the *ruby laser*.[3]

In the field of medicine other than as curative therapy, laser photocoagulation is also carried out as a preventive measure, preventing the occurrence of more serious complications in these patients. At present, laser photocoagulation as a preventive therapy uses argon laser as its main ingredient. Argon lasers are lasers with green light. The purpose of this burning is to repair diseased or damaged eye tissue so that it can prevent complications that will be caused by persistent diseased or damaged tissue. Overall, this laser therapy treatment generally requires more than one treatment.[4,5]

The purpose of writing this literature review is to explain the application of photocoagulation lasers in the field of ophthalmology.

Anatomy

The retina is a thin, semitransparent layer of neural tissue that lines the inside of the posterior two-thirds of the eyeball. The retina extends anteriorly almost as far as the ciliary corpus and ends at the ora serrata with uneven edges. In adults, ora serrata is about 6.5 mm behind the Scwalbe line on the temporal side and 5.7 mm on the nasal side. The outer surface of the sensory retina overlaps the retinal-patterned epithelial layer so that it is also connected to the Bruch, choroid and sclera membranes.[4,7,8,9]

In most places, the retina and *retinal pigment epithelium* (RPE) are easily separated so that the subretinal space formed in retinal detachment can be limited. This contrasts with the sub-choroid space that can form between the choroid and the sclera, which extends to the sclera spurs. Thus, choroidal ablation will extend beyond Ore Serrata, below the pars plana and pars Plicata. The epithelial layers on the inner surface of the ciliary corpus and the posterior surface of the iris represent an expansion of the retina and epithelium of the retinal pigment to the anterior.[4]

The retina is a network consisting of several layers, as follows (from the outside in) 4. Bruch membrane which is the basement membrane of the retinal pigment epithelium (RPE), contains melanin pigment in RPE. The melanin pigment absorbs almost all light waves. The photoreceptor layer, which is a layer consisting of stem cells and cone cells, is the external Limitans membrane, located between the photoreceptor cells and the outer core layer, the outer core layer, constituting a layer of cone and stem cell nuclei. The three layers above are not blood vessels and receive metabolism from the choroid capillaries, the outer plexiform layer, is the acellular layer and is a place of synapses of photoreceptor cells with bipolar cells and horizontal cells, the inner core layer, is the body of bipolar cells, horizontal cells and Muller cells. This layer gets metabolism from the central retinal artery, the deep plexiform layer, an acellular layer where synapses of bipolar cells, amacrine cells and ganglion cells. optical and is an axon from ganglion cells. In this layer lies most of the retinal blood vessels originating from the central retinal arteries, internal limitans membranes, a hyaline membrane between the retina and vitreous humor.

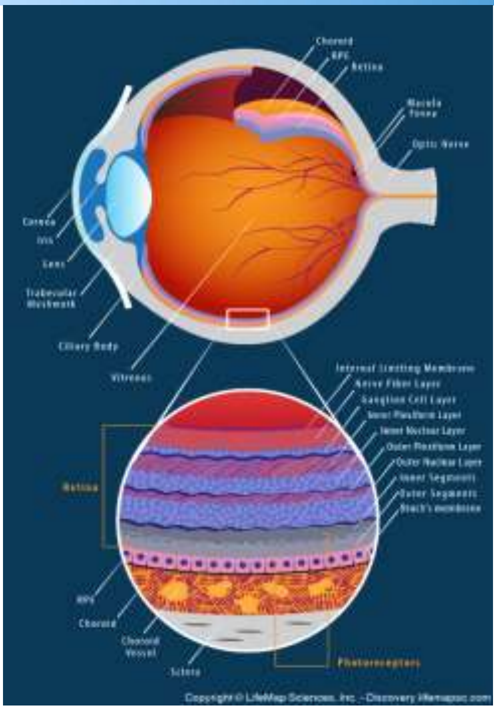

Figure 1. The retina layer Life Map Sciences.

Downloaded from: http://discovery.lifemapsc.com/library/images/human-eye-anatomy.

Accessed May 1, 2017

The retinal pigment epithelium (RPE) plays a role in renewing the outer photoreceptor segments, storing and metabolizing vitamin A, transport and epithelial *barriers*. Melanin pigment in RPE serves to capture free radicals and drug detoxification[4]

Macular lutea is anatomically defined as an area of 3 mm diameter that contains the Kunin-xanthophyll luteal pigment. Xanthophyll pigments absorb blue light well, and absorb less yellow or red light. The macula is located 4 mm lateral to the optic disc. Diseases that cause a buildup of extracellular material in particular can result in macular edema[4]

Fovea is depression on the inner surface of the retina in the central macula with a diameter of about 1.5 mm. The base of the middle part of the fovea is called foveolar and depression in the middle part of the foveolar is called umbo. The parafoveal area is an area of 0.5 mm width where the ganglion cell layer, inner nuclear layer and outer plexiform layer are thickest. The area surrounding it with a width of 1.5 mm is called the perifoveal zone.[4]

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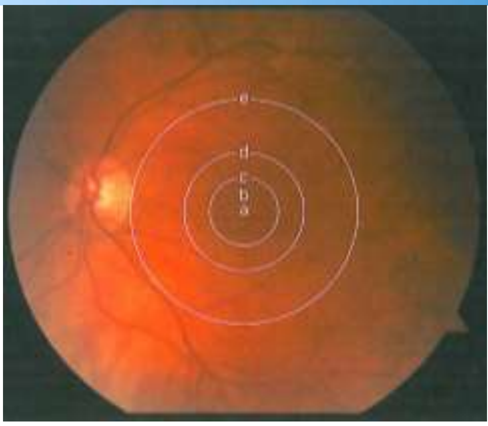

Figure 2. Macular anatomy, also called the central area or posterior Polus. a = umbo; b = foveola; c = fovea; d = parafovea; e = perifovea.

Quoted from: American Academy of Ophthalmology. Retina and Vitreous in Basic and Clinical Science Course, Section 12.2014-2015

The retina receives blood from two sources: the Corio capillary which lies just outside the Bruch membrane, which directs the outer third of the retina, including the outer plexiform layer and the outer core layer, photoreceptors, and the retinal pigment epithelial layer; as well as branches of a. *central retinae,* which enhances two thirds in the retina. The fovea is completely bloody by Corio-capillaries and is vulnerable to damage that cannot be repaired if the retina has ablation. Retinal blood vessels have endothelial layers that are not hollow, which forms the retinal blood barrier. The endothelial lining of the choroid vessels is hollow.[4,8,9]

Photocoagulators produce light with various wavelengths in the visible spectrum and infrared spectrum. Therefore, *full thickness* combustion of the retina is achieved by burning specific tissue made by a *single wavelength photocoagulator*. The first eye laser is the ruby laser, invented by Maimann in 1960. In addition to its better effectiveness, this *solid-state* laser is more compact and reliable than the previous xenon-arc coagulator. Then in 1968, L'Esperance introduced the argon laser which pioneered the widespread use of ophthalmic laser photocoagulation.[2]

Photocoagulation uses a strong light source to agglomerate tissue. Laser light energy can be more focused than normal light energy so it is more efficient for heat production in the target tissue. Light energy is absorbed by the targeted tissue and is converted to heat energy. Protein denaturation and clotting and tissue death are achieved at temperatures above 65ºC.[4]

Radiation is sent to the retina by laser and the following photothermal reaction results in photocoagulation. An increase of only from 10 °C to 20 °C is sufficient to cause coagulation but the dominant coagulation effect occurs at 60-70 °C. The extent of heating depends on the nature of both the laser and the target ocular tissue. Modifiable properties of the laser include the duration, strength and wavelength

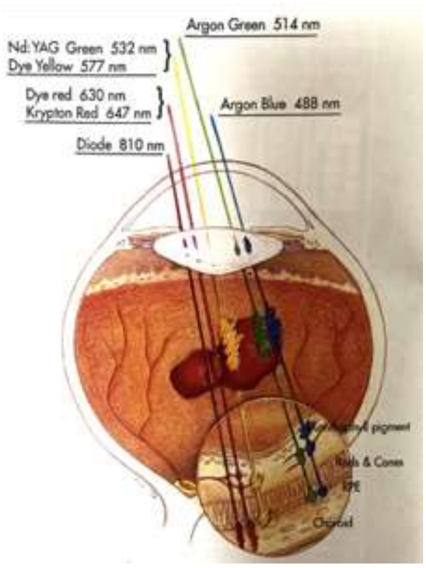

Figure 3. Wavelength and absorption of laser wavelengths by ocular pigments.
Excerpted from: Bloom SM, Brucker AJ. Laser Surgery of the Posterior Segment. Lippincott-Raven Publisher. 1997.

The effectiveness of photocoagulators depends on how well light waves are transmitted by ocular media and how well light waves are absorbed by pigment cells in the target tissue. Light waves are in principle absorbed by the eye tissue containing melanin, xanthophyll or hemoglobin pigments. The most effective wavelength of light for the laser photocoagulation action is that it is poorly absorbed by macular xanthophyll, but is very well absorbed by melanin pigments in the choroid, hemoglobin, and RPE.

	Xanthophyll	**Hemoglobin**	**Melanin**
Blue-green Argon (488 nm)	++++	+++	+++
Green Argon (514 nm)	-	+++	++++
Green ND-YAG (532 nm)	-	++++	++++
Dye yellow (577 nm)	-	++++	++++
Dye red (630 nm)	-	+	+++

Red Crypton (647 nm)	-	+	+++
Diode (810 nm)	-	-	++

Table 1. Characteristics of absorption of laser wavelengths by xanthophyll pigments, hemoglobin, and melanin.

Excerpted from: Bloom SM, Brucker AJ. Laser Surgery of the Posterior Segment. Lippincott-Raven Publisher. 1997.

Conclusion

Photocoagulation laser is a therapeutic modality that uses strong light energy which is converted into heat energy to agglomerate and denaturation tissue. Both of these can occur when the temperature of the thermal energy is more than 65 ° Celsius. The effectiveness of photocoagulation depends on how well the light waves are delivered by ocular media and how well the light waves are absorbed by pigment cells in the target tissue. Light waves are in principle absorbed by the eye tissue containing melanin, xanthophyll or hemoglobin pigments. So it is important for the operator to adjust the location of the pigments in the retinal tissue to the type of light used and the location to be managed.

Laser photocoagulation delivery techniques can use slit lamps, indirect ophthalmoscope, and endo-photocoagulation. Laser delivery techniques using slit lamps can use contact lenses and non-contact lenses to get a visualization of the posterior segment to be managed. The choice of contact lenses, waves, power and intensity settings of the laser used need to be mastered and considered by the operator who performs the laser photocoagulation action. The technique used in laser photocoagulation depends on the patient's disease and the severity of the disease. There are three types of techniques used, namely: pan-retinal, focal and photocoagulation grid.

Photocoagulation laser therapy on the retina primarily to reduce macular edema and eliminate neovascularization. Photocoagulation laser therapy is commonly used in diabetic retinopathy, macular degeneration, macular edema, retinal detachment, retinal venous occlusion, retinopathy of prematurity, and certain intraocular tumors, with the mechanism and technique used differently for each disease. The photocoagulation laser has an irreversible effect on the retinal tissue so it must be performed by an ophthalmologist who already has a background in the field of Vitreoretina.

Some side effects need to be considered after laser photocoagulation are the involvement of tissue outside the target tissue, formation of connective tissue in the retina, macular edema, formation of choroid neovascularization, serous retinal detachment. This of course can reduce vision sharply. *Good informed consent* and education need to be considered and given before performing laser photocoagulation procedures.

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