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Review Article

Laser Pulpotomy, Laser Hazards and Safety Measures: A Comprehensive Review

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Abstract: Diagnosis of pulpal condition is very much important in the determination of most appropriate treatment for primary tooth. For proper pulpal diagnosis, thorough history, clinical and radiographic examinations should be done. Various pulpotomy procedures are there but mostly each is associated with side effects .In present scenario lasers are used most commonly and are associated with very less disadvantages. A thorough understanding of laser physics and biological effects is mandatory for any provider. Comprehensive beginner and ongoing training is imperative to use these devices effectively and safely. Present review article mainly concentrate on the detailed explanation of laser pulpotomy.

Keywords: Caries, Laser, Nd: YAG, Pulpotomy.

INTRODUCTION

Pulpotomy is defined as the surgical removal of the entire coronal pulp presumed to be partially or totally inflamed and quite possibly infected, leaving intact the vital radicular pulp within the canals [1]. Pulpotomy is recommended when the young pulp already is exposed to caries and the roots are not yet fully formed (open apices) [2]. Since the introduction of lasers to dentistry, several studies have shown the effect of different laser devices on dentin and pulpal tissue. Application of laser irradiation in vital pulp therapy has been proposed as another alternative to pharmacotherapeutic techniques [3]. Lasers like CO_2, argon and Nd: YAG was used to perform pulpotomies on dogs and swine. Subsequent to these animal studies, many studies were done to perform pulpotomies in primary teeth [4].

Liu *et al*. published a case report of 23 teeth that received pulpotomy treatment with an Nd:YAG laser with the following settings, 2W, 20Hz, 100mJ and followed for 12 to 24 months. Complete homeostasis was achieved by exposure to Nd: YAG laser at 2 W, 20 Hz, 100mJ (124J/cm2) (The SunLase 800, pulsed Nd: YAG Dental Laser System Sunrise Technology, CA, USA). This was introduced into the canal orifice through a standard quartz 320um optical fiber. Then, IRM paste was placed over the pulp stumps, and the tooth was restored with either composite resin or a stainless steel crown. Clinical and radiographic evaluations of the success of Nd: YAG laser pulpotomy were based on the following: absence of pain, fistula, swelling and abnormal mobility; lack of internal or external root resorption, periapical or furcal radiolucency [5].

Jukic *et al*. used CO_2 and Nd: YAG lasers with energy densities of 4 J/cm2 and 6.3 J/cm2, respectively, on exposed pulp tissue. In experimental groups, carbonization, necrosis, an inflammatory response, edema, and hemorrhage were observed in the pulp tissue. In some specimens, a dentinal bridge was formed [6].

The effect of Nd: YAG laser energy on intrapulpal temperature was investigated by White *et al*. They found that the use of a pulsed Nd: YAG laser with an energy level of below 1 W, a 10-Hz repetition rate, and an overall 10-second exposure time did not significantly elevate the intrapulpal temperature [7].

METHOD

After administration of local anesthesia and isolation of the tooth with a rubber dam, the caries was excavated and the extent of the carious lesion determined. If a carious pulpal exposure was evident, a high-speed bur was used to unroof the pulpal chamber. Coronal pulpal tissue was removed using a sterile sharp spoon excavator, followed by irrigation with sterile saline. Initial hemorrhage control was achieved using a dry, sterile cotton pellet. In the study group, complete hemostasis was achieved by exposure to a Nd: YAG laser at 2 W, 20 Hz, 100 mJ (124 J/cm^2) (The Sun Lase 800, pulsed Nd: YAG laser, Laser Research, CA). This was introduced into the canal orifice through a standard quartz 320 um optical fiber [7].

History and Background of Laser Pulpotomy

Laser light production's theoretical basis was introduced some 90 years ago. Laser is a proposal made by Albert Einstein in 1916 that under proper conditions, atoms are able to release excess energy as light – either voluntarily or when stimulated by light [8]. The History of invention or the evolution of laser may be classified into Pre Maser, Maser and the Laser Period [9]. Rapid development of laser technology has introduced various types like argon carbondioxide, Neodymium-Aluminum-Garnet) (Nd: YAG) or Erbium-Yatrium-Garnet (Er: YAG) and diode lasers with wide applications in dentistry [3].

The Pre maser Period: It started with discovery of existence of stimulated emission process and ended with possibility that this process might lead to a radiation amplifier. Max Plank's published work in 1900 provided the concept stating that Light is a form of electromagnetic radiation. In absence of this concept, laser would not have been developed. In 1917, principle of the laser was first known when Albert Einstein gave the theory of stimulated emission which later was known as Light Amplification by Stimulated Emission of Radiation (LASER) an acronym coined by Gordon Gould(1957)[8, 10].

The Maser Period: An intense outburst of research on maser followed in the mid-1950s, Charles Townes, experimented with microwaves and developed a device by which these radiations could be amplified by passing across ammonia gas. This was the first MASER (microwave amplification by stimulated emission of radiation).In 1958, Dr. Townes, along with his brother-in-law, Dr. A.L. Schawlow (Professor, Stanford University), exhibited theoretically that masers can be made to employ in the optical and infrared region and gave First detailed paper describing "Optical MASER". Credited with invention of LASER from Columbia University [10, 11].

Laser Period: Theodore Maiman Invented first working LASER based on Ruby. The first laser was evolved by Theodore H. Maiman. Using a theory originally postulated by Einstein, Maiman created a device where a crystal medium was stimulated by energy, and radiant, laser light was emitted from the crystal. This first laser was a Ruby laser. One year later, Snitzer released the neodymium laser (Nd: YAG).The search for a laser system with broader applications in dentistry led Dr. Terry Meyers and his brother William, an ophthalmologist, to select the Nd:YAG laser for experiments on the removal of incipient caries (Meyers, Meyers, 1985). First experimentation on lasers in dentistry was delineated in a study which summarized the effectiveness of a pulsed ruby laser on humans in tooth caries [8, 10, 11].

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Adrian reported that irradiation of the buccal tooth surface with the neodymium: yttrium-aluminum-garnet (Nd:YAG) laser produced less pulp damage than the ruby laser with less histologic evidence of coagulation and focal necrosis [13].

Shoji *et al*. histologically studied the carbon-dioxide laser in the pulpotomy procedure. They noted that the least amount of pulp tissue injury occurred with defocused irradiation with lower power settings and shorter application. More tissue destruction occurred in the defocused mode with higher irradiation power settings. They applied CO_2 laser energy to the exposed pulps of dogs using a focused and defocused laser mode and a wide range of energy levels (3, 10, 30, and 60 W). Charring, coagulation necrosis, and degeneration of the odontoblastic layer occurred, although no damage was detected in the radicular portion of the pulp [14].

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Laser Hazards and Laser Safety

Safety is an integral part of providing dental treatment with a laser instrument. In addition to various state governments, the United States has four major organizations that are concerned with regulations regarding the safety of laser systems: The American

National Standards Institute (ANSI); the Food and Drug Administration (FDA) and its regulatory bureau, the Center for Devices and Radiological Health (CDRH); and the Occupational Safety and Health Administration (OSHA) [16].

Proper safety procedures must be put in place by any practice implementing laser use. A laser safety officer needs to be appointed by the clinic whose job it is to implement and monitor safety protocols. The manufacturer of each device is obliged to train the providers the important safeguards needed for each device [17].

Laser classifications are based chiefly on the potential of the primary laser beam or the reflected beam to cause biologic damage to the eyes or skin. There are four general classes of lasers; the higher the classification number, the greater the potential hazard. The classes are differentiated by a combination of the output power of continuous emission lasers or energy [18].

Class I

Lasers in this category working under normal operating conditions do not pose a health hazard. These devices usually are totally enclosed, and the beam does not exit the housing. Per pulse for pulsed lasers and the amount of time that the beam is viewed [19].

Class II

Lasers in this category emit only visible light with low power output and do not normally pose a hazard because of the normal human blinking and aversion reactions. A supermarket bar code scanner and some small laser pointers demonstrate this class. The maximum allowable output power of these devices is 1 mW. There are two subclasses: class IIa is hazardous when directly viewed for longer than 1000 seconds; class IIb has a dangerous viewing time of one fourth of a second, which is the length of time of an ordinary blinking reflex [19].

Class III a

Lasers in this category can emit any wavelength and have output power less than 0.5 W of visible light or approximately 0.1 to 0.2 W in the other portions of the electromagnetic spectrum. In this class, when the laser light is viewed only momentarily (within the aversion response period or blinking reflex one-fourth of a second), it will not harm the unprotected eye [19].

Class III b

These lasers can produce a hazard to the unprotected eye if viewed directly or viewed from reflective light for any duration. The output power can be no greater than 0.5 W of any electromagnetic radiation. Class IIIb lasers will not cause reflective hazards when using matted (not shiny) surfaces and do not normally produce fire hazards. An argon curing laser, only if set at less than 0.5W, would exemplify this type of device. Low-level therapeutic lasers would be class IIIa or class IIIb, depending on the emission wavelength and the duration of exposure. Because these lasers usually have dental treatment time measured in minutes, eye protection must be used [19].

Class IV

This category of lasers is hazardous from direct viewing and may produce hazardous diffuse reflections. Any output power greater than 0.5 W measured in either continuous wave or pulsed emission constitutes a class IV laser. These devices also produce fire and skin hazards.

The lasers presently used in dentistry are class IIIb or class IV; therefore, they present the possibility of serious eye and skin damage. Class IV lasers also may ignite flammable objects (such as alcohol-moistened gauze) and may create hazardous airborne contaminants [19].

Laser Hazards

This subject is broad in scope including not only an awareness of the potential risks and hazards related to how lasers are used, but also recognition of existing standards of care and a thorough understanding of safety control measures. Types of hazards can be grouped as follows: [20].

1. Ocular Injury
2. Tissue Hazards
3. Respiratory Hazards
4. Fire and Explosion
5. Electrical Hazards

Ocular Injury **[17, 21, 22]**

Awareness of the first type of eye protection can be traced back to 1962, with the development of the ruby laser, it was realized that lasers presented unique, specific hazards to the human eye. Lasers produce an intense, highly directional beam of light that is absorbed to some degree if directed, reflected, or focused on an object the eye is a critical target for laser injuries. The dentist, assistant, patient, and others who are inside the nominal hazard zone are at risk from the direct and reflected radiation of class III and class IV lasers. Wearing the correct protective eyewear when using dental lasers is essential because different available wavelengths can and will damage various parts of unprotected eyes quickly.

For example, the cornea, consisting mainly of water, absorbs the emission wavelengths of carbon dioxide, erbium: yttrium-aluminum-garnet (Er: YAG), erbium, chromium: yttrium-scandium-gallium-garnet, and holmium: yttrium-aluminum-garnet lasers. In these cases, corneal burn is the recognized eye hazard.

The erbium and holmium lasers also affect the unprotected aqueous and vitreous humor and lens of the eye, leading to aqueous flare and possibly contributing to cataract formation.

Retinal damage occurs primarily with lasers that have more depth of penetration and are highly absorbed into pigment.

These lasers have shorter wavelengths and include argon, helium-neon, diode, and Nd: YAG. In fact, the retina is approximately 100,000 times more vulnerable to injury than the skin within the retinal hazard range (wavelength emission of 400–1400 nm). Laser-induced retinal damage usually results in irreversible loss of visual function.

Generally, protective glasses must have an optical density (OD) of at least 4 for the particular laser emission and device. Eye protection manufacturers, however, must comply with the standards of the regulatory agencies when calculating the exact OD that provides the correct amount of attenuation for protection of the specific wavelength in question.

Laser safety glasses must protect the eye structures from the specific wavelength in use, and the information about lens protection must be imprinted on the frames of the glasses. Regardless of the eye protection, a practitioner never should look directly at the laser beam.

Tissue Hazards [23]

Laser induced damage to skin can result from the (i) thermal interaction of radiant energy with the tissue proteins, or (ii) cumulative effects of radiant exposure. The potential for mutagenic changes, possibly by the direct alteration of cellular DNA through breaking of molecular bonds. So. the operator must be aware of the absorption and depth of penetration of the laser energy in the tissue.

Respiratory Hazards [24]

This involves the potential inhalation of airborne biohazardous materials that may be released as a result of the surgical application of lasers. Toxic gases and chemical used in lasers are also responsible for some extent. So as a safety measure, moistened drapes and gauge must be used. Proper high vaccum evacuation of the operative field and use of surgical masks is a requirement.

Fire and Explosion [25]

Flammable solids such as clothing, paper products, plastics, and liquids such as ethanol, acetone and gases such as oxygen, nitrous oxide used within the clinical setting can be easily ignited if exposed to the laser beam.

- Use only wet or fire-retardant materials in the operative field.
- Use only noncombustible anesthetic agents.
- Avoid alcohol-based topical anesthetic.
- Avoid alcohol-moistened gauze while firing the laser.
- Protect tissues adjacent to the surgical site.
- Know location and operation of the nearest fire extinguisher.
- Store highly combustible or explosive materials outside the nominal hazardous zone.
- Adhere to the ANSI directive: ‘‘Nitrous oxide supports combustion and should not be used during laser surgery

Electrical Hazards [26]

These can be electric hazards and electrical fire or explosion hazards. So, precautions must be taken to avoid water contact with electric cords and power supplies. The control panel must be protected from splashing water that can occur while working in a wet field.

Sterilization and infection control [27, 28]

Steam sterilization is the standard of care. The small flexible optic fibers, handpieces, or tips must be steam sterilized in separate sterilization pouches after each use. They should be kept in the sterilization pouch until ready for use. It is essential that when using fiber-optically delivered lasers, the port (connecting) end remains clean and oil-free. Therefore, never run the fiber in a sterilizer cycle alongside a high-speed turbine with lubricant.

If an instrument was used to cleave or recleave a fiber during or after a procedure, then it also must be steam sterilized. The protective housing around the laser, including the control panel and articulating arm (if applicable) should receive the spray disinfectant/wipe/spray disinfectant decontamination method, as do the dental cart and counter tops. Some delivery system components such as the large-diameter erbium fiberoptic cable is not designed for steam sterilization and must bed is infected in this way.

How safe are dental lasers?

The professional literature repeatedly demonstrates the safety and effectiveness of dental lasers. Aoki A *et al*. compared a conventional handpiece to an Er:YAG laser for caries removal in vitro. These researchers concluded that the laser provided effective ablation of carious dentin, with minimal thermal damage to the surrounding intact dentin and a much lower degree of vibration [29].

Fife *et al.* demonstrated that the Er:YAG laser with air/water coolant did not increase the pulpal temperatures of any of the teeth and, in fact, decreased the pulp chamber temperature by as much as 5 degrees [28].

SUMMARY AND CONCLUSION

Laser dental care is possible in all of the disciplines of dentistry. The public has an expectation that their dentist should be up to date and wants the most modern, advanced care possible. The future of lasers in dentistry is promising, and new applications and procedures are being developed such as laser pulpotomy. The public is made aware of this by various media, and the word ‘‘laser’’ has power because patients want and trust the doctors who offer advanced technology. Dentists and their staffs can successfully integrate the use of lasers into the everyday practice of dentistry. Education, training, and marketing laser dentistry takes planning and time.

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