Review Article

Received : 18-04-15
Review completed : 24-05-15
Accepted : 30-05-15

AN INSIGHT INTO DENTAL LASERS DELIVERY SYSTEM

Pavan Kumar Dubey, * Jeevan Shetty, ** Amit Kumar, *** Archana Dubey †

* Consultant Prosthodontist, The Dental Evolution Clinic, Varanasi, Uttar Pradesh, India
** Diplomate in Laser Dentistry, The Dental Spa Clinic, Mumbai, Maharashtra, India
*** Senior Lecturer, Department of Public Health Dentistry, Sarjug Dental College & Hospital, Darbhanga, Bihar, India
† Post Graduate Student, Department of Prosthodontics, Army College of Dental Sciences, Secunderabad, Telangana, India

ABSTRACT

With dentistry in the high tech era, we are fortunate to have many technological innovations to enhance treatment, including intraoral video cameras, CAD-CAM units, RVGs and air-abrasive units. However, no instrument is more representative of the term high-tech than, the laser. Dental procedures performed today with the laser are so effective that they should set a new standard of care. This paper intends to discuss the role of lasers in dentistry.

KEYWORDS: Laser; dental; radiation

INTRODUCTION

Researchers have investigated the effects of laser radiation on teeth, bone, pulp and oral mucosal tissues.[1] CO2 lasers have been used extensively in medical field and the first laser to be approved by FDA for dental application was Nd:YAG (Neodymium-Yttrium-Aluminum-Garnet) in 1990s. Since then many types of lasers including CO2, Er:YAG (Erbium-Yttrium-Aluminum-Garnet), Diode, Er Cr:YSGG (Erbium-Chromium-Yttrium-Scallium-Gallium-Garnet) have been approved for dental use. FDA approved Er:YAG for dental hard tissue in 1997 and has approved other types of lasers for soft and hard tissue procedures in many area of dentistry. Many authors have reported the use of Carbon Dioxide (CO2) lasers for soft tissue applications in dentistry. The Food and Drug Administration (FDA) granted clearance for marketing CO2 lasers for soft tissue procedures such as frenectomy, gingivectomy, biopsies, and removal of benign and malignant lesions because CO2 laser energy is well absorbed by water. Specific indications for use in dentistry include apthous ulcer treatment, coagulation of extraction sites, sulcular debridement and intraoral soft tissue surgeries such as ablating, incising, and excising.

HISTORY OF LASERS[2]

Year	Achievements
1917	Einstein in his paper described Physikialische Zeil, "Zur Quantern Theorie der Strahlung", was the first discussion of stimulated emission
1954	Townes and Gordon built the first microwave laser or better known as 'MASER'
1958	Schawlow at Bell Laboratories, published the first theoretic calculations for a visible light maser – or what was then called a LASER
1960	Theodore Maimen at Hughes Aircraft company made the first laser. He used a ruby as the laser medium.
1961	The neodymium – doped (Nd): glass laser was developed by Snitzer
1964.	Nobel Prize for the development of the laser was awarded to Townes, Basor and Prokhovov Nd: YAG was developed by Geusic
1965	CO_2 laser was invented by Patel et al
1968	Polanyi developed articulating arms to deliver CO_2 laser to remote areas
1970	Polanyi in applied CO_2 laser clinically
1990	Ball suggested opthalmologic application of ruby laser.

Laser Physics

Laser is a device that converts electrical or chemical energy into light energy. In contrast to ordinary light that is emitted spontaneously by excited atoms or molecules, the light emitted by laser occurs when an atom or molecule retains excess energy until it is stimulated to emit it. The radiation emitted by lasers including both visible and invisible light is more generally termed as electromagnetic radiation.[2] The concept of stimulated emission of light was first proposed in 1917 by Albert Einstein (Fig. 1 & Fig. 2). He described three processes:

1. Absorption
2. Spontaneous emission &
3. Stimulated emission.

The laser consists of following components.

1. A laser medium or active medium

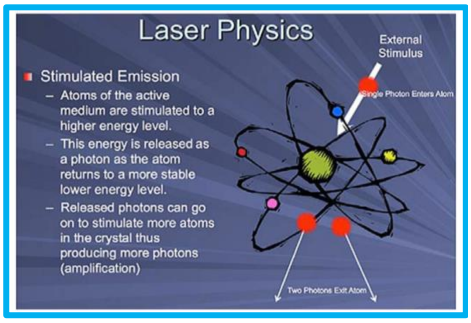

Fig. 1: Laser Physics

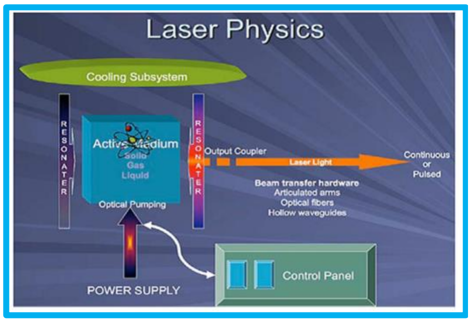

Fig. 2: Laser Physics

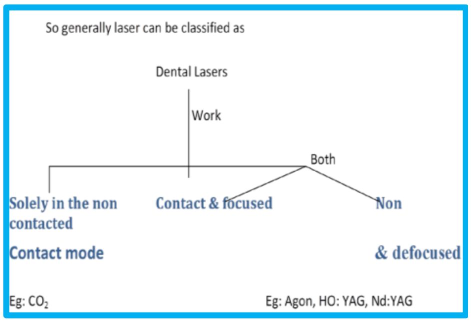

Fig. 3: Contact and Non contact modes

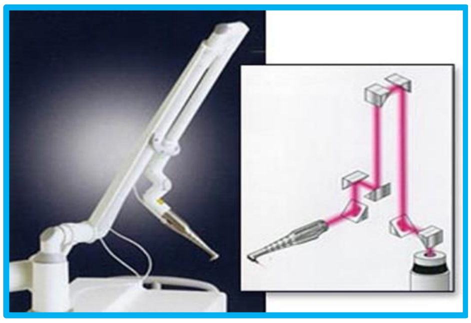

Fig. 4: Articulated arm delivery system

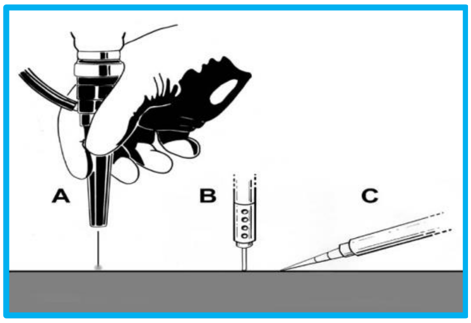

Fig. 5: Hollow wave guide delivery system

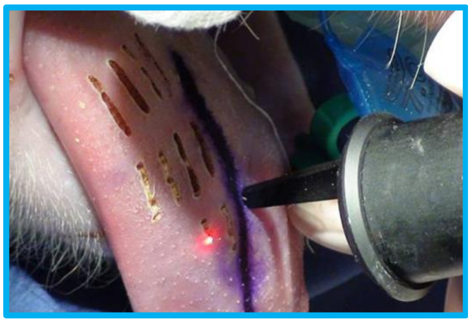

Fig. 6: Free beam and wave guide5

and

2. Housing tube or optical cavity
3. Some form of an external power source
4. Laser Light Delivery

Light can be delivered by a numbered of different mechanisms. Several years ago a hand held laser meant holding a larger, several hundred pound laser usually the size of desk above a patient. Although the idea was comical at the time, it is becoming more feasible as laser technology is producing smaller and lighter weight lasers. In the more future it is probable that hand held lasers will be used routinely in dentistry.

Focussing

Lasers can be used in either a focused mode or in a defocused mode. A *focused mode* is when the laser beam hits the tissue at its focal points or smallest diameter. This diameter is dependent on the size of lens used. This mode can also be referred as cut mode. E.g. while performing biopsies. The other method is the *defocused mode*. By defocusing the laser beam or moving the focal spot away from the tissue plane, this beam size that hits the tissue has a greater diameter, thus causing a wider area of tissue to be vaporized. However, laser intensity / power density is reduced. This method is also known as ablation mode. E.g. In Frenectomies. In removal of inflammatory papillary hyperplasia.

Contact and Non contact modes

In contact mode, the fiber tip is placed in contact with the tissue. The charred tissue formed on the fiber tip or on the tissue outline increases the absorption of laser energy and resultant tissue effects. Char can be eliminated with a water spray and then slightly more energy will be required to provide time efficient results. Advantage is that there is control feed back for the operator.

Non contact mode: Fiber tip is placed away from the target tissue. The clinician operates with visual control with the aid of an aiming beam or by observing the tissue effect being created. So generally laser can be classified as (Fig. 3).

Carbon-dioxide Laser

A report published by American Dental Association (ADA) in 2001 describing the challenges in the future of oral health care mentioned the role of laser applications. The report specifically mentioned that more clinical research and technical developments in CO2 laser delivery systems will promise to expand its clinical applications beyond soft tissue procedures. Although CO2 laser 10.6micron wavelength is absorbed by water and even though 9.3micron is absorbed in hydroxyapetite, it is primarily a soft tissue laser.

Types of laser delivery system

- Fiber delivery system.
- Articulated arm deliver system
- Hollow tube delivery system.

Fiber delivery

- As light of some initial distribution propagates in the fiber, it is converted into modes supported by the fiber or it is lost and appears as leakage or heat. This conversion, however, requires a certain length of fiber to be effected. There are different length scales that must be considered: short, intermediate, and long.[3]
- Quartz fiber: - The ideal delivery system as it is cheap and easily sourced. It is applicable to UV, Visible and near IR wavelengths. High water absorption by longer wavelengths precludes its use in the erbiums, due to hydroxyl groups present in quartz. Higher wavelengths of the mid and far infrared use germanium oxide, zirconium fluoride, sapphire, hollow silica with external cooling of air and water as delivery mechanisms.
- Fiber size is an important consideration in deploying a beam delivery system. Smaller fibers produce less degradation of beam quality. Using a smaller fiber (assuming the same numerical aperture) allows the same focused spot size to be achieved with a greater stand-off distance or, alternatively, smaller spot sizes to be achieved

Articulated Arm Delivery System

- Available in a large number of shapes, sizes, and models, the AA delivery systems are all the same basic technology originally developed in the 1970-1980's. All utilize glass laser generation tubes cooled by flowing liquid. Because of the inefficiency of glass laser tubes, these devices require very high voltage power supplies (>10,000 volts)
- The laser beam is delivered from the laser to the tissue through a thick, bulky, elbowed, mirrored articulated arm. The beam exits the arm through an equally bulky autoclavable focusing lens handpiece. The lens in the handpiece (focal length 50 - 100 mm) focuses the laser beam to a fixed 0.2 - 0.25 mm spot some distance (usually 2 - 3 cm) from the end of the handpiece.
- Since the operator must hold the handpiece away from the tissue for the beam to focus, these devices require an aiming beam that produces a 2 - 3 mm visible spot (Fig. 4).

Hollow wave guide delivery system

- The 1994 HWG delivery system was such a substantial jump forward in technology, and was so stable and adaptable, it remained unchanged for over a decade. A second generation of the devices was released in 2006.[4]
- HWG lasers utilize a more efficient metal laser tube which requires a low voltage power supply (32 volts). The original passive air flow cooling design, while effective, was updated to active air flow cooling with the 2006 release.
- The focusing tips have a focal length of 0.75 – 3 mm which means the handpiece is held very close to the tissue. No aiming beam is required. A gentle flow of air is pumped through the HWG and exits the focusing tip, preventing contamination of the tip by tissue fluid or debris (Fig. 5).
- The laser beam is delivered through a thin flexible hollow tube with a reflective interior coating (commonly called a "fiber", more accurately called a "hollow waveguide"). The laser beam exits through a thin, autocla-

vable handpiece and is focused by interchangeable, autoclavable focusing tips that focus the beam to 0.2, 0.25, 0.3, 0.4, 0.8, 1.4, or 0.4 x 3 mm spots.

Free beam and wave guide [5]

Fig. 6.

CONCLUSION

Multimode optical fibers enable efficient flexible laser beam delivery but at a loss in the quality of the delivered beam. The fiber-optic beam delivery system effectiveness is strengthened by the optimal selection of its components not only for minimizing beam quality degradation but also for robustness. The laser beam to be delivered should be launched properly into the fiber, otherwise damage may arise. Coarse alignment of the beam launch conditions is carried out by checking transmitted power[6]. Fine alignment can be obtained by monitoring the beam profile exiting the fiber for higher order modes.

CONFLICT OF INTEREST & SOURCE OF FUNDING

The author declares that there is no source of funding and there is no conflict of interest among all authors.

BIBLIOGRAPHY

1. Taylor R, Shklar G, Roeber F. The effects of laser radiation on teeth, dental pulp,and oral mucosa of experimental animals.Oral Surg Oral Med Oral Pathol 1965;19:786-95.
2. Viraparia P, White JM, Vaderhobli RM. CO2 Laser: Evidence Based Applications in Dentistry, CO2 Laser - Optimisation and Application, Dr. Dan C. Dumitras (Ed.), 2012;978-953-51-0351-6,
3. Leong KH, Hunter BV. High-power fiberoptic laser beam delivery moves forward. Industrial Laser Review 1996;11:7-12.
4. Nibbling R, Harrington JA. Hollow waveguide delivery systems for high power, industrial CO2 lasers. Applied Optics 1996;35(3):372-80.
5. Lewinsky RM, Mintz Y, Fogel T, Vilan S, Khen R, Iger Y, *et al*. A Comparative,Controlled Study of the CO2 Laser Wave Guide and Free Beam Tissue Effects. White Paper 2011;1-3.
6. Brown TG. Optical Fibers and Fiber-optic Communications in Handbook of Optics. Vol. 11. M. Bass, editor-in-chief. McGraw-Hill: New York. 1995;10-13.