OPEN ACCESS
Saudi Journal of Medicine
Abbreviated Key Title: Saudi J Med
ISSN 2518-3389 (Print) |ISSN 2518-3397 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: http://scholarsmepub.com/sjm/

Review Article

Lasers in Dentistry: A Review

Dr. Siddhartha Bhowmick[1*], Dr. Shajini Sasidharan[2], Dr. Sushil Bhagwan Mahajan[3], Dr. Elaprolu Mallikarjun[4], Dr. Pritee Rajkumar Pandey[5], Dr. Pranoti Hiralkar[6]

[1]Senior Lecturer, Dept of Conservative and Endodontics, Awadh Dental College and Hospital Jamshedpur, Jharkhand, India
[2]Oral and Maxillofacial Pathologist, Mantri Flora, Sarjapur Main Rd, Amblipura, PWD Quarters, 1st Sector, Junction, Bengaluru, Karnataka India
[3]PG Student, Orthodontics and Dentofacial Orthopedic, Dr. H.S.R.S.M. Dental College and Hospital Hingoli, Maharashtra India
[4]Assistant Professor, Dept. Of Conservative Dentistry & Endodontics, GSL dental college, Rajahmundry, Andhra Pradesh, India
[5]PG, OMFS, DJ College of Dental Sciences & Research, Ajit Mahal, Modinagar - Niwari Rd, Modinagar, Uttar Pradesh, India
[6]MDS, Public Health Dentist, Solapur, Maharashtra, India

DOI:10.21276/sjm.2019.4.8.2 | **Received:** 28.06.2019 | **Accepted:** 23.07.2019 | **Published:** 16.08.2019

***Corresponding author:** Dr. Siddhartha Bhowmick

Abstract

Laser is an acronym for light Amplification by Stimulated Emission of Radiation. Several decades ago, the laser was considered like a death ray, the ultimate weapon of destruction, something you would only find in a science fiction story. Then, lasers were developed and actually used, among other places, in light shows. The beam sparkled; it showed pure, vibrant and intense colors. Today the laser is used in the scanners at the grocery store, in compact disc players, as a pointer for lectures and above all in the medical and dental field. The perception of lasers has moved from the comical death ray to the more useful ray for development of health sciences.

Key Words: Laser, Dentistry, Review.

INTRODUCTION

Appropriately, the history of lasers begins and ranges back to modern physics after Einstein's revolutionary concepts. While 43 years were necessary to pass from Einstein's theoretical formulation to Maiman's practical application, less than 20 years have been necessary to multiply the applications of lasers. The fascination exercised by scientists on laser can be explained by their outstanding characteristics. Some people were convinced that this device was facing a brilliant future; they even foretold that it should be the tool of a major technological breakthrough [1, 2].

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 the 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. The Albert Einstein first proposed the concept of stimulated emission of light in 1917. He described three processes:

- Absorption
- Spontaneous emission
- Stimulated emission.

Let us remind a few basic principles which must be understood to know the laser effect. Let us consider an atom which consists of a centrally placed nucleus which contains positively charged particles known as protons, around which the negatively charged particles are involving that is the electrons[3-4]. When an atom is struck by a photon (like aquanta of light), there is an energy transfer causing increase in energy of the atom. This process is termed as absorption. The photon then ceases to exist, and an electron within the atom pumps to a higher energy level. The atom is thus pumped up to an excited state from the ground state [11]. In the excited state, the atom is unstable and will soon spontaneously decay back to the ground state, releasing the stored energy in the form of an emitted photon. This process is called spontaneous emission [5]. (Let us consider a bow. When it is bent, it absorbs energy. Once the string is released, it recovers its shape, the arrow is ejected it gets rid of its excessive energy). If an atom in the excited state is struck by a photon of identical energy as the photon to be emitted, the emission could be stimulated to occur earlier than it would occur spontaneously. This stimulated interaction causes two photons that are identical in frequency and wavelength to leave the atom. This is a process of stimulated emission [5-7].

Properties of the Laser

Coherence: laser means that all waves are in a certain phase of relationship to each other both in space and time. (All the photons of a same radiation are identical in amptitude, phase and wavelength).

Monochromatim: characterized by radiation in which all the waves have the same frequency and energy (same frequency therefore same wave length).

Parallelism: which means all the emitted waves are parallel and the beam divergence is very low. This property is very important for good transmission through delivery systems [3, 8]

Laser Design [9, 10]

This laser consists of the following components:

- Housing tube.
- Lasing medium.
- Some form of external power source.

Housing tube or Optical cavity

Made up of metal, ceramic or both. The structure encapsulates the laser medium and consists of two mirrors, one fully reflective and the other partially transmittive, which are located at either end of the optical cavity.

Lasing medium

Most important component, because this type of medium denotes the name of the laser systems. For eg if CO_2 is used as a lasing medium, it is known as CO_2 laser. This lasing medium determines the wavelength of the light emitted from the laser

External power source

It excites or pumps the atom in the laser medium to their higher energy levels. This causes the population inversion. A population inversion happens when there are more atoms in the excited state pumped by the electrical change rather than a non-excited state. Atoms in the excited state spontaneously emit photons of light which bounce back and forth between the two mirrors in the laser tube. As they bounce within the laser tube, they strike other atoms, stimulating more spontaneous emission. Photons of energy of the same wavelength and frequency escape through the transmittive mirror as the laser beam

Laser Light Delivery [7, 10, 11]

Light can be delivered by a numbered of different mechanisms. Several years ago, a hand held laser meant holding a larger; several hundred pounds laser usually the size of desk above a patient. Although the idea was comical at the time, technological advances are producing smaller and lighter weight lasers.

Articulated arms

Laser light can be delivered by articulated arms, which are very simple but elegant devices. Mirrors are placed at 45^o angles to tubes carrying the laser light. The tubes can rotate about the normal axis of the mirrors. This results in a tremendous amount of flexibility in the arm and in delivering the laser light. This is typically used with CO_2 laser. The arm does have some disadvantages that include the arms counter weight and the limited ability to move in straight line.

Optical fibre

Laser light can be delivered by an optical fibre, which is frequently used with near infrared and visible lasers. The light is trapped in the glass and propagates down through the fiber in a process called total internal reflection. Optical fibres can be very small. They can be either tenths of microns or greater than hundredths of microns in diameter. Advantage of optical fiber is that they provide easy access and transmit high intensities of light with no loss but they have two disadvantages. The beam is no longer collimated when emitted from the fibre. The light diverges at some angle which limits the focal spot size. The second disadvantage is that the light is no longer coherent.

Mode of Delivery of the Laser [12-14]

Once the laser is produced, its output power may be delivered in the following modes:

Continuous Mode

When laser machines are set in a continuous wave mode, the amplitude of the output beam is expressed in terms of watts. The laser emits radiation continuously at constant power levels of between 10 to 100W. The CO_2 laser is the most commonly used laser in general surgery. Like most gas lasers, it can be operated as a confious wave C.W. laser by maintaining a continuous discharge through the gas.

Chopped Mode

The output of a continuous wave laser can be interrupted by a shutter that "chops" the beam into trains of short pulses. The maximum power level of each pulse is same as that obtained in the continuous wave mode. The speed of the shutter is 100 to 500ms (microseconds) or thousandth of a second [1×10^{-6}][15].

Gated or Pulsed Mode

Lasers can be gated or pulsed electronically. This type of gating permits the duration of the pulses to be compressed, producing a corresponding increase in peak power that is much higher than in commonly available in the continuous wave mode.

Super Pulsed Mode

The term superpulse is used to describe the output of a gated high peak power laser with short pulse duration typically between hundreds of microseconds

(1ms = 1 x 10^{-6} seconds). The pulse produced during superpulsing can have a repetition rate of 50 to 250 pulses per second that permits the laser output to appear almost continuous during use.

Ultra-Pulsed Mode

This mode produces an output pulse of high peak power that is maintained for a longer time and delivers more energy in each pulse than in the superpulsed mode. The duration of the ultrapulse is slightly less.

Flash Lamp Pulsing

In these systems, a flash lamp is used to pump the lasing medium, usually for solid state lasers (e.g. Nd:YAG).

Q-Switching

Even shorter duration pulses are achieved with Q-switching. A simple Q-switch uses a rotating mirror as part of the optical cavity. Only when the rotating mirror is precisely aligned with the output mirror, is lasing possible, so lasing is restricted to a very short time interval (1-10 nanose seconds). Between alignments, energy is stored in the excited population. Thus, several hundred millijoules of energy can be squeezed into nano second pulsed.

Focussed/Defocussed mode

Lasers can be used in either a focussed mode or defocussed mode. A focussed mode is when the laser beam hits the tissue at its focal point or smallest diameter. (This diameter is dependent on the size of lens used). This mode can also be referred to as the cutting mode.In the other mode that is the defocused mode, the laser beam is moved away from the focal plane. The beam size that hits the tissue has a greater diameter, thus causing a wider area of tissue to be vapourized. However, the laser intensity of the power density is reduced. This mode is also known as the ablation mode [16].

Contact and Non-Contact Modes

In contact mode, the fibre handpiece is placed in contact to the tissue whereas in the noncontact mode, the handpiece is placed away from the target tissue. In the noncontact mode, the clinician operates with visual control with the aid of an aiming beam or by observing the tissue effect being created.

Laser Types [1-3, 6, 17]

Lasers are classified

Based on wavelength

- Soft lasers
- Hard lasers
- Soft lasers – are lower power lasers with a wavelength of around 632nm eg. He-Ne, Diode.
- Hard lasers – are well known laser systems for possible surgical applications and have a higher wavelength.

Based on the lasing medium

Lasers can be classified according to the state of the active medium i.e.

- Solid eg. Nd:YAG, Diode.
- Liquid eg. Dye.
- Gas eg. CO_2, Argon, Er:YAG.

Lasers are classified into four groups according to the international system - The basis of the third classification is the potential danger posed to the exposed skin and to the unaccommodated eye.

Let us go in detail about the individual lasers.

CO_2 Lasers

The CO_2 laser first developed by Palet *et al*. in 1964 is a gas laser which has a wavelength of 10.6µ or 10,600 nanometers deep in the infrared range of the electromagnetic spectrum. CO_2 lasers have an affinity for wet tissues regardless of tissue color. The laser energy weakens rapidly in most tissues because it is absorbed by water. Because of the water absorption, the CO_2 laser generates a lot of heat, which readily carbonizes tissues. Since this carbonized or charred layer acts as a biological dressing, it should not be removed. They are highly absorbed in oral mucosa, which is more than 90% water. High absorption in small volume, results in a penetration depth as shallow as 0.2 to 0.3mm. There is no scattering, reflection, or transmission in the oral mucosa. Hence, what you see is what you get. CO_2 lasers reflect off mirrors, allowing access to difficult areas. Unfortunately, they also reflect off dental instruments, making accidental reflection to non-target tissue a concern. CO_2 lasers cannot be delivered fibreoptically. Advances in articulated arms and hollow waveguide technologies, now provide easy access to all areas of the mouth. Regardless of the delivery method used, all CO_2 lasers work in a non-contact mode. Of all the lasers for oral use, CO_2 is the fastest in removing tissue. As CO_2 lasers are invisible, an aiming helium – neon (He-Ne) beam must be used in conjunction with this laser [18].

Nd: YAG Laser

Developed in 1964 by Geusic *et al*. it stands for neodymium: yttrium- aluminum-garnet. This solid state laser consists of crystals of yttrium-aluminum-garnet doped with neodymium (1-3% a rare earth element). Nd:YAG laser, has a wavelength of 1.064 nm (0.106□) placing it in the near infrared range of the magnetic spectrum. It shows low absorption with water as well as hydroxyapatite. Therefore the laser power diffuses deeply through the enamel and dentin and finally heats the pulp. Thus, they have various degrees of optical scattering and penetration to the tissue, minimal absorption and no reflection. Nd:YAG lasers work either by a contact or non-contact mode. When working on tissue, however, the contact mode in highly recommended. The Nd: YAG laser is delivered fibreoptically and many sizes of contact fibers are available. Carbonized tissue remnants often buildup on the tip of the contact fibre, creating a 'hot tip'. This increased temperature enhances the effect of the Nd:YAG laser, and it is not necessary to rinse the buildup away. Special tips like the coated sapphire tip, can be used to limit the lateral thermal damage. A black enhancer can be used to speed the action of laser. A helium-neon-aiming beam is generally used with Nd:YAG laser. Penetration depth is 2 to 4mm. Most dental Nd:YAG lasers work in a pulsed mode. At higher powers and pulsing, a superheated gas called plasma can form on the tissue surface. It is this plasma that can be responsible for the effects of coagulation, vapourization or cutting. If not cooled (eg. by running a water stream down the fibre), the plasma can cause damage to the surrounding tissues. The Nd:YAG beam is readily absorbed by amalgam, titanium and non-precious metals, requiring careful operation in the presence of these dental materials[11-13].

Argon Lasers

The active medium is ionized argon gas. They are those lasers in the blue-green visible spectrum (thus they can be seen). They operate at 488nm (blue), 496nm (blue/green) or 514nm (green) and the transmission occurs via a flexible optical flbre. Argon lasers have an affinity for darker colored tissues and also for haemoglobin, making them excellent coagulators. Thus, an argon laser focussed on bleeding vessels stop the haemorrhage. It is not absorbed well by hard tissue and no particular care is needed to protect the teeth during surgery. In oral tissues there is no reflection, some absorption, some scattering and transmission. Argon lasers work both in the contact and non-contact mode. Argon lasers also have the ability to cure composite resins, a feature shared by none of the other lasers. The blue wavelength (488nm) is used mainly for composite curing while the green wavelength (510nm) is mainly used for soft tissue procedures.

Er: YAG laser (Erbium: YAG)

The Er:YAG is a very promising laser system because the emission wavelength of 2.94 m coincides with the main absorption peak of water resulting in good absorption in all biological tissues including enamel and dentin. This is the first laser to be cleared by the FDA on May 7, 1997 for use in preparing human cavities. A number of researchers have demonstrated the Er: YAG lasers /ability to cut, or ablate dental hard tissue effectively and efficiently. A variety of restorative materials such as zinc phosphate, zinc carboxylate, glass ionomer cements and silver amalgam can be effectively removed by the Er: YAG laser. Pulpal response to cavity preparation with an Er:YAG laser was minimal, reversible and comparable with the pulpal response created by a high-speed drill. Er: YAG can also be used for bone ablation and has indications in soft tissue surgeries where no coagulation effect is desired such as removal of hyperplastic gingival tissue, periodontal surgery and ablation of large benign lesions of the oral mucosa and skin [1,4,15].

Ho: YAG laser [Holmium: YAG]

Holmium laser is thallium and holmium doped chromium sensitized YAG crystal and has a wavelength of 2,100 nm. It is delivered through a fibreoptic carrier. A Helium-neon laser is used as an aiming light. Like Nd: YAG, it can be used on both contact and noncontact modes and are pulsed lasers. Ho:YAG lasers has an affinity for white tissues and is an excellent laser for arthroscopic temporomandibular joint surgery. It also has the ability to pass through water and is excellent coagulators.

Excimer Laser

An excimer or excipler, a contraction of the English expression, "excited dimers", is a dimer with associated excited electronic states and a disassociative ground state. It produces light in the ultraviolet region and its mode of action differs from that of the thermal effect lasers. It acts through photochemical effect by breaking the organic molecule bonds i.e. ionization at a microscopic scale, hence electron detachment. It generates neither heat nor optical breakdown. Among the 20 or so excimer molecules investigated, two wavelengths (193nm and 308nm) allow preparation without heating. It appears that the Argon fluoride excimer laser allows preparation without heating. In histologic investigations, no pathologic changes in the tissue layers adjacent to the dissected areas were found after the ablation of tissues with the 193nm Ar-F excimer lasers. The ablation depth per pulse in healthy enamel amounts to 0.15μm and in healthy dentin to 0.20μm in a $1mm^2$ focus area with an energy density of about $10mJ/cm^2$ pulse.

Helium-Neon Laser

The amplifying medium is a gas made up of helium (85%) and neon (15%). Neon is the active element; helium is used as a catalyzer by stabilizing the excited neon atoms at their stimulated levels. The spectral region is in the visible red i.e. 632nm. Power ranges from 0.5-50mw and transmission occurs by means of an optical fibre.

Semiconductor laser (Laser diode)

The diode laser is a semiconductor chip (active medium-gallium arsenide) that works like an electrical diode. In most semiconductor materials, the energy is released as heat but in the above mentioned material the energy is released as photons. Diodes have wavelengths in the red and infrared range (0.62 and 1.5μm) that is determined by the semiconductor material and the operating temperature. To make a diode laser, it is necessary to add a reflective surface at the other end of the junction to establish an optical cavity. These optical cavities are very small (0.05 x 0.15mm). Even on this scale, diode lasers can produce several watts of power.

Laser Interaction with Biologic Tissues [18-20]

Light can interact with tissues in four different mechanisms

Reflection: Reflected laser light bounces off the tissue surface and is directed outward. Energy dissipates after reflection, so there is little danger of damage to other parts of mouth and it limits the amount of energy that enters the tissue.

Scattering: It is shown by a change in the direction of the radiation without loss of energy. This change in direction is the result of the encounter of the ray with small particles or molecules. The directional character is lost and the irradiated volume becomes larger, dissipating the thermal effects.

Absorption: It is the most important process because it leads to transformations due to the energy supply to the medium. It is responsible for the thermal effects within the tissue that is it converts light.

Transmission: Light may be transmitted through the tissue as if the tissue was transparent.

Application of Lasers in Dentistry [6-9, 12-18]

In Restorative Dentistry and Endodontics

Lasers find numerous applications in restorative dentistry and endodontics ranging from prevention of caries to antibacterial action in root canals.

Prevention of caries

Yamamoto and Ooya [6] used Nd:YAG laser at energy densities of 10 to 20 J/cm³ and demonstrated that the lased enamel surface was more resistant to in vitro demineralization than unlased enamel. Stern and Sognnaes [2] demonstrated in vivo that enamel subjected to 10 to 15 J/cm² ruby laser, showed a greater resistance to dental caries. Stern concluded that energy levels below 250 J/cm² did not permanently alter the pulp. Lobene and Collogues [3] and Sirkka Kantola [4] in their experiments with CO_2 laser, observed that CO_2 irradiation to tooth enamel caused small amounts of hydroxyapatite to be converted to insoluble calcium orthophosphate apatite resulting in decrease in acid dissolution of enamel. This has been further corroborated by Featherson Zvi *et al*. in 1988. In dentin Sirkka Kantola [4] showed lased dentin came to closely resemble the hydroxyapatite of normal enamel (due to the increase in calcium and phosphorous contents. Lasers can thus be used for removal of incipient caries, sealing pits and fissures. The CO_2 and Nd: YAG lasers can remove the organic and inorganic debris found in pits and fissures. Power densities used are low and it did not alter the health of pulp tissue. In 1985 Terry Myers used Nd: YAG laser for debridement of incipient caries. The lased fissure areas appeared similar to that of normal enamel. When a topical fluoride treatment was performed after argon fluoride laser conditioning of enamel, an even more dramatic reduction in enamel acid demineralization was observed.

Cavity preparation

The use of lasers for cavity preparation has been under scrutiny for 20 years as many investigators found that pulpal necrosis occur with the use of lasers. The reasons for necrosis are the heat produced and the total power output (J/cm²). The search for a laser that can be used to cut hard tissues began in 1964 by Dr. Leon Goldman who used laser on his brother Bernard's teeth. The subsequent search included many laser wavelengths such as CO_2 but its disadvantages include cracking with flaking of the enamel surface. Nd:YAG laser at 10 J/cm² has shown to inhibit incipient carious lesions but at higher densities, it causes irreversible pulpal damage. Other lasers have been investigated. Er: YAG at the wavelength of 2.94□m has shown most promising results. A number of researchers have demonstrated the Er:YAG laser's ability to cut or ablate dental hard tissues effectively and efficiently. Animal studies have reported that the pulpal response with Er:YAG laser was minimal, reversible and comparable to a high speed drill. The temperature use with these type of laser was less than 3°C. Moreover, a water coolant can also be used. More recently Er, Cr:YSGG (erbium, chromium:yttrium-scandium-gallium-garnet) with a wavelength of 2.97µ has also shown to be effective for cutting enamel, dentin and bone. This device has been shown to create precise hard tissue cuts by virtue of lasers interaction with water at the tissue interface and has therefore been termed, hydrokinetic system or HKS. Animal studies carried out by Eversole et al 1997 has shown that Er, Cr:YSGG HKS is effective for dental hard tissue surgery and fails to exit any adverse pulpal periodontal reactions.

Etching of Enamel and Dentin

The laser absorbed by enamel causes the enamel surface to be heated to a high temperature, generating microcracks in the surface and these aids in enhancing adhesion of composite to the tooth structure. The surfaces appear similar to the acid etched surfaces. This results in significant improvement in shear bond strength of resin composites to lased surfaces [9]. Etching with dentin results in carbonization or charring due to its high organic content. Moreover, the dentin structure is changed. It shows presence of fungiform projections and there is localized melting on the dentinal surface causing sealing of the dentinal tubules thereby reducing microleakage and enhancing the bond of the final composite restoration. This has been proved in studies by Cooper in 1988 and Dederich in 1989.

Curing of Composite Resins

Currently, photoactivated dental resins employ a diketone, such as camphoroquinone, and a tertiary amine reducing agent to initiate polymerization. This photoinitiator is sensitive to light in the blue region of the visible spectrum with broad peak activity in the 480nm region. The argon laser's monochromatic wavelengths of 488nm and 514nm have been shown to be effective in the initiation of polymerization of dental resins. Advantages are:

- Enhanced physical properties due to enhanced and more thorough polymerization.
- improved adhesion
- reduced microleakage
- Reduced exposure time. For the microfilled composite, a 20 second exposure and with the hybrid resin, a 10 second exposure of Argon laser caused polymerization of composite resin at 3mm depth as compared to visible light which requires 40 seconds for polymerization.
- They have access to all locations of the cavity preparation.
- The polymerization of light activated bases and liners can also be accomplished with the argon laser.

Pit and Fissure Sealant Therapy

Lasers are being used as pit and fissure sealants. They remove the fissures by the melting or cracking of enamel and leave a crater which will prevent recurrent caries.

Desensitization

Lasers are an effective tool in the treatment of hypersensitivity. This is possible because of its ability to close dentinal tubules because of its change in hydraulic conductance.

Bleaching

Lasers also find use in bleaching of vital and non-vital teeth.

Treatment of fractured teeth

Lasers have the potential to fuse the segments of fractured teeth.

In endodontics

For Root Canal Preparation

Based on the SEM investigations of prepared teeth, root canals appeared to be free of soft tissue and debris. There was no smear layer detected and there were no cases of over instrumentation of the canals. There was even significant reduction in bacterial growth. It has been shown that the dentin of root canals can be fixed by short exposures of either CO_2 or Nd:YAG laser. As a result, the fused dentin crystallize into a glazed, non-porous surface, this effect is used in decreasing dentinal permeability following root canal obturation. After plugging of filling materials into root canal, it can be used into a continuous non-porous surface which allows little microleakage.

Sterilization of Instruments

CO_2 lasers have also been used for sterilization of files and reamers and for surgical instruments which has been proved by Adrian J.C. and Gross A. in 1979. Hooks et al (1980) exposed contaminated endodontic reamers to a CO_2 laser beam. The laser killed 100% of the contaminating spores. The argon laser was capable of sterilizing selected dental instruments at the lowest energy level was tested.

The laser apicoectomy

Leo J. Miserendino [1] studied the endodontic application of the CO_2 laser for periapical surgery. He has found that out it has got several advantages which consisted of improved haemostasis, potential sterilization of the infected root surface and apex, and reduced risk of contamination of the surgical site by elimination of the need for aerosol producing air turbine handpiece.

Pulpotomy

The most recent development in endodontics is laser pulpotomy. Salomon J.P.G and Franquinin J.C. in 1988 studied the effects of the CO2 laser beam on the human dental pulp. There were no degenerative pulpal manifestations and it does not under tertiary dentin even after 80 days. The acute pulpal reactions marked vasodilatation and numerous inflamamtory cells observed after 15 days disappeared with bone.

In diagnosis

Lasers can be used to detect incipient carious lesions which cannot be detected clinically or radiographically using CO_2 lasers [17]. The technique of laser induced fluoroscence has been used in the assessment of caries. The lesion appears as a distinct dark red area easily differentiated from the rest of the sound tooth structure. Decalcified areas appear as a dull, opaque, orange colour. Enamel fractures and recurrent decay around metallic and resin restoration can also be diagnosed. A promising development in the use of dentistry has been the application of Laser Doppler Flowmetry to vitality testing of teeth. Electrical vitality testing devices work by stimulating nerve endings, but flowmetry detects blood circulation in the pulp which is potentially much more reliable and less uncomfortable to the patient. Low energy He: Ne laser light is applied to the tissue under investigation. Doppler shifted light reflected out of the tissue is then analysed and the shift of frequency is quantitated. The output signal is proportional to the flow of blood cells in the tissue. Devices are now commercially available, for example Perimed PF2b (Perimed, Sweden) which uses 633nm He: Ne laser light.

CONCLUSION

Lasers have become a ray of hope in dentistry. When used efficaciously and ethically, lasers are an exceptional modality of treatment for many clinical conditions that dentists treat on a daily basis. But lasers has never been the "magic wand" that many people have hoped for. It has got its own limitations. However, the future of the dental laser is bright with some of the newest ongoing research.

REFERENCES

1. Leo, J. Miserendino, Robert M. Pick "Lasers in dentistry". 1st edition, Quintessence Publishing Co. Inc
2. "Laser beam impacts on dental hard tissues".(1964). Stern Ralph H. and Sognnaes Reidar F., J. Dent. Res, *43*(15): 873 (Abstr. no. 307).
3. Lobene, R. R., Bhussry, B. R., & Fine, S. (1968). Interaction of carbon dioxide laser radiation with enamel and dentin. *Journal of dental research*, *47*(2), 311-317.
4. "X-ray diffraction study of dentin exposed to a CO_2 laser.(1973)". Sirka Kantola 1973, Acta Odont Scand. 31: 381-386.
5. "X-ray diffraction study of dental enamel exposed to a CO2 laser.(1973)". Acta Odont. Scand, 31: 369-379.
6. "Potential of yttrium-aluminium-garnet laser in caries prevention.(1974)". Yamamoto H., Ooya K. J. Oral Pathol, 3:7.
7. Myers, T. D., & Myers, W. D. (1985). The use of a laser for debridement of incipient caries. *The Journal of prosthetic dentistry*, *53*(6), 776-779.
8. Kantorowitz, Z. V. I., Featherstone, J. D., & Fried, D. (1998). Caries prevention by CO2 laser treatment: dependency on the number of pulses used. *The Journal of the American Dental Association*, *129*(5), 585-591.
9. Walsh, L. J., Abood, D., & Brockhurst, P. J. (1994). Bonding of resin composite to carbon dioxide laser-modified human enamel. *Dental Materials*, *10*(3), 162-166.
10. Goldman, L., Gray, J. A., Goldman, J., Goldman, B., & Meyer, R. (1965). Effect of laser beam impacts on teeth. *The Journal of the American Dental Association*, *70*(3), 601-606.
11. Eversole, L. R., & Rizoiu, I. (1997). Pulpal response to cavity preparation by an erbium, chromium: YSGG laser-powered hydrokinetic system. *The Journal of the American Dental Association*, *128*(8), 1099-1106.
12. Cooper, L. F., Myers, M. L., Nelson, D. G., & Mowery, A. S. (1988). Shear strength of composite bonded to laser-pretreated dentin. *Journal of Prosthetic Dentistry*, *60*(1), 45-49.
13. Dederich, D. N., Hinkelman, K. W., Albert, A., & Tulip, J. (1990, June). Effect of CO2 laser on dentinal bonding. In *Laser Surgery: Advanced Characterization, Therapeutics, and Systems II* (Vol. 1200, pp. 420-424). International Society for Optics and Photonics.
14. Adrian, J. C., & Gross, A. (1978). *A new method of sterilization: the carbon dioxide laser*. Army inst of dental research washington dc.
15. Miserendino, L. J. (1988). The laser apicoectomy: endodontic application of the CO2 laser for periapical surgery. *Oral Surgery, Oral Medicine, Oral Pathology*, *66*(5), 615-619.
16. Salomon, J., & Franquin, J. (1988, April). Pulpal reactions to the action of the co2-laser beam on the human dental-pulp. In *journal of dental research* (Vol. 67, No. 4, pp. 694-694). 1619 DUKE ST, ALEXANDRIA, VA 22314: AMER ASSOC DENTAL RESEARCH.
17. Benedetto, M. D. (1988). Use of CO_2 laser for visible detection of enamel fissure caries. *Quintessence Int*, *19*, 187-190.
18. Mercer, C. (1996). Lasers in dentistry: a review. Part 1. *Dental update*, *23*(2), 74-80.
19. Karimbux, N. Y., Rosenblum, N. D., & Nishimura, I. (1992). Site-specific expression of collagen I and XII mRNAs in the rat periodontal ligament at two developmental stages. *Journal of dental research*, *71*(7), 1355-1362.
20. Reyto, R. (1998). Laser tooth whitening. *Dental Clinics of North America*, *42*(4), 755-62.