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Components, procedures and Characteristics of Waterlase: Advantages, Contraindications and Precautions

Afrah Ahmed Alkhars[1], Faizah Ali Aloufi[2], Nora Abdulrahman Aleid[3], Haneen Abdullah Aljuieed[4], Fahad AlnashmyKhodhair Alshammri[5], Batool Abdullah Almubarak[5], Mohammed Dakhil Alelyani[6], Fatimah Nasser Albader[6], Marwan Hussein Alsaedy[7], Fatimah Hassan Almubarak[7], Abdulrahman Abdullah Alzahrani[8], Ahmed Mohammed Alrefaei[8], Alanoud Khalid M Alamoudi[9], Alaa Shayem Alshammari[10], Mohammed Hany Ahmad Fouad[11]*

1. Ministry of Health, Primary Health Care, Al-Ahsaa, Saudi Arabia
2. Al-Khalediah Primary Healthcare, Madinah, Saudi Arabia
3. Security Force Hospital, Riyadh, Saudi Arabia
4. King Abdulaziz Medical City, National Guard Hospital, Primary Healthcare Makkah, Saudi Arabia
5. Hail Health Cluster, King Abdulziz Road, Al Matar, Hail, 55421,Saudi Arabia
6. Medical Services of Public Security, Ministry of Interior, Public Security, Medical Services,Dhahran-34451, Saudi Arabia
7. Medical Services of Public Security, Ministry of Interior, Riyadh, Saudi Arabia
8. Ibn Sina National College For Medical Studies, Al Mahjar, Jeddah 22421, Saudi Arabia
9. King Abdulaziz University, P.O. Box: 80200, Jeddah - 21589, Saudi Arabia
10. Primary Healthcare, Alwasayta, Hail, Saudi Arabia
11. College Cairo University, Department Conservative Dentistry, Cairo, Egypt

*Corresponding author: E-mail:abdelghanymohamedhany@gmail.com

Abstract
Introduction: The ideal method of caries removal by drilling leads to the production of a dentinal smear layer that impairs the adhesion of the restorative material. The drilling process is also associated with pain and discomfort for the patients. To overcome these obstacles, the usage of ultrasonics and laser was implemented in the caries removal process. Waterlase (WaterLaseBiolase USA) is an Erbium-based laser that has been used to remove cavities from enamel and dentin while not producing significant thermal changes, thus protecting the underlying pulp from any thermal or mechanical damage. Waterlase (WaterLaseBiolase USA) works by evaporation of hard tissue with minimal to no contact with the tooth, thus reducing the frictional forces and heat produced during the process. With the reduction of heat and frictional force, the amount of discomfort and pain to the patient also reduces remarkably. **Objective:** This review focuses on applications of Waterlase in Operative dentistry. **Methodology:** The review is a comprehensive research of PUBMED and Google Scholar from the year 1997 to 2022. **Conclusion:** In recent times, practitioners have started focussing on minimally invasive dentistry, and Waterlase is proving to be a very valuable aid in achieving the same. Patient compliance is of utmost importance while performing restorative procedures and is a key factor in the treatment's success.
Keywords: Laser, Waterlase, Er Cr: YSGG, Ablation, Caries

Introduction

Dental caries is a chronic multifactorial dynamic disease that is dietomicrobial and site-specific and is caused when the protective factors which help in the remineralization of the teeth are shifted to destructive elements, causing demineralization.[1] Recent data regarding the distribution of caries has revealed that the pits and fissures of permanent molar teeth are mostly affected by caries resulting from the interaction between the tooth structure, biofilm, the patient's diet, the constituency of saliva, and genetic factors. With the rapid development and advances in the composition and mechanism of action of dental materials, there has been a shift in the management of caries using conventional techniques. Along with the dental materials, the caries excavation process also witnessed a great deal of advancement. It was seen that the ideal method of caries removal by drilling led to the production of a dentinal smear layer that impaired the adhesion of the final filling material. The drilling process was also associated with pain and discomfort for the patients. To overcome these obstacles, the usage of ultrasonics and laser was implemented in the caries removal process. [2,3]

In 1957 a German physicist coined the term LASER, which stands for LightAmplification by Stimulated Emission of Radiation. The principle of action followed by laser is in accordance with Einstein's principle of photons given in 1917 (mass-less particles in light), where the energy of the photon and the wave's frequency is directly correlated, and the energy increases as the frequency increases. The electromagnetic energy is converted to thermal energy by heat produced by the laser. In the 1950s, Charles Townes with his co-workers coined the

term MASER which stands for microwave amplification by stimulated emission of radiation. He passed a beam of ammonia particles through a system of focusing electrodes, and once a microwave at an appropriate frequency was sent through, amplification was seen. In 1960 Theodore H. Miaman generated the first laser beam using a pink ruby crystal. It has a cylindrical cavity of polished aluminum enclosing a flash tube, and the cooling mechanism is air. [4]

Since the last 30 years, there has been a growing emergence of the use of lasers in dentistry. A lot of research has been coming forward to support the applications of lasers in dentistry. With the growing knowledge and the supported research, lasers which were once considered a complicated process, have now been used as an alternative (or adjunct) and a more conservative dental procedure. Lasers reduce the susceptibility of the tooth to caries and acid attacks by altering the calcium-to-phosphate ratio, which forms a more stable compound in acid. [5]Waterlase is an Erbium-based laser that has been used to remove cavities from enamel and dentin while not producing significant thermal changes, thus protecting the underlying pulp from any thermal or mechanical damage. Old composite and Glass Ionomer restoration can also be removed by Erbium lasers. The mechanism of action of waterlase (WaterLaseBiolase USA) is the evaporation of hard tissue with minimal to no contact with the tooth, thus reducing the frictional forces and heat produced during the process. With the reduction of heat and frictional force, the amount of discomfort and pain to the patient also reduces remarkably. This review focuses on applications of Waterlase in operative dentistry. [6]

Components and Characteristics of Laser

The main components of a laser are the Laser medium, Resonating chamber, and Power source.

1. The laser medium can be described as any medium through which the external energy source is passed; this medium can be in any state, i.e., solid, liquid, or gas.
2. The resonating chamber comprises a tube with 2 mirrors placed at either side of the optical cavity, out of which one is completely reflective, and the other transmits light partially.
3. The power source can be a chemical, mechanical, or optical source of energy that helps the atoms in the laser medium attain a high energy level.

The design of the resonating chamber, the type and intensity of the energy source, and the composition of the laser medium determine the characteristics of the laser. A photon is released by stimulating an excited atom, and this energized emission produces a monochromatic, collimated, and coherent form of light. When the tissue comes in contact with the laser, the laser light might scatter, reflect, or get transmitted or absorbed by the tissue. The mouth contains free water molecules, proteins, and other macromolecules which help in photonic absorption, which causes changes in the tissue at the intracellular and intercellular levels. Absorption of the wavelength by different parts of the tissue depends on the subsequent length. [7]

Figure 1 summarises various lasers and their subsequent wavelengths.[7]

According to their wavelengths, lasers also can be divided into two categories.

1. Deep penetrating lasers such as Nd: YAG and Diode. It scatters after entering deep into the tissue.
2. Superficial lasers such as Er: YAG, Er, Cr: YSGG and CO2 get absorbed superficially and do not penetrate deeper tissues.

The following table summarises the absorption of different wavelengths by different tissue [4]

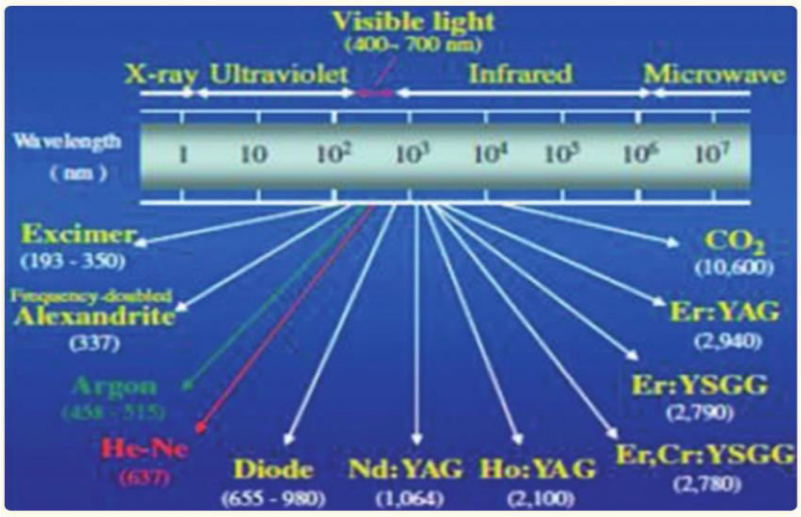

Figure 1: Lasers and corresponding wavelengths [7]

Table 1: Different lasers with selective tissue action at corresponding wavelengths [4]

Wavelengths	**Absorbing tissue**
500-1000 nm	Blood elements and chromophores
Argon laser (450-515 nm)	Haemoglobin
Diode (655-980nm)	Melanin
Nd:YAG(1064 nm)	Melanin
Er:YAG (3000 nm)	Water and Hydroxyapatite
CO2 l(10,600nm)	Water and Hydroxyapatite

Waterlase

Erbium Chromium doped: Yttrium-Selenium Gallium-Garnet (Er, Cr: YSGG) is commercially available as The Waterlase® C100 and Periodontal Waterlase MD™. Waterlase uses a perfect combination of water and laser energy which facilitates minimal tooth removal with no damage to the underlying and surrounding tissue structures. The use of waterlase has various advantages, like reduced use of anesthesia during the procedure hence making the patient more comfortable, which helps in comfortably preparing the patients for invasive procedures. The use of waterlase has also been shown to reduce the chances of re-treatment as it has a better reduction in the depth of the caries lesion irrespective of the fluoride content of the restorative material and makes enamel more caries resistant. [8]

Another major advantage that is consistent with waterlase is the remarkable reduction in aerosol production. The novel coronavirus started in December 2019 in Wuhan, China, and its high transmission rate created great concern in the field of surgical dentistry. The route of transmission for the virus is through direct contact with the virus or indirect contact through any contaminated surface. Dental procedures like oral prophylaxis and restorative dentistry tend to produce a large amount of splatter and aerosols due to the use of high-speed rotary instruments. The use of waterlase has been shown to reduce the production of aerosols by 70% [9] Waterlase also reduces post-operative discomfort and bleeding and brings it to a minimum. [8]

The Waterlase(Waterlaseiplus®) handpiece appears very similar to a high-speed handpiece, but instead of the bur attachment, there is a fiber optic tip attachment. It weighs around 75 pounds, and the dimensions are roughly 11 x 19 x 33 in (28 x 48 x 84cm). [Figure 2] The diameter of the fiber optic tip is 200 – 1200 µm which is kept at a distance of 0.5 – 5.0 mm from the target. Air pressure is provided from an external source at about 80 to 120 pounds per square inch. [10] De-ionized or distilled water is placed in an attached bottle, and this laser energy, with the combination of a spray of water, produces Hydrokinetic energy. As a result of the hydrokinetic energy, smooth cutting of the soft and hard tissues, including enamel, is then done. [4]

Figure 2: WaterlaseiPlus® - All tissue laser [10]

Table 2: Advantages of Waterlase[4]

Advantages of Waterlase
1. Minimal discomfort for the patient due to reduced generation of heat (less than 4 degrees)
2. Reduced usage of anesthesia
3. Minimal trauma to the surrounding tissue due to increased precision
4. Reduced post-operative discomfort for the patient
5. Greater efficiency in multi-quadrant treatment
6. Reduces the number of sittings for the patient due to high-efficiency

Hard Tissue procedures:

Optical energy is generated by the YSGG laser, which is then focused on a group of atomized water droplets as controlled by the user. The water droplets absorb the optical energy and achieve a highly energized state which initiates the hydrokinetic process resulting in the removal of tissue. The absorption of laser energy by atomized water results in an intense micro expansion and excitation of the particles, which is controlled by the user. A micro explosion occurs within the tissue, which is a rapid increase in the internal pressure of the tissue caused by water vapor. The microexplosion results in photomechanical and thermomechanical ablation, termed **water-mediated explosive ablation**. While working on osseous tissue, there is no direct contact of the laser with the tissue. Laser energy is carried onto the water spray, which further causes tissue ablation. The absence of direct contact of the laser with tissue alleviates any charring or melting in the same. [11]

Tudose et al. presented a case of a 27-year-old patient presented with multiple caries in the upper and lower anterior teeth. Considering the age and the anxiety level of the patient, a minimally invasive approach for restoration was adopted. The patient had an increased caries rate, and hence maintaining pulpal vitality was of utmost importance. Keeping all these prerequisites in mind, Er Cr: YSGG laser at 2790 nm was used for removing caries, followed by direct composite restoration. [12] A WaterlaseBiolase was used in H mode. A working distance of 3-4mm was kept, and power at 5.5 W for enamel and 4-4.5 W for the deeper dentinal area was applied. Water was kept at 35% to 40% and air at 40%. The result of this case study showed that caries removal, when done by Er, Cr: YSGG laser showed lesser bacterial contamination and reduced heat dissipation which helped in maintaining the vitality of underlying pulpal tissue. Decreased post-operative sensitivity was seen, and hypersensitive areas like caries present on the root surfaces were managed more comfortably. [13]

Figure 3: Preoperative, Intra-operative, and post-operative pictures of restoration done with the help of Waterlase. [12]

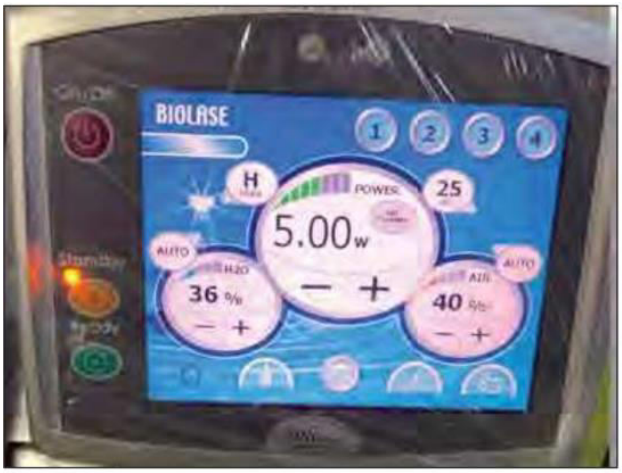

Figure 4: Er, Cr:YSGG laser used for caries removal in the case presented with the parameters set as described. [12]

Soft tissue procedures:

Soft tissue procedures can also be performed using waterlase, but it requires direct contact of the laser energy with the tissue where it cuts or ablates the tissue. The water spray acts as a coolant and hydrates the tissue while also maintaining moisture and cleanliness in the working area. The tip used for soft tissue procedures is delivered through a flexible fiber optic device. The major advantages of using waterlase in soft tissue procedures are reduced bleeding in the operative field and reduced post-operative discomfort. [4]

Discussion

Er Cr: YSGG laser or waterlase is used for the removal of caries and older restorative materials in operative dentistry as it proves to be a more efficient and less invasive alternative to high-speed handpieces and bur. In a study performed by Tedesco et al., YSGG lasers have been shown to reduce the occurrence of secondary caries as there is to increase the enamel's resistance to acid. [14] During cavity preparation by traditional high-speed handpieces, microfractures occurring due to increased vibration are common. This is reduced remarkably by the YSGG laser. The end cavity achieved is free from carbonization, and the surface is flat. [15]

Working parameters (like the power, quantity of air and water, and diameter of the fiber used) of the waterlase machine are of utmost importance, and the parameters should be set in such a way that there is maximal absorption of the laser energy by hydroxyapatite crystals thus reducing the damage and minimizing ablation of the surrounding tissue. White performing a direct adhesive technique during restorations, it is very important to maintain the acid demineralization at the level of enamel, and the YSGG laser has been shown to maintain a good enamel configuration which helps in better adhesion. [16] Another advantage is the health of dentine. After using the waterlase,the dentinal canals are seen to be free of the smear layer, and no carbonization or melting is seen in the dentine. The dentine being free from the smear layer opens the possibility of the usage of new adhesive systems, which could not be used formerly. [17] Reduced pain leading to decreased usage of anesthetics makes the usage of waterlase a more comfortable procedure for patients requiring multiple restorative procedures and who cannot be given anesthetics due to any form of limitations. [18]

Contraindications while using Waterlase

1. Patients with systemic diseases like immunodeficiency disorders, cardiac diseases, and respiratory disorders are generally contraindicated for laser treatment. In such patients, a prior physician's consent needs to be taken before starting the treatment.
2. Subgingival defects cannot be treated with lasers as the visibility of the operative field is impaired, and it requires special flexible tips for subgingival access.
3. While treating pockets, there is a splatter of blood and water, and hence high-speed evacuation is required for such cases. An extraoral high-speed evacuator is necessary for suctioning out the splatter.[4]

Precautions required while using Waterlase

1. Adequate knowledge about the functioning of the laser machine is extremely important, and no procedures should be carried out if any one of the parameters is not working properly.
2. The operative field should be free of any highly reflective items.
3. All the operators, assistants, and patients should wear laser-protective eyewear that should be able to block the laser wavelength
4. The direction of the cutting ray should be defined and should be maintained at all times.
5. The laser should not be present in the direct line of vision.

6. Any water or moisture present on the handpiece of the laser machine should be removed before the procedure is started.
7. STAND BY button should always be turned on while changing handpieces or before switching off the machine. [4]

Conclusion

In recent times, practitioners have started focussing on minimally invasive dentistry, and Waterlase is proving to be a very valuable aid in achieving the same. Patient compliance is of utmost importance while performing restorative procedures and is a key factor in the treatment's success. Waterlase aids this by keeping the patient comfortable during the procedure. It reduces the requirement for anesthesia and alleviates the possibility of other iatrogenic errors associated with high-speed handpieces. It also increases the enamel's resistance to acid, thereby decreasing the occurrence of secondary caries, further affirming the patient's faith in the treatment. Reduced aerosol production decreases the transmission rate of infectious diseases, which is a major concern in recent times. Minimal heat produced while treating deep caries helps maintain the pulp vitality, increasing the longevity of the tooth. With increased research on Waterlase and its development, a more conservative approach can be adopted in the field of operative dentistry.

Author Contributions

Every author takes part in the process of editing the paper, gathering relevant literature, and approving the final submission to the journal. The paper was drafted by the first author and was overseen by the corresponding author.

Conflict of Interest

The authors declare they don’t have any conflicts of interest.

Ethical Approval

Not Applicable

References:

1. **Pitts N B, Zero D T, Marsh P D, Ekstrand K, Weintraub J A, Ramos-Gomez F, & Ismail A (2017).**Dental caries Nat Rev Dis Primers 3: 17030.
2. **Beltrán-Aguilar E D, Barker L K, Canto M T, Dye B A, Gooch B F, Griffin S O, &Centers for Disease Control and Prevention (2005).** Surveillance for dental caries, dental sealants, tooth retention, edentulism, and enamel fluorosis--United States, 1988-1994 and 1999-2002.
3. **Machiulskiene V, Campus G, Carvalho J C, Dige I, Ekstrand K R, Jablonski-Momeni A, & Nyvad B (2020).**Terminology of dental caries and dental caries management: consensus report of a workshop organized by ORCA and Cariology Research Group of IADR. *Caries research*, *54*(1), 7-14.
4. **Mohanty R, Lenka B, Nayak R, Satpathy A, Das A C, & Mohanty G (2020).** A New Pioneering Advancement: Waterlase. *Indian Journal of Forensic Medicine & Toxicology*, *14*(4), 8237.
5. **Apsari R, Pratomo D A, Hikmawati D, & Bidin N (2016, March).** Microstructure and mechanical changes induced by Q-Switched pulse laser on human enamel with aim of caries prevention. In *AIP Conference Proceedings* (Vol. 1718, No. 1, p. 020001). AIP Publishing LLC.
6. **Galui S, Pal S, Mahata S, Saha S, & Sarkar S (2019).**Laser and its use in pediatric dentistry: a review of literature and a recent update. *International Journal of Pedodontic Rehabilitation*, *4*(1), 1.
7. **Verma S K, Maheshwari S, Singh R K, & Chaudhari P K (2012)**. Laser in dentistry: An innovative tool in modern dental practice. *National journal of maxillofacial surgery*, *3*(2), 124.
8. **Jorge A C T, Cassoni A, de Freitas P M, Reis A F, Junior A B, & Rodrigues J A (2015).**Influence of cavity preparation with Er, Cr: YSGG laser and restorative materials on in situ secondary caries development. *Photomedicine and Laser Surgery*, *33*(2), 98-103.
9. **Abdelkarim-Elafifi H, Arnabat-Artés C, Parada-Avendaño I, Polonsky M, & Arnabat-Domínguez J (2021).**Aerosols generation using Er, Cr: YSGG laser compared to rotary instruments in conservative dentistry: A preliminary study. *Journal of Clinical and Experimental Dentistry*, *13*(1), e30.
10. http://www.biolase.com/brochure
11. **Hadley J, Young D A, Eversole L R, &Gornbein J A (2000).** A laser-powered hydrokinetic system: for caries removal and cavity preparation. *The Journal of the American Dental Association*, *131*(6), 777-785.
12. **Tudose D A, & Biclesanu C (2020)**. Optimizing the treatment of dental caries with laser Er Cr: YSGG 2,790 nm (WaterLaseBiolase USA). *Romanian JouRnal of Stomatology*, *66*(3), 188.
13. **Du Q, Ge L, Zhang S, & Zhang Q (2019).**Effects of Erbium: Yttrium–Aluminum–Garnet Laser Irradiation on Bovine Dentin Contaminated by Cariogenic Bacteria. *Photobiomodulation, Photomedicine, and Laser Surgery*, *37*(5), 305-311.
14. **Jorge A C T, Cassoni A, de Freitas P M, Reis A F, Junior A B, & Rodrigues J A (2015).**Influence of cavity preparation with Er, Cr: YSGG laser and restorative materials on in situ secondary caries development. *Photomedicine and Laser Surgery*, *33*(2), 98-103.

15. **Jacobsen T, Norlund A, Englund G S, &Tranæus S (2011).** Application of laser technology for removal of caries: a systematic review of controlled clinical trials. *Acta Odontologica Scandinavica*, *69*(2), 65-74.
16. **de Jesus Tavarez R R, Rodrigues L L, Diniz A C, Lage L M, Torres C R, Bandeca M C, & Firoozmand L M (2018).**Does ErbiumiYttrium-Aluminum-Garnet Laser to Enamel improve the Performance of Etch-and-rinse and Universal Adhesives?.*The Journal of Contemporary Dental Practice*, *19*(3), 278-282.
17. **Mehl A, Kremers L, Salzmann K, & Hickel R (1997).** 3D volume-ablation rate and thermal side effects with the Er: YAG and Nd: YAG laser. *Dental Materials*, *13*(4), 246-251.
18. **Brignardello-Petersen R (2018).** Caries removal with an erbium laser may result in a small increase in cavity preparation time but also in a reduction in required extra local anesthetic compared with traditional drilling. *The Journal of the American Dental Association*, *149*(6), e94.