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REVIEW

Role of laser power and focus diameter in increasing retention of metal porcelain fixed dentures with short clinical crowns

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Keywords: Fixed denture, Laser, Shear bond strength, Short clinical crown, Surface roughness.

ABSTRACT

In teeth with short clinical crowns that will be used as a support for metal porcelain fixed dentures, the problem that often occurs is that the dentures easily fall off after being installed. Surface treatment is one of the efforts to increase retention. Advances in laser technology provide advantages in increasing microstructural and wear resistance on the metal surface of the crown that will be used as abutment teeth. In addressing the retention problem of short clinical crowns, modification of tooth preparation, casting, and proper cementation procedures need to be considered. Improving the mechanical properties by surface treatment of the dental crown to be cemented by modifying the strength and focus of the laser diameter can play a role in surface roughness and shear bond strength. The use of lasers to increase microstructural and wear resistance in teeth with short clinical crowns can minimize the failure of making metal porcelain fixed dentures. (IJP 2024;5(1):18-23)

INTRODUCTION

In teeth with short clinical crowns that will be used as metal porcelain fixed dentures, the problem that often occurs is that the dentures easily fall off after being installed. A short clinical crown in this case is defined as a crown wall height of less than 2 mm in tooth preparation that will be used as a fixed denture abutment.[1] Aesthetic success and adequate dimensions in short clinical crowns that will be used as abutments are difficult to determine. If done, complex planning and procedures are needed.[1,2] Factors that play a role in the success of fixed dentures are biological, mechanical, and aesthetic factors.[3] According to Prasad (2017) 27 % of failure of fixed partial denture is retention, which is influenced by improper preparation, short proximal walls, lack of resistance form, surface area, surface roughness of the material to be cemented, and the cementation material.[1-4]

Improving the mechanical bond and chemical bonding between the tooth and the restorative material with a surface treatment procedure before the cementation procedure can be performed to increase retention and resistance.[4-5] Advances in laser technology in improving surface treatment procedures provide advantages in increasing microstructural, friction, fatigue, wear resistance, and reducing corrosion on the metal surface of the crown to be used as abutment teeth.[7] It is known that surface treatment uses an laser produces a more stable surface than using other techniques commonly used in surface treatment procedures.[5] Surface treatment using laser is known to increase microhardness and wear resistance on metal surfaces as well as surface roughness which affects the surface roughness and shear bond strength of clinical crowns of fixed dentures.[7]

The purpose of this paper is to examine the role of strength and focal diameter of laser surface treatment on retention in the manufacture of metal porcelain fixed dentures with short clinical crowns.

LITERATURE STUDIES

Successful Factor in Preparation Fixed Partial Denture

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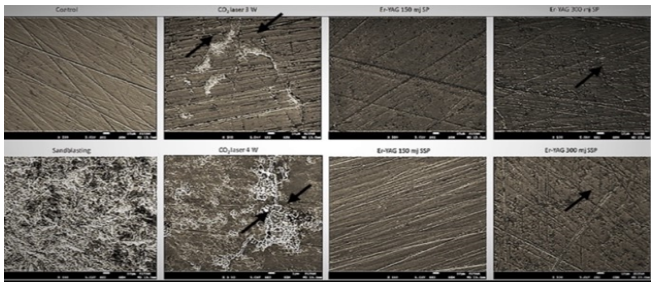

Figure 1. Surface roughness using sandblasting and laser (measurement with SEM).

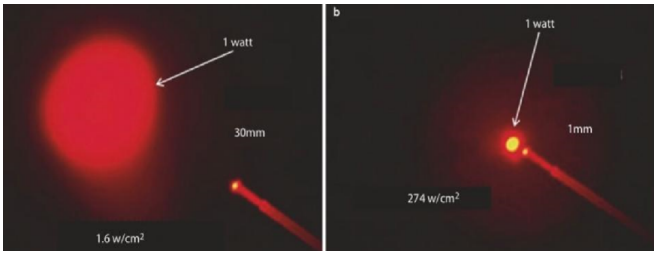

Figure 2. Laser.

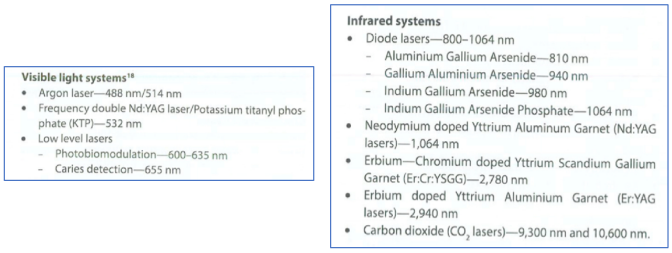

Figure 3. Classification of the laser beam.

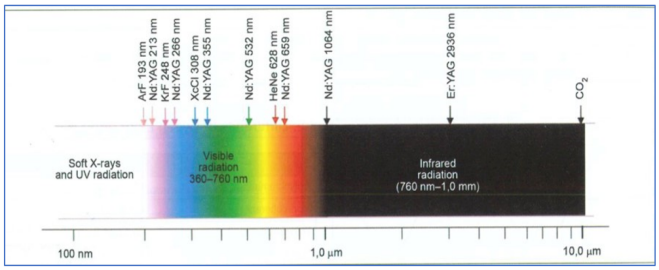

Figure 4. Classification of laser beam by power.

Table 1. Comparison of laser surface treatment and sandblasting.

Testing specimens	Bonding load	Bonding strength (MPa)
Laser textured Ni-Cr	38.245	80.316*
Sandblasted Ni-Cr	36.529	74.230*
Laser textured Ni-Cr-Ti	37.673	77.206*
Sandblasted Ni-Cr-Ti	37.625	76.393*

*Mean value were not significantly different (P>0.05)

Several principles that determine the success in making fixed dentures so that restorations become retentive, and last a long time, including.[3] Biological considerations: factors affecting oral tissue health which include conservation of tooth structure, avoidance of over contouring, supragingival margins, harmonious occlusion, and protection against tooth fracture; Mechanical considerations: factors affecting the integrity and durability of restorations; Aesthetic considerations: factors that affect the patient's appearance.

Mechanical considerations are the factors that determine the retention and resistance of a fixed denture.[3] In short clinical crowns as abutments, and mechanical factors in this case retention are difficult to obtain and become a problem that can hinder the success of making fixed dentures.

Short Clinical Crown

A short clinical crown was defined as a tooth with a crown height of less than 2 mm, on parallel walls remaining after occlusal and axial reduction. The causes of short clinical crowns are diseases and abnormalities in the teeth (caries, erosion, dental malformations), trauma (broken teeth, attrition), iatrogenic factors (reduction of excess teeth, large endodontic access openings), disharmony eruption, exostosis, and genetic variations. in the shape of the teeth. Things that must be considered before performing treatment on short clinical crowns include consideration of dental arch position, periodontal considerations, crown-root ratio, and occlusion. feasibility of endodontic treatment, and aesthetics.[1]

Treatment for short clinical crowns includes changes to the tooth preparation design and placement of retention features, additional forms of resistance, The addition of a foundation to the teeth, surgical crown lengthening, orthodontic eruption, endodontic treatment, and placement of removable partial denture overlays. An appropriate comprehensive treatment plan is needed to address the problems posed by short clinical crowns. The addition of a clinical crown can be done by placing a subgingival margin, but if the restoration margin exceeds the biological width, it can interfere with the health of the periodontal tissue. To evaluate the clinical crown height, visual examination, radiographic examination, and analysis of diagnostic models are required.[1] Adequate clinical crown height is required to increase retention in the fabrication of fixed dentures.[12]

Factors affecting crown retention and resistance form in short clinical crowns were crown lengths, degree of occlusal convergence, axial surface area, and the relationship between axial wall height and tooth preparation area. Secondary forms of retention and resistance can come from the manufacture of boxes, grooves, or pins placed on the abutment tooth structure.[1,8] Crowns on short tooth preparations have a greater displacement tendency than tall crowns in the axial wall region.[8]

Factors that can affect retention are grouped into three categories, namely the modification of the tooth preparation, casting procedure, and cementation procedure.[6] In the modification of the tooth preparation, the things that affect the surface area, the height of the crown of the prepared tooth, the convergence of the preparation walls, the texture of the surface of the prepared tooth, intracoronary retentive device.

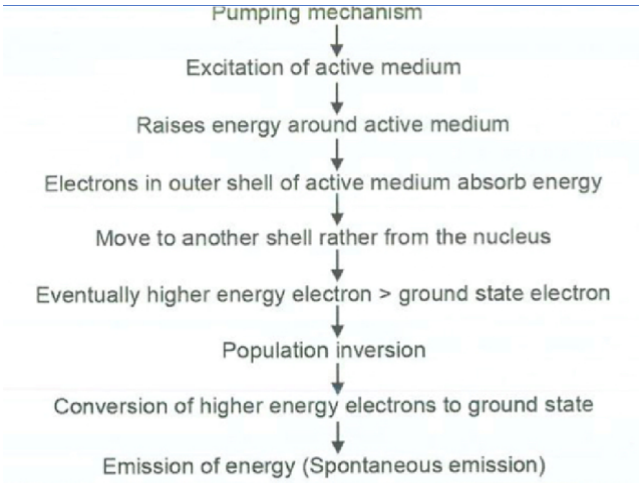

Figure 5. Laser beam production procedure.

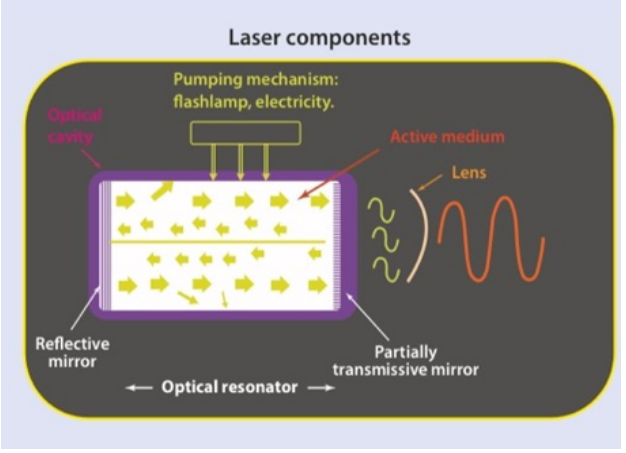

Figure 6. Laser tool projection.

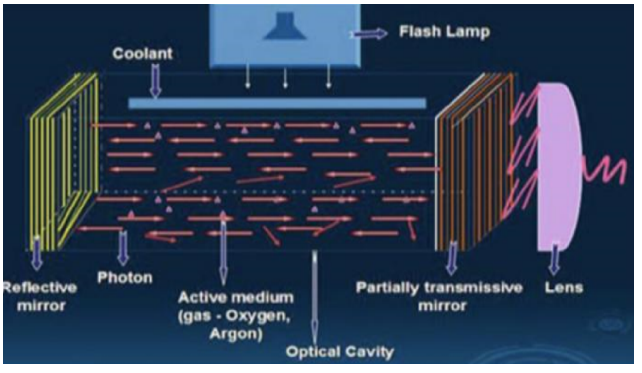

Figure 7. The basic components of a typical laser cavity.

The retention denture crown casting procedure includes the relative adaptation factors of the casting material to the prepared tooth surface, the internal surface texture of the casting, the effect on the retention of each of the restored and cemented castings together, and the strength properties of the cast metal material. While in the cementation procedure, retention is influenced by the type of cement, the casting surface variations in cement viscosity, setting force, duration of force, the time lapse between procedures cementing and removal of denture crowns, angle unseating force, the magnitude of force release (magnitude of the lever arm of the unseating force), the magnitude of the compressive strength, shear strength, surface roughness.[6] Surface treatment procedures before the cementation procedure alone are known to increase the retention of 64% of castings.[5-6] Surface roughness in the surface treatment procedure before cementation itself is known to increase the retention of 64% of the casting.[5-6]

Surface Treatment

Surface treatment in the manufacture of dentures is a procedure to change the mechanical properties of a restorative material which will later be used as a clinical crown in manufacturing dentures. There are several methods commonly used in surface treatment, including hydrofluoric acid etching, airborne particle abrasion, and using diamond burs and lasers.[5] With advances in laser technology, it is used as an alternative in increasing the surface roughness and increasing the mechanical bond between the clinical crown surfaces of dentures and teeth.[5-7] In the laser surface treatment procedure used is erbium; yttrium aluminum garnet. (Er: YAG) because it has good wavelength synchronization and absorption.[10,15] Laser works by using parameter control including laser power, focus diameter, pulse direction, and pulse frequency. The presence of parameters is the key to success and laser control works by increasing the mechanical and metallurgical properties of the surface area.[7,16,17]

The surface treatment procedure using sandblasting air abrasion in terms of surface roughness produces a rougher surface area than the use of a laser. However, the sandblasting procedure produces a uniform surface roughness and some particles can contaminate the metal surface Figure 1.[9] The following are the results of the SEM surface area examination after surface treatment using sandblasting and laser.

The bonding strength of metal using a laser has advantages over sandblasting. Surface treatment using sandblasting has a rougher surface but lower bonding strength Table 1. The following is a comparison table of bonding load and bonding strength of laser and sandblasting surface treatment.

In some cases, excessive surface roughness in the use of sandblasting can cause fractures, especially in the transgranular and intergranular interface areas in porcelain.[9] To overcome this problem, it is necessary to have a surface modification using a laser which produces a better surface and can increase the strength of the matrix and affect the bonding strength.[9]

Laser

A laser is a device that produces a very narrow and intense beam of light energy (electromagnetic radiation) through a process called emission stimulation. Albert Einstein is the developer of the laser theory. He was the first to coin the -

term "Stimulated Emission" in his publication "Zur Quantentheorie der Strahlung", published in 1917 in the "Physikalische Zeitschrift".[9-11] Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. In prosthodontics, the use of lasers has advantages, namely more precise results, faster healing time, has advantages in coagulation factors, besides that the laser also has convenience in use for patients efficiently delivering wavelengths.[10,11]

Currently, many laser systems are available for dental use including Neodymiumdoped: Yttrium Aluminum-Garnet (Nd: YAG), carbon dioxide (CO2), and semiconductor diode lasers which have been approved by the United States Food and Drug Administration for the treatment of soft tissues in the oral cavity.[9-14]

Laser Type and Classification

The types of laser beams can be classified as follows[13]

Laser Components

Lasers are straight and always the same regardless of the type of equipment. The laser consists of an active amplifying medium in the optical cavity (resonator) and a pumping source (energy source). The optical cavity consists of two mirrors placed on either side of the laser medium. Due to this arrangement, the photons generated from the stimulated emission will form a continuous avalanche process. As long as the pumping energy maintains the population inversion in the active medium, more stimulated photons are generated thereby generating energy. The energy is absorbed and emitted in the resonator and with the help of the mirror, is reflected and resonates within this space, and finally produces a laser beam. The light energy is converted into heat energy, which is cooled locally.[9,12]

The following is the procedure for the formation of a laser beam and the projection of light from a laser device: The laser component consists of Figure 6.

Active medium: the core of the laser device, can be in the form of crystal crystals (Er; YAG), solid semiconductor (diode laser), or gas canister (CO2 laser); Pumping mechanism: the transmitter source can be a flash, an electrical circuit, or a coil. Where the excitation source pumps energy around the active medium and generates electrons which absorb energy and convert it into lower energies, then produce progressive amplification of the emitted energy emitting a laser beam; Optical resonator: consists of two mirrors placed at each end of the laser chamber which are placed parallel or opposite. These mirrors are called optical resonators because they reflect waves and allow laser light to be projected from the laser emitting device.

The basic unit of energy is called the photon. The photon waves generated by the laser can be defined by measuring the velocity (the speed of light), the amplitude includes the speed of the light intensity in the wave, the total height of the wave from the top of the peak to the bottom of the vertical axis (the greater the amplitude, the greater the laser work), the wavelength (the distance between two corresponding points on the wave on the horizontal axis).[12,13]

Laser Characteristics

There are several characteristics of the laser.[12] Monochromacy: the laser has one specific color/single wavelength Collimation: has a spatial boundary that ensures a constant size of the beam emitted from the laser device; Coherency: the light waves produced by the laser device have identical waveforms. Efficiency: low average power can be used to perform specific functions.

Benefits of Laser in Prosthodontics

Other benefits of lasers used in prosthodontics.[14] Complete denture: Prototyping and CAD/CAM (Computer-Aided Design and Computer Aided Manufacturing) technology; occlusion analysis with CAD/CAM; analysis of printing accuracy using a laser scanne; Fixed partial denture: tissue management; crown preparation; Removable partial teeth: laser welding; Dental implants: soft tissue Surgery; implant surface debridement; implant surface treatment; Maxillofacial: sintering with CAD/CAM technology in the manufacture of wax pattern maxillofacial prosthesis.

Advantages and Limitations of Using Lasers

The advantage of using lasers is that they are efficient in reducing processing time, more precise results can be achieved, minimal heat input, chemical cleanliness, and surface treatment procedures are effective in improving mechanical properties, microhardness, and wear resistance.[7] While the limitations of using lasers are the need for additional training and education for the clinical use and type of laser, the high costs involved in equipment purchase, technology application, and equipment investment, more than one laser may be required as different wavelengths are required for different procedures.[14]

DISCUSSION

The manufacture of fixed dentures with short clinical crowns for gaining retention and resistance is difficult and a factor of greatest failure of the restoration.[1,2] several factors must be considered in increasing the success of fixed dentures with clinical crowns including the design of the tooth preparation, the addition of additional retention in the form of pins and groove casting procedure as well as proper cementation procedure.[3] According to Sharma et al. (2012) when the clinical dimensions of the denture crown are inadequate, the success of the tooth will be high both aesthetic and biological imitation is difficult to achieve.[1] A proper treatment plan is required complex and appropriate procedures to increase the success of treatment in the short clinical crown. Meanwhile, according to Shujaulla et al. (2020) the main failures in the manufacture of fixed dentures are poor denture design, inadequate tooth preparation, and poor biomechanical application.[18] There is a difference in retention in the manufacture of crowns with a height of 2.5 mm and 3.5 mm. The higher the clinical crown height, the greater the retention obtained.[19]

Short clinical crowns that can complicate the mechanical preparation of abutments in the manufacture of fixed dentures are caused by several things, including; caries, erosion, dental malformations, trauma factors such as tooth fractures, attrition, iatrogenic (excessive reduction of teeth after endodontic treatment), disharmony eruptions, exostosis, and genetic factors. The over-preparation of short clinical crowns can reduce the supporting structures of the teeth and harm the supporting tissues. The prosthodontist must maintain the concept of minimal tooth preparation, slope the tooth preparation wall parallel to 6^0, eliminate, undercuts and must

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have a one-way attachment to the fixed denture abutments. The presence of other factors that can cause fracture of the short clinical crown should also be considered, such as parafunctional trauma and bruxism. Pressure on mastication and habit parafunction can lead to a short clinical crown with poor retention of the manufacture of fixed dentures is easy to fall off and fractures occur after being installed.[1]

Treatments that can be performed on short clinical crowns include placement of the subgingival margin in tooth preparation, orthodontic treatment, and crown lengthening procedures to obtain an adequate height for the crown of the tooth to be prepared. However, chronic inflammation of the gingiva due to preparations that exceed the biological width at the time of placement of the subgingival margin and inadequate interocclusal space in orthodontic treatment can make it difficult to increase the height of the clinical crown length in some cases. Although crown lengthening procedures are more effective in increasing the height of short clinical crowns, it may take at least 6-12 weeks for periodontal tissue to heal before restorative procedures can be performed. There are anatomical limitations inadequate tooth furcation and proximal areas are difficult for reduction of bone in the apical area of the tooth to be crown lengthened and abutment tooth preparation.[5]

In an abutment preparation procedure for the manufacture of fixed denture restorations, the denture crown must have adequate height while reducing the incisal and occlusal areas to achieve retention. Meanwhile, in short, in clinical crowns, the presence of inadequate height during preparation for abutment teeth can hinder the success of making dentures so complex procedures are needed, namely modifying tooth preparation, casting, and proper cementation procedures to obtain mechanical retention and chemical bonding in tooth fabrication. fixed denture with a short clinical crown.[1,5,6]

To improve the biomechanics of chemical bonding, the roughness of the intaglio metal surface of the fixed denture crown is needed. The mechanical and chemical bond formed between the metal surface and the tooth is obtained by modifying the strength with a surface treatment procedure. The surface treatment procedure is known to significantly increase the surface roughness and shear bond strength.[1,5,7,20-23] Many methods are used in carrying out surface treatment procedures, one of which is using a laser.[7,24]

Laser is a straight beam exposure produced from a device that is generated from an energy source through a resonator. Optical consists of two pieces of glass that reflect light that comes from exposure to energy sources that are reflected through a resonator Figure 7. According to Khansaa et al. (2011) mechanical test trial laser surface treatment done with different powers 2.7, 3.3, and 4.3 watt, laser power 4.3 watt obviously improve the mechanical properties on CK45 steel compared with other watt power and decreased far from the surface.[7] Lasers have highly intensive, monochromatic, coherent, and highly polarized light waves. Laser procedures work include laser surface melting, surface alloying, cladding, and amorphization processes.[17,25,26] According to Aziz et al. (2020) the effect of laser parameters such as laser energy, and focus diameter has an influence on the microhardness of the metal surface in the surface treatment procedure.[7] Laser surface treatment is effective in increasing the bond strength - of metal surfaces with ceramic materials in alloy recycling procedures.[24] There are effects on corrosion, yield strength, surface hardness, and flexural strength which affect changes in mechanical properties in the form of macrostructural and porosity in metal alloys seen in the scanning electron microscope (SEM) procedure.[7]

Surface treatment increases the bond strength between the metal crown and the cementitious material. However, several journals state that there is no significant difference in surface roughness with metal-ceramic on bond strength. It was also reported that the presence of intaglio surface roughness can reduce the bond strength of the metal-ceramic surface.[27,28]

CONCLUSION

The use of lasers to improve mechanical properties such as microhardness and wear resistance on teeth with short clinical crowns can minimize failure in the manufacture of fixed metal dentures with short clinical crowns. Laser has advantages compared to the use of other methods commonly used in surface treatment procedures.

Some parameters can be used to generate energy including strength and focal diameter. Lasers have the advantages of using low power in the heat treatment procedure, being fast in the cooling process, and producing a clean and uncontaminated surface area to increase the surface roughness and shear bond strength of the metal surface of the clinical denture crown.

SUGGESTIONS

Surface treatment procedures using lasers must be accompanied by clinical examination, diagnostics, and appropriate treatment plans and must take into account other factors considered in increasing retention, especially in short clinical crowns. To avoid any risks that may occur when using lasers, doctors should have knowledge and training before using laser tools.

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