Original Article

Evaluation of Tensile Bonding Strength of Permanent Soft Relining Material to Denture Base Acrylic Resin after Erbium:Yttrium–Aluminum–Garnet Laser Treatment – An *in vitro* Study

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ABSTRACT

Purpose: The purpose of the study was to assess the effectiveness of erbium:yttrium–aluminum–garnet (Er:YAG) laser surface pretreatment at various pulse durations of exposure on increasing the tensile bonding strength of permanent soft relining material and acrylic resin. **Materials and Methods:** Polymethyl methacrylate resin samples were fabricated and grouped as comparison group (no laser surface pretreatment) and three test groups (received Er:YAG laser surface pretreatment at various pulse durations of 10 s, 20 s, and 30 s) for bonding with the permanent soft relining material, Molloplast B. Following the surface pretreatment, the samples were tested for tensile stress using a universal testing machine. Loads at the point of failure were noted and the tensile bond strength values were obtained. Parametric tests of one-way-ANOVA and Tukey's *post hoc* tests were done. **Results:** The highest tensile bonding strength was recorded in Group C, and the control group recorded the lowest bonding strength. **Conclusion:** Er:YAG laser surface pretreatment at 10 Hz, 3 W, and 300 mJ for 30 s improved the bonding strength of the permanent soft relining material to heat-processed acrylic resin material.

Keywords: *Erbium:yttrium–aluminum–garnet laser, methylmethacrylate monomer, permanent soft relining material, polymethyl methacrylate, surface pretreatment, tensile bond strength*

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Introduction

The importance of bonding strength of the soft relining material to the denture base is emphasized by many researchers and the bonding failure has mostly been attributed to the poor bond.[1,2] To improve the bond strength, several surface modification methods, for example, mechanical roughening by sandblasting or lasers, chemical treatment, and mechanochemical treatment, have been investigated.[3-6] However, lasers have been found to perform well in enhancing the bond between the soft relining material and acrylic resin.[5,7,8] Various lasers such as carbon dioxide (CO_2), potassium-titanyl-phosphate (KTP) , neodymium:yttrium-aluminum-garnet Nd:YAG, and erbium: yttrium-aluminum-garnet (Er:YAG) lasers have been recorded to improve the bond strength.[5,7-10] However, there is scanty evidence of the Er:YAG laser treatment of the exposed surfaces.

Materials and Methods

A customized two-piece die maker with the base as lower member and upper member with four mold spaces of dimensions 40 mm length and 10 mm × 10 mm

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cross-sectional area was used. Petroleum jelly was applied onto the mold and molten wax was flown in. One hundred and four wax blocks thus obtained were invested in dental flask by the conventional compression molding technique. Dewaxing was carried out and molds were cleaned thoroughly with soap and warm water. Samples of desired dimensions were fabricated using a conventional heat-processed polymethyl methacrylate (PMMA) denture resin [Figure 1]. The flasks were closed using a hydraulic bench press and bench cured for 60 min at room temperature. Processing was carried out at 74°C for 2 h followed by boiling at 100°C for 1 h using a temperature-controlled acrylizer. A total of 104 acrylic resin blocks were obtained to prepare 52 specimens, which were split into four groups of 13 specimens each based on the duration of laser surface pretreatment they received. Before the surface pretreatment, the surfaces to be bonded were prepared using sandpaper. The control group received no laser treatment and Groups A, B, and C received Er:YAG laser treatment at 10 Hz, 3 W, and 300 mJ for 10 s, 20 s, and 30 s, respectively.The research has been approved by the Majmaah University for Research Ethics (MUREC) (HA-01-R-088) with the number: MUREC-Nov.08/COM-2020/8-3.

Laser treatment

The resin blocks were positioned at 90°to the laser tip at a fixed distance of 10 mm. R02-C: noncontact Er:YAG handpiece was used to treat the specimens [Figure 2-AT Fidelis Laser unit, Fotona, Slovenia] in pulse mode 10 Hz, 3 W, and 300 mJ with a long pulse duration for 10, 20, and 30 s. Brass die spacer of dimensions 3-mm length and 10 mm × 10 mm cross-sectional area was used as a spacer between two acrylic blocks before packing of the soft liner and invested in dental stone [Figure 3a]. Once the dental stone had completely set, deflasking was done and the brass die spacer was removed. Primo (Detax GmbH Co, Germany) adhesive was painted on the surfaces to be bonded and let to dry for 1 h before packing the soft relining material. The soft liner (Molloplast B) was packed and trial closure was done [Figure 3b], excess Molloplast-B was removed. The flask was clamped and placed in an acrylizer. Processing was done by heating slowly to 100°C and maintained for 2 h as per the manufacturer's instructions.

Testing for tensile bond strength

All the prepared samples were tested for tensile stress in a universal testing machine (Fine testing machine, Miraj) [Figure 4] at a crosshead speed of 5 mm per minute. On failure of the bond, the load was recorded in newtons (N) and used to obtain the tensile bonding strength in megapascals (MPa) using the below formula.

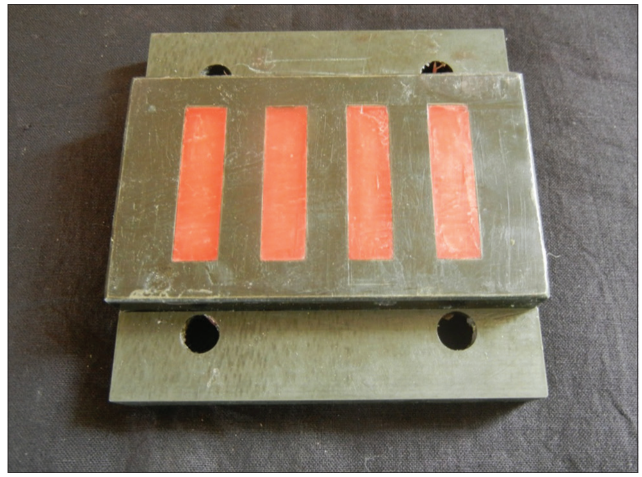


Figure 1: Metallic die maker for fabrication of acrylic resin

Figure 2: Erbium:yttrium–aluminum–garnet laser unit

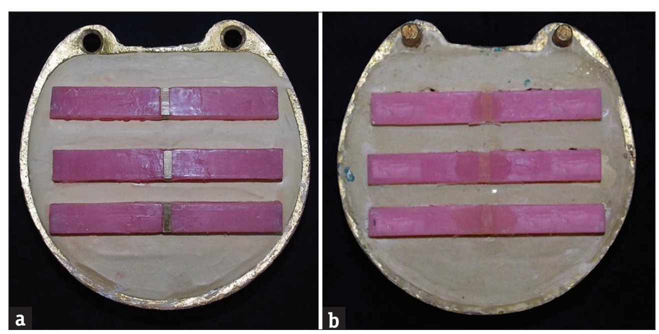


Figure 3: (a and b) Fabrication of specimens for testing tensile bond strength

$$\text{Tensile bond strength (MPa)} = \frac{\text{Load at failure (N)}}{\text{Cross-sectional area}\left(\text{mm}^2\right)}$$

Results

The highest tensile bond strength was recorded in Group C (1.40 MPa) and the least with the control

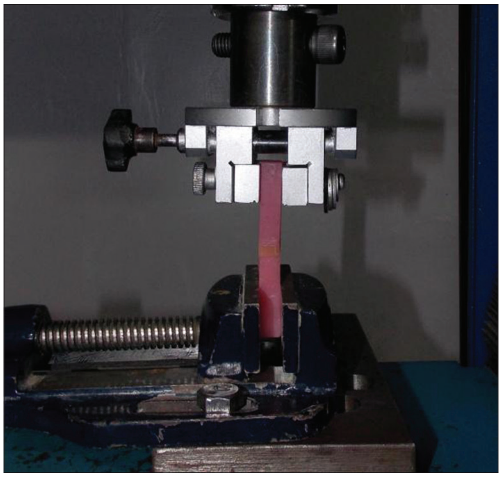


Figure 4: Specimen tested using universal testing machine

Table 1: Mean tensile bond strength values and standard deviation the study groups

Groups	Mean	SD
Control	1.020	0.02915
Group A	1.250	0.04143
Group B	1.320	0.02799
Group C	1.400	0.03512
Total	1.2475	0.14677

SD: Standard deviation

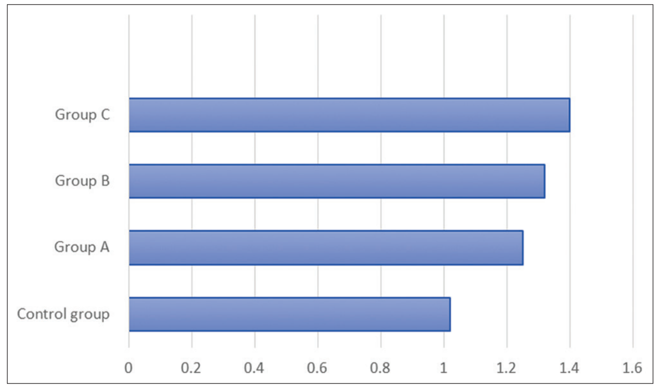
Table 2: Results of one-way ANOVA for tensile bond strength between and within the study groups

	Sum of squares	df	Mean square	*F*	Significant
Between groups	1.044	3	0.348	303.585	0.000
Within groups	0.055	48	0.001		

group (1.02 MPa). Table 1 shows a significant difference in the tensile bonding strength of all study groups. The results of one-way ANOVA for tensile bonding strength of and among the groups showed a statistically significant difference [Table 2]. Graph 1 shows a representation of the mean tensile bond strength of all the study groups.

Discussion

For improving the bonding between soft relining material and denture base resins, several surface pretreatments are used such as mechanical, chemical, mechanochemical, and plasma treatment. Sandblasting was used to create irregularities on the bonding surface to provide mechanical retentive features.[11,12] Sandblasting was advocated by Craig RG *et al*., although Amin WM *et al*. reported that it weakened the bond. Chemical surface pretreatment reportedly led to the bond failure of the soft relining material to the acrylic resin.[13,14] Time-dependent property of plasma treatment makes the approach



Graph 1: The mean tensile bond strength in MPa of the study groups

less effective, as delayed bonding can affect the bond strength.[13]

According to Usumez *et al*., Nd:YAG laser surface treatment created surface irregularities on the acrylic resin resulting in better bond strength values. Akin *et al*. in a study concluded that Er:YAG laser treatment on PMMA was effective than the Nd:YAG laser and KTP laser treatment to increase the bonding of soft liner and acrylic resin. Furthermore, as reported by Tugut *et al*., Er:YAG laser surface pretreatment led to an improved bonding strength. Hence, Er:YAG laser treatment was studied in the current study.

The Er:YAG irradiation vaporizes the water content of the PMMA, leading to volumetric expansion and increasing the surface area. The Er:YAG laser handpiece with an integrated spray nozzle helps in the ablation of the PMMA surface while simultaneously cooling with air and water spray to avoid overheating. These small perforations created by Er: YAG laser ablation helps in penetration and retention of the soft liner and improves the bond strength.[15] Tugut *et al*. studied the Er:YAG laser treatment at varying pulse duration and energy levels and reported that 300 mJ, 3W, and long pulse duration resulted in the highest mean tensile bond strength. However, the same treatment at 400 mJ, 4 W created larger pits and damaged the adhesive surface.[10] Haghi *et al*. studied various surface pretreatments to improve the bonding strength of soft relining material to acrylic resin. They concluded that the Er:YAG treatment at 200 mJ at 10 Hz for 10s resulted in unsatisfactory bonding when compared to the no treatment group. However, due to conflicting results obtained by the previously mentioned studies, it opens doors for further studies.[16] A systematic review conducted by Mudduganghadar *et al*. concluded that four of the six articles included for the review showed improved bonding following laser treatment of the acrylic resin.[17] Hence, this study was formulated to assess the effectiveness of the Er:YAG laser treatment at 300 mJ and 3 W for 10s, 20s, and 30s to improve the bonding of soft relining material to the acrylic resin material. This study recorded the highest tensile bonding strength of 1.400 MPa with Group C, the least of 1.02 MPa with the control group, whereas Group B was 1.32 MPa and Group A was 1.25 MPa. At least 0.44 MPa bonding strength is needed for acceptable clinical uses according to Khan *et al*.[18] Bond strength values following the Er:YAG surface pretreatments were higher than this value.

Conclusion

Er:YAG laser surface pretreatment had significant effects on the bonding of permanent soft relining material to the acrylic resin. Thus, to improve the bonding and longevity of the soft-lined denture, Er:YAG laser may be a good alternative to the conventionally available methods.

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Conflicts of interest

There are no conflicts of interest.

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