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EVALUATION OF BOND STRENGTH OF SOFT LINER ON PMMA AFTER PHYSICAL AND CHEMICAL SURFACE TREATMENTS: AN IN-VITRO STUDY

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ABSTRACT

Aim**:* To evaluate and compare the effectiveness of physical and chemical agents on tensile bond strength of soft liner to the PMMA. ***Purpose: The purpose of this in vitro study was to evaluate the effect of Diode laser and Ethyl acetate treatments on the bond strengths of acrylic resin to silicon liners. ***Materials and methods**:* Heat-polymerized acrylic resin (Acralyn-H) was bonded to silicone softliner material (GC Reline II Soft) to create control specimens (n=22), Diode laser treatment (n=22), and Ethyl acetate treatment (n=22). Silicone liner was polymerized on resin specimens. The tensile bond strength test was performed at a crosshead speed of 1 mm/min with a 10-N load until failure. Data were analyzed by using the anova and posthoctukey test. ***Results:*** The laser group showed significantly higher bond strength than the Ethyl acetate group ($p<0.05$). The Maximum tensile bond strength values were determined in the laser-treated group (1.23 MPa) while the lowest bond strength values were determined in the control group (0.323 MPa). ***Conclusions:*** Diode laser and Ethyl acetate applications increases the tensile bond strength between soft-liner material and resin. Diode laser treatment results in higher bond strength values than treatment with Ethyl acetate for 1 minute.

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INTRODUCTION

Soft liners are commonly utilized in the treatment of ridge atrophy, bruxism, congenital or acquired abnormalities of the palate and oral cavity, and injured oral mucosa (Canan, 2020 and Gorler, 2015). In an effort to improve the comfort of patients with knife edge ridges, ridge resorption, and persistent discomfort (Botega et al., 2008), they serve as a shock absorber on the tissuesurface of dentures (Kulkarni and Parkhedkar, 2011). This evenly distributes the functional stresses to the underlying mucosa and lowers the local stress concentration (Jacobsen, 1997 and Braden et al., 1995). By closely adapting the denture base to the underlying mucosa, softliners can aid in enhancing retention (Delgado-Ruiz, 2021). The four main categories of soft liners are (i) vinyl resins; (ii) plasticized acrylic resins, either heat- or chemical-cured; (iii) polyurethane and polyphazine rubbers; and (iv) silicone rubbers, either heat- or self-cured (Almuraikhi, 2022). The self-cure liners enable the dentist to reline a denture inside the patient's mouth (Lau et al., 2014). When it comes to lining materials, silicon based materials are superior to acrylic-based liners because of their intrinsic softness over extended periods of time, low solubility, and strong rupture resistance (Coelho Goiato et al., 2009). This in vitro study aims to examine the tensile bond strength following various surface treatments (ethyl acetate and diode laser) between silicon liner and denture base resin.

MATERIALS AND METHODS

1a. Designing and milling custom made metal mold: A custom-made metal mold was designed and milled at Sri VenkataRamana Engineering Works, Nellore for the purpose of fabricating intact and test specimen putty indices, as per American Dental Association Specification No. 12. The master metal mold consists of a rectangular mold space with 65x10x2.5mm dimensions.

1b. Fabrication of putty indices and processing with heat cure acrylic: The putty material (GC Flexceed putty and kit) mixed according to the manufacturer's instruction and the material gently pushed into the respective master and specimen mold spaces using glass slab. After the material set, glass slabremoved, putty indices were retrieved and excess material and flash was trimmed using B.P. blade without damaging the original dimensions. Thus, a total of intact 66 Group (65x10x2.5mm) putty indices were prepared.

The prepared putty indices invested in dental flask using Type 2 Gypsum product. After the investing medium set, flask opened carefully and putty indices were removed and thus mold space for heat cure resin was created. After separating medium application, the heat cure material (Acralyn-H heat cure denture base material) is packed into the mold space in the dough stage. Trial & final closure was performed and kept for bench curing for 30 minutes. Acrylization was done at 740 C for 2 hours and 1000 C for 1 hour. The flasks were bench cooled, specimens retrieved and excess flash removed with fine abrasives without damaging the original dimensions of the specimens.

***Specimen distribution**:* All 66 specimens were divided into 3 groups (22 each group) based on the surface treatment as (control; ethyl acetate; diode laser).

***Sectioning of samples**:* All the samples were sectioned using a thin diamond disc bur, 3mm of mid section was markedand removed from all the samples and were smoothened using a 50 grid sandpaper.

***Surface treatment of different specimens**:* After specimen distribution according to numbering system, bonding surfaces of Group 1 specimens were not treated with any chemical etchants, whereas the specimens of Group-2 were treated with Ethyl acetate for 120 secondsand Group 3 were treated with Diode laser for 1 min at 3W, 980nm with 50ms pulse held at 5mm from the sample.

***Surface evaluation**:* 1 sample from each group was evaluated for surface topography using a scanning electron microscope (JEOL, DS100, 10KeV, NON – FEI) at nanowatt technologies private limited, Bangalore.

***Soft liner application**:* After the surface treatment, the sectioned specimens were placed back into the mold (65x10x2.5mm) which was made for the fabrication of samples, leaving a gap of 3mm that is created for the softliner application and then soft liner catridges were loaded to the injecting gun and was applied according the manufacturer instructions and allowed to set for 1 minute. The samples were then retrieved and excess is trimmed with a scissor and carbide bur, Finishing and polishing was done without damaging the original dimensions. All the specimens were stored in distilled water at 370 C for 48 hrs.

***Tensile strength evaluation of specimens**:* All the specimens were subjected to tensile bond strength test on a universal testing machine (FIE-UTES-40-HGFL). With each sample attached to upper member at one end and lower member at another end and a pulling force is applied at a cross head speed of 1mm/min with maximum load application till the bond failure occurs. The values obtained after testing were tabulated and subjected to statistical analysis.

RESULTS

Table 1 presents a comparison of tensile break strength among different study groups using ANOVA. The results suggest a statistically significant difference in tensile break strength among the study groups. Table 2 presents results from a posthoc Tukey test for multiple comparisons of tensile break strength among different study groups. Significant mean differences exist between control and chemical groups (-0.56524*) and control and laser groups (-0.90682*), as well as between chemical and laser groups (-0.34158*), all at a significance level of 0.05. The 95% confidence intervals are provided. The overall posthoc Tukey test showed significance (p<0.05), denoting significance differences.

DISCUSSION

A soft liner is a material applied to the tissue surface of complete or removable partial dentures to reduce the pressure on thin and atrophic mucosa. The function of soft lining material include shock absorption for the denture-bearing mucosa and increasing retention of the prosthesis. They are used in cases of bony undercuts, xerostomia, Parafunction, congenital oral defects requiring obturation, sensitivity in the mental foramen region, implant placement surgery, wrong

Statistical Analysis

Table 1. Comparison of tensile break strength among study groups using ANOVA

Groups	Mean	Std. Deviation	F value	Pvalue
Control	0.32	0.19	48.101	0.000*
Chemical	0.89	0.31		
Laser	1.23	0.39		

ANOVA P<0.05*, NS: not significant

Table 2. Multiple comparison of tensile break strength among study groups using posthoctukey test

Groups		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Chemical	-0.56524*	0.09339	0.000*	-.7894	-.3411
	Laser	-0.90682*	0.09339	0.000*	-1.1310	-.6827
Chemical	Laser	-0.34158*	0.09339	0.001*	-.5657	-.1174
*. The mean difference is significant at the 0.05 level.						

Post hoc tukey P<0.05* significant, NS: not significant

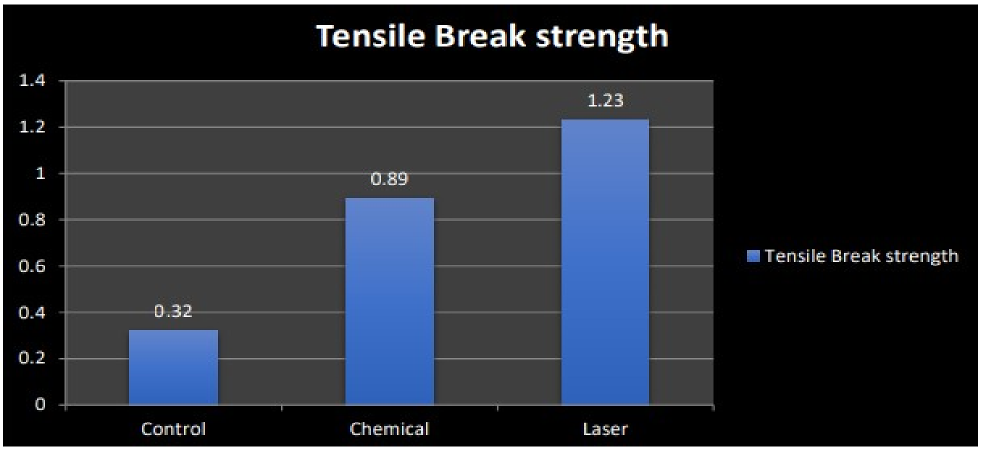
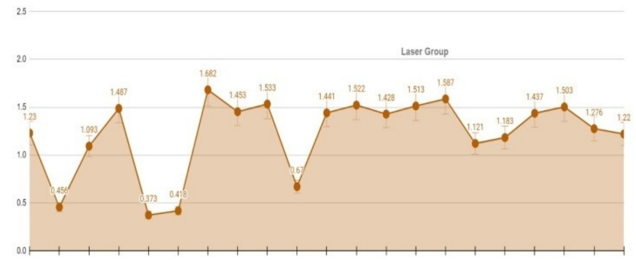


Figure. Tensile break strength among study groups

occlusal relationship, bony spicules, irregular bony resorption and hyperplastic tissue requiring pre prosthetic surgery, in which the patient cannot undergo the procedure due to financial or surgical problems. Application of a soft liner prevents the mucosal irritation and injury under the hard surface of polymethyl methacrylate thus preventing the occurrence of chronic soreness (Kim, 2014). The prosthetic surface that comes into contact with tissue is coated with a soft liner, is anticipated to comfort the patient and promote mucosal healing (Gundogdu, 2014).

Graph 1. Graphical representation of tensile bond strength values of control group specimens

Graph 2. Graphical representation of tensile bond strength values of ethyl acetate group specimens



Graph 3. Graphical representation of tensile bond strength values of Diode laser group specimens

Soft liners have been divided according to the chemical structure into 4 groups: Plasticized acrylic resins (either chemical or heat-polymerized), Vinyl resins, Polyurethane, Polyphosphazine and Silicone rubbers (Almuraikhi, 2022) and were categorized according to durability as short term and long term liners (Demir et al., 2011 and Dogan, 2007). Silicone-based lining materials don't need an external plasticizer, their polymer is an elastomer, which makes it more stable, elastic and softer that last for extended periods of time and has a higher degree of colour stability due to their increased hydrophobicity (Atsü, 2013; Sarac et al., 2006). These liners present mechanical superiority and greater longevity however they lack adherence to denture base resin due to the difference in chemical composition leading to absence of chemical interaction between the two materials. So, adhesives are required to strengthen the bond (Zhang, 2010). In order to solve this, researchers have modified the Polymethyl methacrylate surface before adding a soft liner. Bonding surface of Polymethyl methacrylate been altered by lasers and chemicals to enhance surface area and create mechanical interlocks leading to stronger bonds (Akin, 2008 and Usumez, 2004). Lasers been advocated as one of the aids in increasing surface microporosities of PMMA resin.

The applied laser's specifications and the substance being irradiated determine its optical penetration depth (Verma, 2012). It is a useful technique for achieving the intended rough but stable surface morphology to modify the wettability properties of acrylics, ceramics, and metals for improved adhesion and bonding (Soygun, 2011). An interfacial adhesive is absolutely necessary for the bonding of the silicone-based lining material to the denture base resin. The most popular solvent being acrylic resin monomer, which dissolves the polymethyl methacrylate surface (Tugut et al., 2012 and Nakhaei, 2016). Other chemicals such as methylene chloride, acetone, dichloromethane, isopropanol, toluidine, chloroform, phosphoric acid and isobutyl methacrylate improved bond strength values. The swelling of the outer denture base with porous structure by these chemical etchants and the penetration of the adhesive resulted in a formation of interprismatic network and improving the bond strength (Haghi, 2020). Dugyu et al reported that chemical surface treatment with MMA and acetone increased the bond strength of softliner to polymethyl methacrylate as they cause swelling of outer denture base & increases the penetration of adhesive (Haghi, 2020), Rahul et al also states application of MMA monomer before the liner application has increased the bond values (Kulkarni, 2011). Mustafa et al concluded that 36 % phosphoric acid provide better bond strength values compared to sandblasting with AL2O3 and Er:YAG laser13. In another study mohammedreza et al reported that sandblasting + laser shown highest bond values compared to the sandblasting and laser alone (Colvenkar, 2008).

The present study evaluated the effect of different surface treatments on the tensile bond strength of a silicon soft liner to an acrylic denture base. Significant differences were seen in specimens that were surface treated with both chemical and laser compared to control and also laser gave better values than chemical. The results are in accordance with Scanning Electron Microscopic views, as the control group reveals a smoother surface with scratches and grooves. Chemical treated specimens have shown surface irregularities with porous structure and the diode laser treatment developed several tiny pits and irregularities. Soft lining material could therefore enter the pits or irregularities leading to mechanical interlocking increasing the bond strength. Upon examination of the failure types, it was noted that the groups exhibited both adhesive and mixed failures. This could suggest that there are almost equal bond strengths between the liner molecules and between the liner and resin. This study confirms the findings of Lawrence and Li, who found that polymethyl methacrylate 's surface roughness increased from 1.95 to 2.22 mm when exposed to a Nd:YAG laser (Gupta, 2010). Hakan's application of Er:YAG laser to a denture base resin caused irregularities and numerous tiny pits on the surface. As a result, soft lining materials can strengthen the bond by penetrating the pits or imperfections created by the Er: YAG laser (Krishna, 2014). In the current study laser treatment provided better results than chemical as the laser causes large amount of volumetric expansion with greater surface area leading to deeper penetration of liner whereas ethyl acetate produces dissolution of surface layer that may account for lesser penetration of liner into resin and formation of interprismatic network. Soft liners have a major impact on the related denture bases. Denture base strength decreases when a soft liner's thickness increases because the corresponding denture foundation thickness needs to be lowered. Additionally, products like adhesives and monomers used in conjunction with soft liners may partially dissolve the accompanying denture foundation that may lead to fracture of denture base.

Limitations of this study:

- Oral conditions could not be exactly simulated as the Removable dentures are exposed to saliva, Thermal changes, staining beverages, and occlusal forces during clinical usage.
- Only 1 type of liner (chair side liner) was evaluated with 2 different surface treatments.
- Laser with only single pulse of duration was observed.
- Further studies should investigate the effect of different types of chair side and heat cured liners with various Physical and

chemical surface treatments at different concentrations and durations.

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