Comparative Evaluation of the Effect of Different Surface Treatments on Shear Bond Strength between Silicone Soft Liner and Denture Base Resin – A Three Dimensional Study.

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Abstract

Background: One of the most serious problems with silicone soft liner is bond failure between the liner and the heat polymerized acrylic denture base. Since the forces that the lining material clinically exposed to, is closely related to shear and tear test, the shear test is considered an appropriate method for testing bond strength of softliners to denture base resin.

Aim: The present in vitro study was conducted to comparatively evaluate the effect of two different surface treatments on the shear bond strength between silicone soft liner and heat polymerized denture base resin after thermocycling.

Materials And Methods: Thirty three heat cure acrylic blocks of 14mmx14mmx2mm were prepared and randomly divided into three groups A, B, C of eleven blocks each, based on the method of surface treatment rendered. One of the 14mmx14mm surfaces of each block was designated as test surface. Group A test surfaces were left untreated (Control), Group B were airabraded and Group C were laser irradiated. Only one representative treated test surface of the sample from each group was subjected to 3-D surface texture analysis before bonding with soft liner. Silicone soft liner was bonded to the remaining test surfaces. The testsamples were subjected to thermocycling and then shear bond strength testing in an universal testing machine. One representative debonded sample from each group was qualitatively analysed for mode of failure using scanning electron microscope.

The results were tabulated and statistically analysed using ANOVA and post-hoc Tukey's HSD analysis (P value < 0.05 considered significant).

Results: Surface texture analysis revealed well defined peaks and valleys for both sandblasted (4.40μm) and laser irradiated (1.59μm) groups compared to control (0.44μm). Laser irradiated group exhibited the maximum and significantly higher shear bond strength (0.5535±13Mpa) compared to air abrasion (0.4951±6Mpa) and control (0.3205±7Mpa) groups. Control group showed significantly less bond strength (0.449±μm). Laser irradiated group exhibited a predominantly cohesive pattern of failure, whereas Groups Band C exhibited a predominantly cohesive pattern of failure.

Conclusion: Surface treatment by air abrasion and laser irradiation increases the surface roughness of acrylic resin and also significantly improves the shear bond strength compared to untreated surfaces.

KeyWords: dental materials, synthetic resins, dental air abrasions, lasers, denture liners, shear strength, scanning electron microscopy.

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I. Introduction

Prevention and treatment of soreness from removable dentures with preservation of supporting structures is the goal of prosthodontics. Liners act as a cushion for the denture-bearing tissues by absorbing and redistributing forces transmitted to the stress-bearing areas of the edentulous ridges. They also offer a valuable solution for managing painful or fragile mucosa or ulcerated tissues associated with the wearing of dentures and provide comfort for patients who cannot tolerate occlusal pressures, such as, in cases of alveolar ridge resorption, knife-edge ridges, bony undercuts, bruxing tendencies, congenital or acquired oral defects requiring obturation, xerostomia, dentures opposing natural dentition in the opposing arch and for transitional prosthesis after implantation surgery. The ideal properties for a soft liner include, resilience, tear resistance, viscoelasticity, biocompatibility, adhesive bond strength, low solubility and low absorption in saliva, ease of adjustability, dimensional stability, color stability, lack of adverse effects on denture base material, resistance to abrasion and ease of cleaning.

Short term resilient liners are used intraorally for a period of up to thirtydays and also called as temporary soft liners. Liners intended to be used over a period of 1-6 months are categorized as intermediate liners and are mainly used when pre-prosthetic surgery is not indicated but the patient presents with bony undercuts or knife-edge ridges. Long term soft liners are those intended to function for a longer period and are indicated insituations when pre-prosthetic surgery is not indicated, but the patient has significant bony undercuts. Soft or resilient liners can also be classified as room temperature vulcanized (RTV) and heat temperature vulcanized (HTV). These can be further divided into 4 groups according to their chemical structure: a) plasticized acrylic resin, b) vinyl resin, c) polymethane and polyphosphazene rubbers (d) silicone rubbers.

Silicone-based resilient lining material is similar in basic composition to silicone impression materials as both are dimethylsiloxane polymers. Polydimethylsiloxane is a viscous liquid that can be cross-linked to form a rubber with good elastic properties. Softness of these liners is controlled by the amount of cross-linking in the rubber and no plasticizer is
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necessary to produce a softening effect with this material [8]. Silicone liners have been reported to keep their softness for longer periods than acrylic resin liners [4]. Silicone liners have little or no chemical adhesion to PMMA resins and an adhesive is supplied to aid in bonding the liner to the resin denture base. One of the concerns with these materials is bond failure between the resilient denture liner and denture base. Bond failure creates a potential surface for bacterial growth, and plaque and calculus formation [16,17]. A variety of parameters affect the bond between resilient lining materials and the denture base including water absorption, surface primer use, and temperature changes [4,5,18,19]. In vitro studies on the bond strength between soft liners and denture base resin have focused on either tensile and/or shear bond strength testing. In this study we had included 3D surface profilometry as a study parameter apart from scanning electron microscopy analysis.

Fluctuations in temperature, as encountered in the oral cavity, can influence material’s mechanical and physical properties, especially the bond strength. As such, the thermocycling process conducted in invitro studies, can give useful data on the longevity of soft denture liners with respect to bond strength under conditions that simulate clinical usage. The effect of thermocycling on the tensile bond strength of denture liners has been widely reviewed [15,22,24]. Adequate data on the effect of thermocycling on the shear bond strength of soft liners is lacking which is more critical than tensile loading, as shear bond strength can also impact the tensile bond strength [2].

The paucity of data comparing the effect of laser surface treatments with other surface treatment methods on the shear bond strength between chair-side silicone-based soft liner and denture base resin prompted the present study, in view of its clinical impact and significance.

Hence, the aim of this present in vitro study was to comparatively evaluate the effect of laser surface treatment with that of the conventional surface treatment by air-abrasion on the shear bond strength between chair-side silicone soft liner and heat polymerized denture base resin after thermocycling. The null hypothesis for the present study was that different surface treatments will not significantly affect the shear bond strength between these materials.

II. Materials And Methods

An in vitro study was conducted at our post graduate department with the following materials and methodology. A custom-made stainless steel rectangular block with the standardized dimension of 14mm x 14mm x 25mm (Fig-1) was used as a template for obtaining wax blocks of similar dimensions, which were then converted to heat cure acrylic resin blocks and subsequently smoothened with 100 and 200 grit silicon carbide paper. One of the 14 x 14mm surface of each resin block was designated as the test surface for subsequent surface treatment and liner bonding procedures.

Thirty-three such resin blocks were fabricated and were stored under distilled water for 50±2 hours, for the denture base polymer to reach water saturation.

The resin blocks thus obtained were randomly divided into three groups of eleven blocks each, according to the type of surface treatment to be rendered on them as follows: Group A - untreated surface of acrylic resin blocks (Control group), Group B - surface treatment by air abrasion of acrylic resin blocks (Air abrasion group), Group C - surface treatment by laser irradiation of acrylic resin blocks (Laser irradiation group).

The test blocks of the Group A were designated as control, and hence no surface treatment was performed on these test surfaces. These untreated samples were stored as obtained after finishing under distilled water in an airtight container to avoid contamination till future use.

The test surfaces of Group B blocks were subjected to air abrasion using 110μm aluminium oxide (Korox, Bego, Germany), by holding the blocks at a distance of 10mm from the nozzle, maintaining the pressure at 2psi for a period of 30 seconds, with the test surface facing the nozzle. They were then cleaned using a steam cleaner. Treated samples were stored in an air tight container to prevent contamination prior to application.

The test surfaces of the Group C were subjected to laser surfacetreatment using Er,Cr:YSGG laser system (Waterlase iplus laser unit, Biolase Technology, CA, USA). Laser irradiation was done at the wavelength of 2.78μm, pulse duration of 700ps and repetition rate of 10Hz.
The power output was set at 3W. The air and water sprays from the handpiece were adjusted to a level of 85% air and 85% water to prevent the acrylic surface from overheating. Laser energy was delivered through a fibre-optic system to a sapphire tip terminal 600 pm in diameter and 6mm long. The focused laser beam was aligned to the test surface perpendicularly at a distance of 10mm. The test surface was lased manually in a circular motion for a period of 30 seconds. The surface treated samples were stored in an air tight container to prevent contamination prior to application of silicone liner. One surface-treated acrylic resin block from each test group was subjected to surface topography and surface roughness analysis using 3-D profilometry (Talysurf CCI, Ametek, UK). (Fig. 3). The surface roughness (Ra) value of each acrylic block was obtained. The magnification of the optical lens was 50x. Each acrylic block was placed under the objective lens and photomicrographs at 50x magnification were obtained in advanced 3D views using Advanced Aspherics Analysis software. (Fig. 4, Fig. 5, Fig. 6)
The remaining surface treated ten resin blocks of each group were used for bonding with the silicone liner and further shear bond strength testing. The test surfaces of all the acrylic resin blocks of each test group were coated once with primer (GC liner, Germany). Each coating was applied to the test surface using an applicator with an application time of 30 seconds as per the manufacturer’s instructions. Care was taken such that there was no contamination of test surface after application of the primer.

A cylindrical Teflon jig, 20mm in diameter and 6mm in height was custom-milled. (Fig- 7, Fig- 8) The jig had a fitting surface and superior surface. It had a central circular opening, 6mm in diameter and 3mm in height, so as to limit the soft liner to a circular area of 6mm diameter and a height of 3mm on each test surface for all the test samples. The jig was positioned over the primed test surface of the resin block prior to the bonding with the liner.

FIGURE 5 - Er, Cr, YSGG LASER UNIT

FIGURE 6- PERFORMING SURFACE TEXTURE ANALYSIS WITH 3D PROFIOMETER

FIGURE 7- 3D SURFACE TEXTURE ANALYSIS PHOTO OF GROUP A (CONTROL)
One block at a time was assembled with the custom-made Teflon jig described before. The design of the jig was such that the resin block fitted snugly into the indentation present in the fitting surface of the cylindrical jig. (Fig-9) Thus, the assembly served the dual purpose of delineating the shape and size of the bonding area and preventing the soft liner from contacting the acrylic resin surface outside the circular bonding area.

The silicone-based soft liner (GC liner, Germany), supplied in cartridges was mixed using a hand held auto-mixing device (GC liner, Germany) and was introduced gently from one end into the bonding area to avoid air entrapment till the material completely filled the central hole. An acetate sheet was placed over the material and finger pressure was applied until polymerization was completed. A working time of 2 minutes and setting time for 5 minutes was followed. After the soft liner had set, the acetate sheet and the Teflon jig were removed to obtain a test sample of acrylic resin surface bonded with silicone based soft liner as per the specifications previously mentioned. This process was carried out for all the resin blocks to obtain 30 test samples, with ten test samples per group.

All the test samples of the three test groups were subjected to thermocycling for a total of 250 cycles in a distilled water bath between 5°C and 55°C with a dwell time of 60 seconds and a dry time of 10 seconds at 27°C between the warm and cold cycles using a thermo cycling apparatus (Fig-10) (Haake, W15, Germany), to simulate three months of clinical use. All the test samples of each group (n=10) were tied in a cloth pouch and the three sets of pouches were collectively thermocycled in the apparatus. Upon completion of thermocycling, the specimens were stored under distilled water in their respective containers until they were subjected to shear bond strength testing.
Each test sample was tested individually for shear bond strength in a Universal Testing Machine (Fig-11), (Instron, Llyod instruments, UK). The test sample was fixed to the sample fixture at the bench vice of the machine with a knife edged chisel blade positioned parallel to the material interface. Force was applied to the sample in such a way that shear load was exerted directly to the bonding interface at a cross head speed of 1 mm/min until failure of the bond occurred. The tests were conducted in an open room at room temperature. Shear bond force at which the bond failed was recorded in newton (N) and shear bond strength (MPa) was calculated by dividing the force (N) at which failure of the bond occurred by the surface area of adhesion (mm$^2$).

\[
\text{Bond Strength (MPa)} = \frac{\text{Force (N)}}{\text{surface area (sqmm)}}
\]

Surface analysis of the tested specimens was carried out using scanning electron microscope (Fig-12), (SA400N, Canada), to assess the mode of the failure. Samples were examined under 100x magnification to qualitatively assess the surface topography of debonded samples of each test group (Fig-13, Fig-14, Fig-15).
The data obtained were tabulated and subjected to statistical analysis using SPSS software package (SPSS 16 for Windows 8.0, SPSS Software Corp., Munich, Germany). Mean and standard deviation were estimated from the results obtained. The data were analyzed with One Way Analysis Of Variance (ANOVA) for overall significance and further pairwise multiple comparisons were done by Post-Hoc test (Tukey’s HSD Analysis). (p value < 0.05 was considered significant.)
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III. Results

The basic data obtained in this study showed a mean shear bond strength values for untreated test samples (Group A), for sandblasted test samples (Group B) and for laser irradiated test samples (Group C), which had been mentioned below.

Table 1: Comparative evaluation of the mean shear bond strength value of 3 groups using One Way Analysis of Variance (ANOVA)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean shear bond strength (MPa)</th>
<th>Standard Deviation</th>
<th>‘p’ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.32</td>
<td>0.042</td>
<td>0.000*</td>
</tr>
<tr>
<td>B</td>
<td>0.50</td>
<td>0.056</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.55</td>
<td>0.029</td>
<td></td>
</tr>
</tbody>
</table>

Note: ‘p’ value < 0.05 denotes statistical significance.

One way analysis of variance (ANOVA) shows overall statistically significant difference between the test groups at 5% level. Group C showed the highest mean shear bond strength followed by Group B and least by Group A.

Table 2: Multiple comparisons of mean shear bond strength values of untreated samples (Group A), sandblasted samples (Group B) and laser irradiated samples (Group C) using Post-hoc Tukey’s HSD analysis

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean shear bond strength (MPa)</th>
<th>‘p’ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>0.50</td>
<td>0.00</td>
</tr>
<tr>
<td>Group A</td>
<td>0.32</td>
<td>0.00</td>
</tr>
<tr>
<td>Group C</td>
<td>0.55</td>
<td>0.01</td>
</tr>
<tr>
<td>Group C</td>
<td>0.55</td>
<td></td>
</tr>
</tbody>
</table>

‘p’ value < 0.05 denotes statistical significance.

Post Hoc Tukey’s HSD analysis revealed significant differences between all the three test groups: Group A - Group B; Group A - Group C and Group B - Group C (p value < 0.05). On statistical comparison, Group A (Untreated/Control Group) exhibited the least mean shear bond strength value among the three test groups and this was significantly lesser (p value < 0.05) than those of both Group B (Sandblasted Group) and Group C (Laser irradiated Group). Statistical comparison between the mean shear bond strength values of Group B and Group C revealed that Group C (Laser irradiated Group) had significantly higher shear bond strength value (p value < 0.05) than Group B (Sandblasted Group).

IV. Discussion

Soft denture liners have been recognized as a valuable adjunct in prosthodontic practice since they were introduced by Mathews in 1945 in the form of plasticized polyvinyl chloride [1]. Bond strength is considered to be very important with regards to clinical outcome [4]. According to Glossary of Prosthodontic terms, bond is the force that holds two or more units of matter together. Bond strength is the force required to break a bonded assembly with failure occurring in or near the adhesive interface [27]. Lack of durable bond between the resilient liner and the denture is reported to be a common clinical problem [2,4,18].

Several methods have been advocated to enhance the bonding of acrylic denture base to silicone soft liner. They can be broadly categorized into mechanical and chemical modifications or a combination of both [2]. Mechanical methods are reported to produce an improvement in bond strength [6,7,12,17,20].

Among these methods, air abrasion involves spraying a stream of aluminium oxide particles against the material surface intended for bonding under high pressure, since alumina particles employed produced micromechanical retention by producing surface irregularities. Aluminium oxide of various particle sizes has been employed to enhance the bond between the silicone based soft liner and denture base resin [7,12,28]. The role of sandblasting in improving the bond strength between soft liners and acrylic resin remains controversial and has been recommended for further investigation in the previous studies [2,6,7,22,23].

Recently, lasers have been found to provide relatively safe and easy means of altering the bonding surface of materials. It has been indicated in one study that Er,Tm:YSGG laser treatment (Figure 4) may significantly enhance the shear bond strength between silicone soft liner and denture base resin. However, literature using Er,Cr:YSGG laser as a surface modification method of denture base to yield better bond strengths is sparse [17]. The bond strength of the liner-denture base interface has been researched extensively by some authors. Al-Athel et al studied the various bond strength assessment methods, namely, peel test, tensile bond strength bond strength between the liner-denture base interfaces [29]. He concluded that shear forces best represent the oral conditions in which the liner functions. Hence shear bond strength of the material is more indicative of its clinical longevity. The peel test is believed to simulate the horizontal component of masticatory forces as it causes lateral displacement of the denture. Tensile test on the other hand predominantly represents the vertical component of the masticatory forces.

It has also been pointed out that tensile failure was not caused by tensile forces alone because some shear forces also developed during tensile testing. This specially stands true in case of silicone lining material which has a high Poisson ratio. These materials undergo a reduction in cross-sectional area on tensile load application, whereas, the bonded portion of the liner maintains a constant area. This induces shear forces at the margins of the bonded interface.
Since soft denture liners function in an aqueous oral environment under rapidly changing temperature conditions, the impact of these two parameters on the bond strength is also important while conducting bond strength tests in vitro. Thermocycling of test samples prior to testing of bond strength is done in in-vitro studies to assess the impact of these parameters and mimic oral conditions.

Cyclic thermal stress causes shear stress at the bond interface, as it provokes repetitive shrinkage and expansion and results in a difference in thermal volumetric change between denture base and soft denture liner. During thermocycling, soft denture liner absorbs large amount of water which may result in hydrolytic degradation of the bond due to water diffusion into the interface.

A chair-side liner was evaluated in the present study because of the advantages of these reliners mentioned earlier. Silicone soft reliner was selected based on its aforementioned advantages over acrylic chairside reliners. The type of bond strength testing in the present in-vitro study was limited to shear testing because of the previously explained stress patterns that are generated during such testing.

Heat cure acrylic denture base resin was the material employed for obtaining the test resin blocks since PMMA is the most widely used denturebase material clinically and has been considered as an ideal material for this purpose. The test blocks were fabricated and stored as per standard protocols.

The test blocks were fabricated and stored as per standard protocols. Sandblasting and laser irradiation were chosen as the two test surfacetreatment methods in the present study based on previously outlined reasons. Sandblasting with different grits of aluminum oxide has been employed in the literature. Sandblasting the denture base area with 50μm could only remove the surface glaze on the denture base area but had no significant effect in improving the bond strength between the denture base resin and soft liner. Most of the studies reported that grit size in the range of 110-120μm Aluminum oxide particle is adequate to improve the bond strength. Hence, in the present study, Aluminum oxide of 110 μm was chosen for this type of surfacetreatment. Laser irradiation was carried out using Er,Cr:YSGG.

3-D surface profilometry was carried out for all the three types of test surfaces (Untreated, Sandblasted, and Laser irradiated) to assess the surfacetopography and roughness of these surfaces, as it may aid in interpretation of the test results as reported in a previous study. Surface roughness (Ra value) is the arithmetic average deviation of surface valleys and peaks expressed in microns and are a measure of the finer surfaceregularities in surface texture.

The surface texture analysis of one respective sample of each test group revealed that surface treatment by both air abrasion and laser irradiation increased the surface roughness values (Ra - 1.40μm and Ra - 1.59μm respectively), compared to that of the untreated surface (Ra - 0.449μm). The surfacetopography of the treated specimens also exhibited pronounced peaks and valleys indicative of a roughened surface. These peaks and valleys are more evenly distributed for the laser-irradiated sample. This was in contrast to the sparse and poorly distributed peaks and valleys seen in the untreated sample.

The silicone liner application was done only for the designated testsurfaces of each test block in the form of cylindrical columns of 3mm height and 6mm diameter based on similar procedures followed in previous studies. A custom-made Teflon jig was fabricated to achieve this purpose to obtain silicone liners of uniform dimensions on each test block. Since the Teflon jig was milled, it obviated the need for making individual templates for bonding as in source previous studies. Additionally, Teflon being an inert material does not react with the liner employed in the test and also facilitated easy retrieval of the test samples after the bonding procedure. In the present study, a small thermocycling period simulating three months of clinical use was employed.

The test specimen interface resembled a clinical scenario of a single soft liner-denture base interface, along with which parallel shear forces could be applied to evaluate the shear bond strength. The load at which the bond failed under shear stress was recorded in Newton (N) and was taken as the shear load value of the particular sample. The shear bond strength values in MPa were obtained by dividing the shear load values (N) by the cross-sectional area of bonding. In the present study, since the bonding was confined to a circular area of 6mm diameter, the cross-sectional area was calculated using the formula r² (area of a circle). The bonding area of the specimen was around 28.274 mm² which was used to calculate the bond strength.

In a previous study by the Jacobson NL et al., both laser treatment as well as sandblasting surface treatments were shown to be ineffective in reducing the adhesive failure between soft liner and acrylic resin. This could be attributed to the CO2 laser used in that study in contrast to the Er,Cr:YSGG laser employed in the present study which could have yielded the superior results here. Further, the significant improvement by sandblasting observed in the present study compared to that obtained in a study by Jacobson NL et al., can be attributed to differences in study design, sample preparation and study environment.

Korkmaz FM et al. evaluated the effect of acid etching treatments with laser irradiation and sandblasting on the peel strength between silicone softliner and denture base resin. They reported a significant increase in peel strength values when treated with laser irradiation than with sandblasting. The results obtained in the present study are in line with those obtained for shear bond strength in that study, which has also shown that laser irradiation, could significantly improve the shear bond strength of the test samples. The type of laser used in the present study and by Korkmaz FM et al. in their study was also Er,Cr:YSGG. Since the peel strength results obtained in Korkmaz FM et al. are in correlation with the shear bond strength results obtained in the present study, it can be said that the type of laser used may also impact test results.

Since studies on the effect of laser surface treatment on shear bond strength between silicone liner and denture base resin are lacking, further direct correlation with the results of the present study cannot be obtained. Air abrasion by sandblasting is said to improve the surface roughness by providing an irregular surface for the mechanical locking of the soft material and is said to be the cause of improved bond strength. However, some studies employing sandblasting as a mode of surfacetreatment have reported decreased bond strength values with this surfacetreatment. This has been attributed to stress concentration at the bond interface resulting in bond failure. However, most of these bond strength studies are either peel or tensile strength stress tests. Studies comparing the effect of surface treatment with sandblasting on the shear bond strength are few.

In a study, surface treatment by sandblasting resulted in significantly higher shear bond...
strength values between silicone soft liner and acrylic denture base resin as compared to the untreated or untreated samples. The results obtained in the present study are in line with those obtained in the above studies.

The increased surface roughness (Ra values) observed for both the surface treated groups is in direct correlation to the significantly increased shear bond strength values for these groups as against those of the untreated group in the present study. This indicates that surface treatment by either method, especially by laser irradiation, could improve the surface roughness and yield significantly higher shear bond strengths. Most studies on bond strength between soft liners and acrylic resin have not included surface treatment analysis as part of test protocol. Only one study [35] has included this investigation to study the surface of soft liners and found significant differences between surfaces of different liner materials. Surface texture analysis is significant in studies where the effects of different surfacetreatments are tested, since the surface topography can play an important role in impacting the results.

The direct correlation between surface texture analysis and shear bond strength improvements obtained in the present study further validate this point and hence this investigation can be included in future similar studies. SEM analysis of one representative debonded test sample of each test group was done to correlate the shear bond strength test values with the SEM observations of the debonded interface as done in previous studies. [1,2,5,9,16] SEM analysis of the debonded representative one specimen revealed a mixed type of failure for test groups. The untreated surface exhibited a predominantly adhesive pattern within the mixed mode of failure. There was more of visible resin surface, with the sparsely distributed liner material. Both surface treated samples exhibited a cohesive pattern within the mixed mode of failure. There were several patches of silicone lining material distributed over the resin surface. This was more pronounced in the laser irradiated sample which showed greater cohesive pattern compared to that observed for the sandblasted group.

This observation for the laser irradiated sample is in line with those observed by Jacobson et al, who found that a majority of laser treated specimens experienced cohesive pattern of failure [7]. The types of failures observed under SEM in previous similar studies [1,2,7,9,16] revealed that silicone liners showed different failure patterns under different testing conditions. The type of bond strength testing (whether peel, tensile or shear), mode of surface treatment rendered, etc. can impact the mode of failure, and this could have resulted in the different modes of failures observed. Previous studies have revealed a cohesive pattern of failure for silicone liners bonded to acrylic resin, which is in line with the SEM observations of the present study [1,2,7,16]. Further investigations are recommended to arrive at the exact mode of failure between silicone liners and acrylic resins following shear testing.

Since a silicone soft denture liner does not adhere chemically to denture base resins, primers are used as a part of routine bonding procedures. Therefore, the bond strength would also be impacted by the chemical composition of the primer which is not revealed by the manufacturers. This aspect also needs further evaluation. The null hypothesis of the present study is rejected because of significant differences in shear bond strength values between sandblasting and laser irradiation. It has been reported that a bond strength of 0.44 MPa is a minimum acceptable measure of bond strength that is required for clinical use of soft denture lining materials. [18] When viewed in this light, the mean shear bond strength result obtained for both the surface treated groups (Sandblasted and Laser irradiated) are within clinically acceptable limits for bond strength (0.495116 MPa and 0.553513 MPa respectively). The mean shear bond strength obtained for the control group is 0.320557 MPa, indicated less than optimal bond strength value for untreated group.

Hence, it can be recommended that surface modification of acrylic resin prior to bonding with chair-side silicone soft liner should be carried out preferably for better clinical outcomes. The choice of surface treatments between sandblasting and laser irradiation can be based on availability and operator’s preference, though laser irradiation yields better results.

V. Limitations

The present study had some limitations. Only one composition of chair-side reliner was tested. The effects of other type of surface treatments mentioned in the literature were not included. Thermocycling which is used to mimic oral conditions was done for a short period, simulating 3 months of clinical use. Longer durations might impact the study results differently. Further, different intensities of laser irradiation can bring about differences in test outcomes. Further studies that include the above variables with larger sample size are recommended to enhance the results obtained from the present study.

VI. Conclusions

Within the limitations of the present study, following conclusions were made.

1) Surface modification by both air-abrasion and laser irradiation significantly improves the bond strength between silicone soft liner and heat cure denture base resin compared to untreated surfaces.
2) Laser irradiation showed significantly higher bond strength values as compared to those obtained by air abrasion.

References

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