IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 11 Ser.1 (November. 2019), PP 24-34
www.iosrjournals.org

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.

Sree Varun M,[1] Hariharan Ramakrishnan[2],Chitra Shankar Krishnan[3], Jayakrishnakumar S[4], Azhagarasan NS[5]
Department of Prosthodontics and Implantology
Ragas dental college and hospital, 2/102, East coast road, Uthandi, Chennai- 600119, Tamilnadu, India
Corresponding author: Hariharan Ramakrishnan , abcv2005@yahoo.com

Abstract
Background: *One of the most serious problems with silicone soft liner is bondfailure between the liner and theheat polymerized acrylic denture base. Since the forces that the liningmaterial clinically exposed to, is closely related to shear and tear test, theshear test is considered an appropriate method for testing bond strength of softliners to denture base resin.*
Aim: *The present in vitro study was conducted tocomparatively evaluate the effect of two different surface treatments on the shearbond strength between silicone soft liner and heat polymerized denture base resinafter thermocycling* ***Materials And Methods****: Thirty threeheat cure acrylic blocks of14mmx14mmx25mm were prepared and randomlydivided 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 wasdesignated as test surface. Group A test surfaces were left untreated (Control),Group B were airabraded and Group C were laser irradiated. Only one representativetreated test surface of the sample from each group was subjected to 3-D surface textureanalysis 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 inuniversal testing machine. One representative debonded sample from each groupwas qualitatively analysed for mode of failure using scanning electron microscope.The results were tabulated and statistically analysed using ANOVA and post-hocTukey's HSD analysis (P value < 0.05 considered significant).* ***Results:*** *Surfacetexture analysis revealed well defined peaks and valleys for both sandblasted(l.40µm) and laser irradiated (1.59µm) groups compared to control (0.449µm).Laser irradiated group exhibited the maximum and significantly higher 'shear bondstrength (0.553513Mpa) compared to airabrasion (0.495116Mpa) and control(0.320557Mpa) groups. Control group showed significantly less bond strength(0.320557Mpa). SEM analysis revealed mixed type of failure for all three groups.Group A exhibited a predominantly adhesive pattern of failure, whereas Groups Band C exhibited a predominantly cohesive pattern of failure.*
Conclusion*: Surfacetreatment by airabrasion and laser irradiation increases the surface roughness ofacrylic resin and also significantly improves the shear bond strength compared tountreated surfaces.*
KeyWords: dental materials, synthetic resins, dental air abrasions, lasers, denture liners, shear strength,scanning electron microscopy.

Date of Submission: 17-10-2019 Date of Acceptance: 02-11-2019

I. Introduction

Prevention and treatment of soreness from removable dentures with preservation of supporting structures is the goal of prosthodontics [1,2,5,6,]. 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 afterimplant surgery [4,9]. The ideal properties for a soft liner include, resilience, tear resistance, viscoelasticity, biocompatibility, adhesive bond strength, low solubility andlow 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 [5,10,11].

Short term resilient liners are used intraorally for a period of upto thirtydays and also called as temporary soft liners. Liners intended to be used overa period of 1-6 months are categorized as intermediate liners and are mainlyused when pre-prosthetic surgery is not indicated but the patient presentswith bony undercuts or knife- edge ridges [9,12]. Long term soft liners arethose that are intended to function for a longer period and are indicated insituations when pre-prosthetic surgery is not indicated, but the patient hassignificant bony undercuts [13].Soft or resilient liners can also be classified as room temperaturevulcanized(RTV) and heat temperature vulcanized (HTV). These can befurther divided into 4 groups according to their chemical structure: a)plasticized acrylic resin, b) vinyl resin, c) polymethane and polyphosphazinerubbers (d) silicone rubbers [3,14].

Silicone-based resilient lining material is similar in basic compositionto silicone impression materials as both are dimethylsiloxane polymers[15].Polydimethylsiloxane is a viscous liquid that can be cross-linked to form arubber with good elastic properties. Softness of these liners is controlled bythe amount of cross-linking in the rubber and no plasticizer is necessary toproduce a softening effect with this material [8]. Silicone liners have beenreported to keep their softness for longer periods than acrylic resin liners [4].Silicone liners have little or no chemical adhesion to PMMA resinsand an adhesive is supplied to aid in bonding the liner to the resin denturebase. One of the concerns with these materials is bond failure between theresilient denture liner and denture base. Bond failure creates a potentialsurface for bacterial growth, and plaque and calculus formation [16,17]. Avariety of parameters affect the bond between resilient lining materials andthe denture base including water absorption, surface primer use,and temperature changes [4,5,18,19]. In vitro studies on the bondstrength between softliners and denture base resin have focused on eithertensile and/or shear bond strength testing. In this study we had included 3D surface profilometery as a study parameter apart from scanning electron microscopy analysis.

Fluctuations in temperature, as encountered in the oral cavity, can influencea material's mechanical and physical properties, especially the bond strength. As such, the thermocycling process conducted in *invitro* studies, cangive useful data on the longevity of soft denture liners with respect to bondstrength under conditions that simulate clinical usage. The effect ofthermocycling on the tensile bond strength ofdenture liners has been widelyreviewed [5,22,24]. Adequate data on the effect of thermocycling on the shear bond strength of soft liners is lacking which is more critical thantensile loading, as shear bond strength can also impact the tensile bondstrength [2].

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

Hence, the aim of this present in-vitro study was to comparativelyevaluate the effect of laser surface treatmentwith that of the conventionalsurface treatment by air-abrasion on theshear bond strengthbetween chairsidesilicone soft liner and heat polymerized denture base resin afterthermocycling. The null hypothesis for the present study was that differentsurface treatments will not significantly affect the shear bond strengthbetween these materials.

II. Materials And Methods

An invitro 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 14mmxl4mmx25mm **(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 x14mm surface of each resin block was designated as the test surface for subsequent surface treatment and liner bonding procedures.

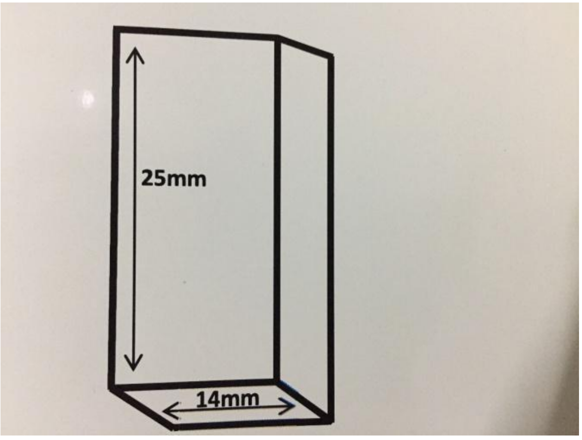


FIGURE 1 - SCHEMATIC DIAGRAM OF STAINLESS STEEL BLOCK

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

The resin blocks thus obtained were randomly divided into threegroups of eleven blocks each, according to the type of surface treatment tobe 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 henceno surface treatment was performed on these test surfaces. These untreatedsamples 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 abrasionusing 110μm aluminium oxide (Korox, Bego, Germany), by holding theblocks at a distance of 10mm from the nozzle, maintaining the pressure at2psi for a period of 30 seconds, with the test surface facing the nozzle. Theywere then cleaned using a steam cleaner. Treated samples were stored in anair 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 **(Fig-2**), (Waterlase iplus laser unit,Biolase Technology, CA, USA). Laser irradiation was done at thewavelength of 2.78μm, pulse duration of 700ps and repetition rate of 10Hz.

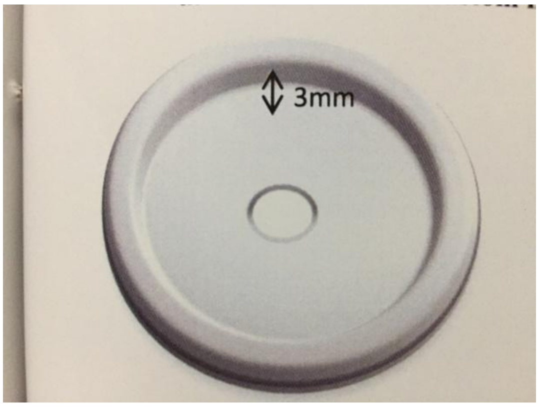


FIGURE 2 - CUSTOM MADE TEFLON JIG- FITTING SURFACE

The power output was set at 3W. The air and water sprays from thehandpiece were adjusted to a level of 85% air and 85% water to prevent theacrylic surface from overheating. Laser energy was delivered through afibre-optic system to a sapphire tip terminal 600 pm in diameter and 6mmlong. The focused laser beam was aligned to the test surface perpendicularlyat a distance of 10mm. The test surface was lased manually in a circularmotion for a period of 30 seconds. The surface treated samples were storedin an air tight container to prevent contamination prior to application ofsilicone liner. One surface-treated acrylic resin block from each test group wassubjected to surface topography and surface roughness analysis using 3-Dprofilometry (TalysurfCCI, Ametek, UK**), (Fig -3).**The surface roughness (Ra) valueof each acrylic block was obtained. The magnification of the optical lenswas 50x. Each acrylic block was placed under the objective lens andphotomicrographs at 50xmagnification were obtained in advanced 3- Dviews using Advanced Aspherics Analysis software.(**Fig - 4,Fig-5, Fig -6)**

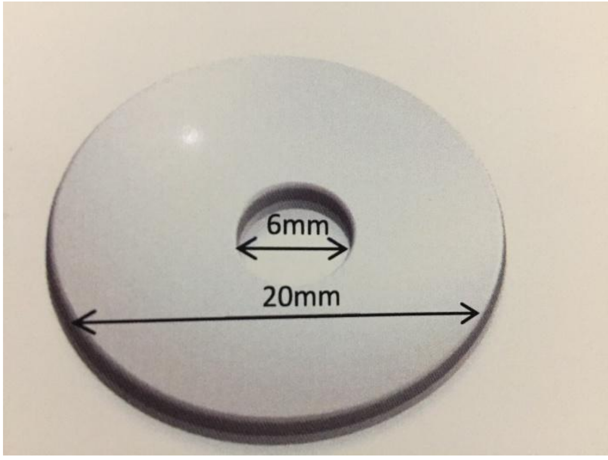


FIGURE 3 - CUSTOM MADE TEFLON JIG – SUPERIOR SURFACE

FIGURE 4 - ASSEMBLY OF ACRYLIC RESIN BLOCK AND TEFLON

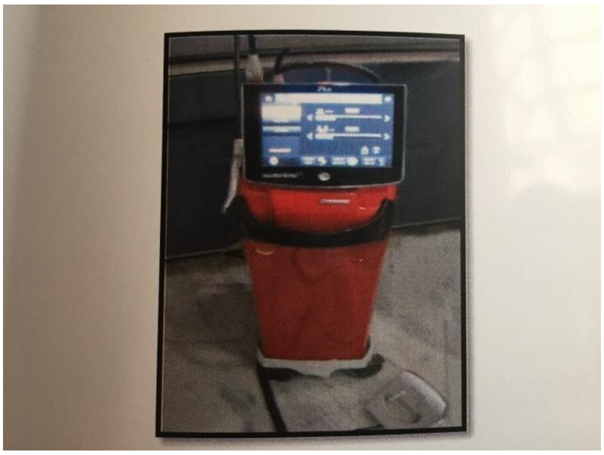
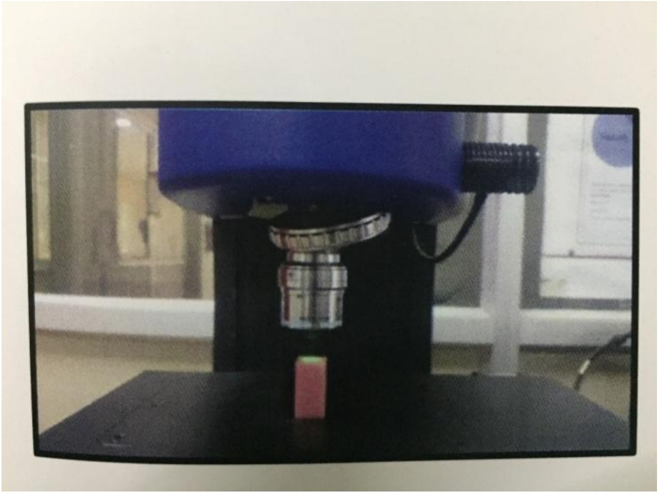


FIGURE 5 - Er, Cr,YSGG LASER UNIT

FIGURE 6- PERFORMING SURTACE TEXTURE ANALYSIS WITH 3D PROFILOMETER



The remaining surface treated ten resin blocks of each group were usedfor bonding with the silicone liner and further shear bond strength testing.The test surfaces of all the acrylic resin blocks of each test group werecoated once with primer (GC liner, Germany). Each coating was applied tothe test surface using an applicator with an application time of 30 seconds asper the manufacturer’s instructions. Care was taken such that there was nocontamination of test surface after application of the primer.

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

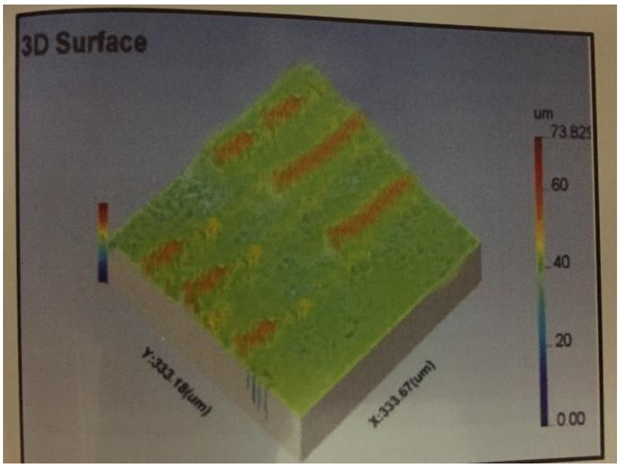


FIGURE 7- 3D SURFACE TEXTURE ANALYSIS PHOTO OF GROUP A (CONTROL)

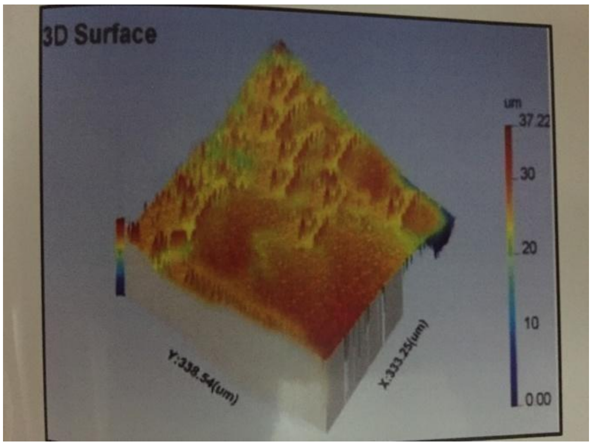


FIGURE 8 -3D SURFACE TEXTURE ANALYSIS PHOTO OF GROUP B (AIR ABRASION)

One block at a time was assembled with the custom-made Teflon jigdescribed before. The design of the jig was such that the resin block fittedsnugly into the indentation present in the fitting surface of the cylindrical jig.**(Fig-9)** Thus, the assembly served the dual purpose of delineating theshape and size of the bonding area and preventing the soft liner fromcontacting the acrylic resin surface outside the circular bonding area.

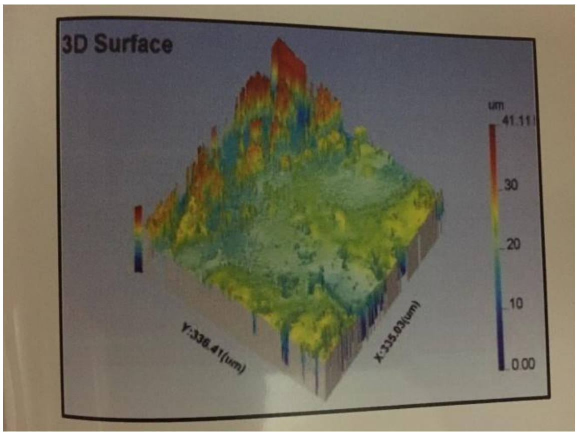


FIGURE 9 -3D SURFACE TEXTURE ANALYSIS PHOTO OF GROUP C (LASER IRRADATION

The silicone-based soft liner (GC liner, Germany), supplied incartridges was mixed using a hand held auto-mixing device(GC liner,Germany) and was introduced gently from one end into the bonding area toavoid air entrapment till the material completely filled the central hole. Anacetate sheet was placed over the material and finger pressure was applieduntil polymerization was completed. A working time of 2 minutes andsetting time for 5 minutes was followed. After the soft liner had set, theacetate sheet and the Teflon jig were removed to obtain a test sample ofacrylic resin surface bondedwith silicone based soft liner as per thespecifications previously mentioned. This process wascarried out for all theresin blocks to obtain 30 test samples, with ten test samples per group.

All the test samples of the three test groups were subjected tothermocycling for a total of 250 cycles in a distilled water bath between 5°Cand 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. The testsamples of each group (n=10) were tied in a cloth pouch and the three sets ofpouches were collectively thermocycled in the apparatus. Upon completionof thermocycling, the specimens were stored under distilled water in theirrespective containers until they were subjected to shear bond strength testing.

FIGURE 10- THERMOCYCLING UNIT

Each test sample was tested individually for shear bond strength in aUniversal Testing Machine **(Fig -11),**(Instron, Llyod instruments, UK). The testsample was fixed to the sample fixture at the bench vice of the machine witha knife edged chisel blade positioned parallel to the material interface. Forcewas applied to the sample in such a way that shear load was exerted directlyto the bonding interface at a cross head speed of 1 mm/min until failure ofthe bond occurred. The tests were conducted in an open room at roomtemperature. Shear bond force at which the bond failed was recorded innewton (N) and shear bond strength (MPa) was calculated by dividing theforce (N) at which failure of the bond occurred by the surface area ofadhesion (mm^2**).[36]**

FIGURE 11 - SHEAR BOND TESTING OF TEST SAMPLES

Bond Strength (MPa) =Force (N) /surface area (sqmm)

Surface analysis of the tested specimens was carried out usingscanning electron microscope**(Fig-12**),(SA400N, Canada), to assess themode of thefailure.Samples were examined under 100x magnification to qualitativelyassess the surface topography of debonded samples of each test group.(**Fig-13, Fig-14, Fig-15).**

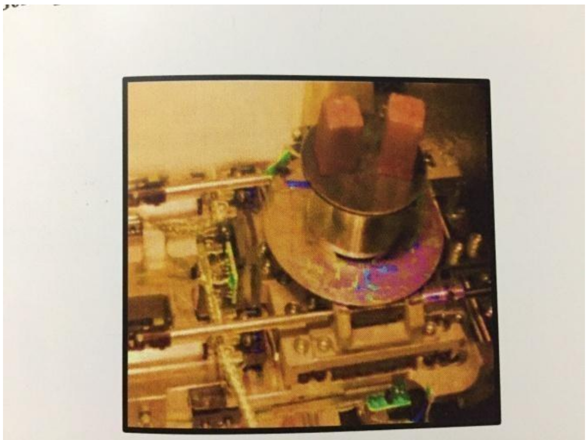


FIGURE 12 - SURFACE ANALYSIS OF DEBONDED SPECIMEN USING SCANNING ELECTRON MICROSCOPE

FIGURE 13- SEM PHOTOMICROGRAPH OF DEBONDED SAMPLE FROM GROUP A (CONTROL)

FIGURE 14- SEM PHOTOMICROGRAPH OF DEBONDED SAMPLE FROM GROUP B (AIR ABRASION)

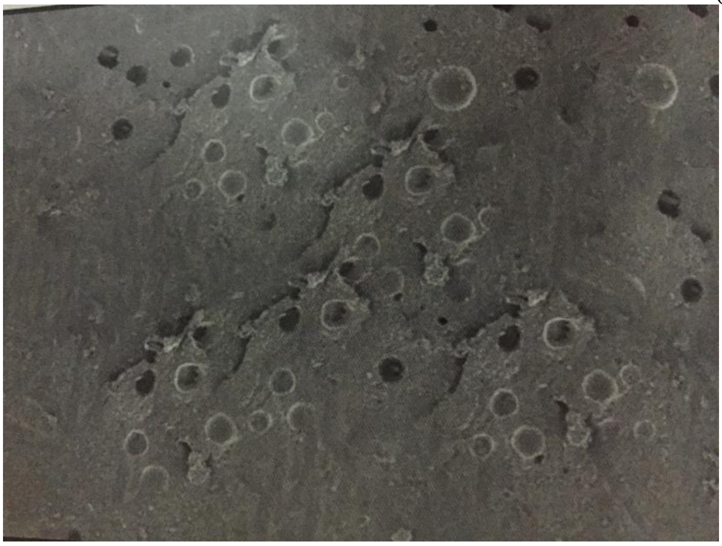


FIGURE 15 - SEM PHOTOMICROGRAPH OF DEBONDED SAMPLE FROM GROUP C (LASER IRRADIATION)

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 pair-wise multiple comparisons were done by Post-Hoc test (Tukey's HSD Analysis). (p value < 0.05 was considered significant

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)

Groups	Mean shear bond strength (Mpa)	Standard Deviation	'p' Value
A	0.32	0.042	0.000*
B	0.50	0.056	
C	0.55	0.029	

Note: 'p' value < 0.05 denotes statistical significance.

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

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

Groups	Mean shear bond strength(MPa)	'p' Value
Group A	0.32	0.00
Group B	0.50	
Group A	0.32	0.00
Group C	0.55	
Group B	0.50	0.01*
Group C	0.55	

'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 polyvinylchloride [11]. 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 ofacrylic denture base to silicone soft liner. They can be broadly categorizedinto mechanical and chemical modifications or a combination of both[2].Mechanical methods are reported to produce an improvement in bondstrength [6,7,12,17,20].

Among these methods, air abrasion involves spraying a stream ofaluminium oxide particles against the material surface intended for bondingunder high pressure, since alumina particles employed producemicromechanical retention by producing surface irregularities. Aluminiumoxide of various particle sizes has been employed to enhance the bondbetween the silicone based soft liner and denture base resin [7, 12, 28]. Therole of sandblasting in improving the bond strength between soft liners andacrylic resin remains controversial and has been recommended for furtherinvestigation in the previous studies [2,6,7,22,23].

Recently, lasers have been found to provide relatively safe and easymeans of altering the bonding surface of materials. It has been indicated inone study that Er,Cr:YSGG laser treatment **(Figure 4)**may significantlyenhance the shear bond strength between silicone soft liner and denture baseresin . However, literature using Er,Cr:YSGG laser as a surface modificationmethod of denture base to yield better bond strengths is sparse[17].The bond strength of the liner-denture base interface has beenresearched extensively by some authors. Al-Athel et al studied the variousbond strength assessment methods, namely, peel test, tensile bond strengthand shear bond strength between the liner-denture base interfaces [29]. Heconcluded that shear forces best represent the oral conditions in which theliner functions. Hence shear bond strength of the material is more indicativeof its clinical longevity. The peel test is believed to simulate the horizontalcomponent of masticatory forces as it causes lateral displacement of thedenture. Tensile test on the other hand predominantly represents the verticalcomponent of the masticatory forces.

It has also been pointed out that tensile failure was not caused bytensile forces alone because some shear forces also developed during tensiletesting. This specially stands true in case of silicone lining material whichhas a high Poisson ratio. These materials undergo a reduction in crosssectional area on tensile load application, whereas, the bonded portion of theliner maintains a constant area. This induces shear forces at the margins ofthe bonded interface.

Since soft denture liners function in an aqueous oral environmentunder rapidly changing temperature conditions, the impact of these twoparameters on the bond strength is also important while conducting bondstrength tests in-vitro. Thermocycling of test samples prior to testing of bondstrength is done in in-vitro studies to assess the impact of these parametersand mimic oral conditions.

Cyclic thermal stress causes shear stress at the bonding interface, as itprovokes repetitive shrinkage and expansion and results in a difference ofthermal volumetric change between denture base and soft denture liner.During thermocycling, soft denture liner absorbs large amount of waterwhich may result in hydrolytic degradation of the bond due to waterdiffusion into the interface [2,19,22,23,24,30,31,32].

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

Heat cure acrylic denture base resin was the material employed forobtaining the test resin blocks since PMMA is the most widely used denturebase material clinically and has been considered as an near-ideal material forthis purpose [23,33]. The test blocks were fabricated and stored as perstandard protocols [33].

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 aluminium oxide has been employed inthe literature. Sandblasting the denture base area with 50μm could onlyremove the surface glaze on the denture base area but had no significanteffect in improving the bond strength between the denture base resin andsoft liner. Most of the studies reported that grit size in the range of 110-120μm Aluminium oxide particle is adequate to improve the bond strength[12,34]. Hence in the present study, Aluminium oxide of 110 μm waschosen for this type of surface treatment. Laser irradiation was carried outusing Er,Cr:YSGG[17].

3-D surface profilometry was carried out for all the threetypes of test surfaces (Untreated, Sandblasted and Laser irradiated) to assessthe surface topography and roughness of these surfaces, since it may aid ininterpretation of the test results as reported in a previous study [35]. Surfaceroughness (Ra value) is the arithmetic average deviation of surface valleysand peaks expressed in microns and are a measure of the finer surfaceirregularities in surface texture.

The surface texture analysis of one respective sample of each testgroup revealed that surface treatment by bothairabrasionas well as laser irradiation increased the surface roughness values (Ra - 1.40μm and Ra - 1.59μmrespectively), compared to that of the untreated surface (Ra - 0.449μm). Thesurface topography of the treated specimens also exhibited pronouncedpeaks and valleys indicative of a roughened surface. These peaks and valleysare more evenly distributed for the laser irradiated sample. This was incontrast to the sparse and poorly distributed peaks and valleys seen in theuntreated sample.

The silicone liner application was done only for the designated testsurfaces of each test block in the form of cylindrical columns of 3mm heightand 6mm diameter based on similar procedures followed in previous studies[16, 32, 36,]. A custom-made Teflon jig was fabricated to achieve thispurpose to obtain silicone liners of uniform dimensions on each test block.Since the Teflon jig was milled, it obviated the need for making individualtemplates for bonding as used in source previous studies. Additionally,Teflon being an inert material does not react with the liner employed in thisstudy and also facilitated easy retrieval of the test samples after the bondingprocedure.In the present study, a small thermocycling period simulating threemonths of clinical use was employed.

The test specimen interface resembled a clinical scenario of a singlesoft liner-denture base interface, along which parallel shear forces could beapplied to evaluate the shear bond strength. The load at which the bondfailed under shear stress was recorded in Newton (N) and was taken as ashear load value of the particular sample. The shear bond strength values inMPa were obtained bydividing the shear load values (N) by the crosssectional area of bonding. In the present study, since the bonding wasconfined to a circular area of 6mm diameter, the cross-sectional area wascalculated using the formula r^2 (area of a circle). The bonding area of thespecimens was around 28.274 mm which was used to calculate thebondstrength.

In a previous study by the Jacobson NL et al, both laser treatment aswell as sandblasting surface treatments were shown to be ineffective inreducing the adhesive failure between soft liner and acrylic resin. This couldbe attributed to the CO_2 laser used in that study in contrast to theEr,Cr:YSGG laser employed in the present study [7], which could haveyielded the superior results here. Further, the significant improvement bysandblasting observed in the present study compared to that obtained in thestudy 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 acrylic surfaces treated withlaser irradiation and sandblasting on the peel strength between silicone softliner and denture base resin [17]. They reported a significant increase in peelstrength values when surface was treated with laser irradiation than withsandblasting. The results obtained in the present study are in line with thoseobtained for shear bond strength in that study, which has also shown thatlaser irradiation, could significantly improve the shear bond strength of thetest samples. The type of laser used in the present study and by Korkmaz FMet al in their study was also Er,Cr:YSGG. Since the peel strength resultsobtained in Korkmaz FM et al are in correlation with the shear bond strengthresults obtained in the present study, it can be said that the type of laser usedmay also impact testresults.

Since studies on the effect of laser surface treatment on shear bondstrength between silicone liner and denture base resin are lacking, furtherdirect correlation with the results of the present study cannot be obtained.Air abrasion by sandblasting is said to improve the surface roughnessby providing an irregular surface for the mechanical locking of the softmaterial and is said to be the cause of improved bond strength [2,7].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 bondinterface resulting in bond failure [6,23,24,25,26]. However, most of these bondstrength studies are either peel or tensile strength stress tests. Studies comparing the effect of surface treatment with sandblasting on the shearbond strength are few [2,20]. In a study, surface treatment by sandblastingresulted in significantly higher shear bond strength values between silicone soft liner and acrylic denture base resin as compared to the untreated orcontrolled samples. The results obtained in the present study are in linewith those obtained in the above studies.

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

The direct correlation between surface texture analysis and shear bondstrength improvements obtained in the present study further validate thispoint and hence this investigation can be included in future similar studies.SEM analysis of one representative debonded test sample of eachtest group was done to correlate the shear bond strength testvalues with the SEM observations of the debonded interface as done inpreviousstudies [1,2 3,4,5,8,16,21,36,].

SEM analysis of the debonded representative one specimen revealed a mixed type offailure for test groups. The untreated surfaceexhibited a predominant adhesive pattern within the mixed mode of failure.There was more of visible resin surface, with the sparsely distributed linermaterial. Both surface treated samples exhibited a cohesive pattern withinthe mixed mode of failure. There were several patches of silicone liningmaterial distributed over the resin surface. This was more pronounced in thelaser irradiated sample which showed greater cohesive pattern compared tothat observed for the sandblasted group.

This observation for the laserirradiated sample is in line with those observed by Jacobson et al, who foundthat a majority of laser treated specimens experienced cohesive pattern offailure [7].The types of failures observed under SEM in previous similar studies[1,2,3,7,8,16,] revealed that silicone liners showed different failurepatterns under different testing conditions. The type of bond strength testing(whether peel, tensile or shear), mode of surface treatment rendered, etc. canimpact the mode of failure, and this could have resulted in the differentmodes of failures observed. Previous studies have revealed a cohesivepattern of failure for silicone liners bonded to acrylic resin, which is in linewith the SEM observations of the present study [1,2,7,16,]. Furtherinvestigations are recommended to arrive at the exact mode of failurebetween silicone liners and acrylic resins following shear testing.

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

Hence, it can be recommended that surface modification of acrylicresin prior to bonding with chair-side silicone soft liner should be carried outpreferably for better clinical outcomes. The choice of surface treatmentsbetween sandblasting and laser irradiation can be based on availability andoperator's preference, though laser irradiation yield better results.

V. Limitations

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

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 shear bond strength between silicone soft liner and heat cure denture base resincompared to untreated surfaces.
2) Laser irradiation showed significant andhigher bond strength values as compared to those obtained by airabrasion.

References

[1]. **Amin WM, Fletcher AM, Ritchie GM.** The nature of the interface between polymethyl methaacrylate denture base materials and soft lining materials. J Dent. 1981 Dec; 9(4):336-46.

[2]. **Anshul khanna, Bhatnagar VM, Karani JT, Madria K, Mistry S.** Acomparative evaluation of shear bond strength between twocommerciallyavailable heat curesd resilient liners and denture baseresin with different surface treatments. Journal of Clinical and Diagnostic Research,2015 vol-9(5).

[3]. **Aydın A.K, Terzioglu H, Akinary AE, Ulubayram K, Hasirci N.** Bond strength and failure analysis of lining materials to denture resin.Dent Mater J. 1999 May; 15(3):211-8.

[4]. **Botega Daniela Maffei, sanchez JLL.** Effects of ThermoCycling on the Tensile Bond Strength of Three Permanent Soft Denture Liners. J Prosthodont. 2008 Oct;17(7):550-4.

[5]. **Geramipanah farideh, Ghandari M, Zeighami S**. The effect of thermocycling on tensile bond strength of two soft liner. J Dent :2013;10-5.

[6]. **Hemchand surapaneni, Ariga P, Haribabu R.** Comparative evaluation of tensile bond strength between silicon soft liners and processed denture base resin conditionedby three surface treatment. JIndian Prosthodont Soc 13(3)274-280,2013.
[7]. **Jacobson nancy L, Mitchell DL, Johnson DL, Holt RA.** lased and sandblasted denture base surface preparation affecting resilient liner bonding. J ProsthetDent 1997;78:153-8.
[8]. **Sarac Duygu, Sarac YS, Basoglu T, Yapici O, Emir Y**. The evaluation of microleakage and bond strength of a silicone-basedresilient liner followingdenture base surface pretreatment. J ProsthetDent. 2006 Feb; 95(2):143-51.
[9]. **Fujii Koichi.** Mechanical Properties and Bond Strength of Siliconebased Resilient Denture Liners. Dent Mater J. 2005 Dec; 24(4):667-75.
[10]. **Anupama Prasad D, Prasad R, Shetty V.** Tissue conditioners: A review. NUJHS vol.4, Jun 2014.
[11]. **Craig RG, Gibbons P, Arbor A, Mich**. Properties of resilient dentures liners. J Am Dent Assoc. 1961 Sep; 63:382-90.
[12]. **Akin Hakan, Tugut F, Mutaf B, Guney U, Ozdemir AK.** Tensile bond strength of silicone-based soft denture liner to two chemically different denture base resins after various surface treatments: Lasers Med Sci 2012 ,Mar 25.
[13]. **Garcia Lily T., Jones John D.** Soft liners. Dental Clinics of North America 2004 July: 48(3):709-720.
[14]. **Lau Mayank, Amaranth GS, Swetha MU.** Tensile and shear bond strength of hard and soft denture relining materials to the conventional PMMA: An In-vitro study.J Int Oral Health 2014; 6(2):55-61
[15]. **Mahajan Neerja, Datta K.** Comparison of Bond Strength of Auto Polymerizing, heat cure Soft Denture Liners with Denture Base Resin – An In Vitro Study. J Indian Prosthodont Soc. 2010 Mar; 10(1):31-35.
[16]. **Azevedo Andrea, Machado L, Giampaolo ET, Pavarina AC, Vergani CE.** The Effect of Water Immersion on the Shear BondStrength between Chair sideReline and Denture Base Acrylic Resins.J Prosthodont. 2007 Jul-Aug;16(4):255-62.
[17]. **Korkmaz FM, Bagis B, Ozcan M, Durkan R, Turgut S, Ates SM.** Peel strength of denture liner to PMMA and polyamide: laser versusair-abrasion. J Adv Prosthodont.2013; 5:287-295.
[18]. **Kulak-Ozkan Yasemin, Sertgoz A, Gedik H.** Effect of thermocycling on tensile bond strength of six silicone-based, resilient denture liners.J Prosthet Dent. 2003 Mar; 89(3):303-10.
[19]. **Leon Blanca Liliana Torres, Cury A, Garcia R.** Water sorption, solubility, and tensile bond strength of resilient denture lining materials polymerized by different methods after thermal cycling. J Prosthet Dent. 2005 Mar; 93(3):282-7.
[20]. **Jagger Robert G, Al-athel MS.** Effect of test method on the bond strength of a silicone resilient denture lining material. J Prosthet Dent 1996;76:535-40.
[21]. **Elias Carlos Nelson, Henriques FQ.** Effect of thermocycling on the tensile and shear bond strengths of three soft liners to a denture base resin. J Appl Oral Sci 2007 Feb: 15(1):18-23.
[22]. **Madan Nishitha, Datta K.** Evaluation of tensile bond strength of heat cure and autopolymerizing silicone-based resilient denture liners before and after thermocycling. Indian J Dent Res. 2012 Feb 23(1), 2012: 64-68.
[23]. **Minami Hiroyuki, Suzuki S, Minesaki y .** Effect of SurfaceTreatment on the bonding of an Autopolymerizing Soft Denture Linerto a Denture Base Resin. Int J Prosthodont. 2004 May-Jun; 17(3):297-301. Journal of Clinical and Diagnostic Research 29
[24]. **Nagarsekar A, Aras M** . Evaluation of the effect of denture basesurface treatment on tensile bond strength of RTV Silicone soft dentureliners - JIDA, Vol 7 - Issue 1 – January2013.
[25]. **Noegroho Waloejo, .** The change of temperature on the shear strengthofpermanent soft-liner on acrylic resin. Dent. J ,Vol 39 ,No2 Apr-June 2006: 77-79.
[26]. **Takahashi Yutaka.** Shear Bond Strength of Denture Reline Polymersto Denture Base Polymers. Int J Prosthodont. 2001 May-Jun;14(3):271-5.
[27]. **The Glossary of Prosthodontic Terms 8th edition** – The Academy of Prosthodontics 2005, by the Editorial Council of Journal of Prosthetic Dentistry.
[28]. **Kawano Fumiaki, Bagis B, Ozcan M,.** Comparison of bond strength of six soft denture liners to denture base resin. J Prosthet Dent. 1992 Aug; 68(2):368-71.
[29]. **Al-Athel, Jagger R, Jagger D .**Effect of ageing on the bond strength of a permanent denture soft lining material. J Oral Rehabil. 2002 Oct; 29(10):992-6.
[30]. **Neppelenbroek Karin Hermana, Pavarina AC, Gomes MN,Machado AL, Vergani CE.** Bond Strength of Hard Chair Side RelineResins to a RapidPolymerizing Denture Base Resin before and afterthermal Cycling. J. Appl. OralSci. 2006 Dec; 14(6):436-42.
[31]. **Saloni gupta.** Effect of surface treatment on the flexural strength ofdenture base resin and tensile strength of autopolymerizing siliconebased denture liner bonded to denture base resin. J of Ind Prosthodont Soc 10(4):208-212,2010.
[32]. **Takahashi Yutaka, Chai J.** Assessment of Shear Bond Strength Between Three Denture Reline Materials and a Denture Base AcrylicResin. Int J Prosthodont. 2001 Nov-Dec; 14(6):531-5.
[33]. **Anusavice KJ.** Phillips' Science of dental materials, South Asia edition. 13th ed Saunders: Elsevier; 2003:168-171, 513-14.
[34]. **Parr Gregory.R.** In vitro hardness, water sorption, and resin solubilityof laboratory processed and autopolymerized long-term resilientdenture liners overone year of water storage. J Prosthet Dent. 2002Aug; 88(2):139-44.
[35]. **Mohammed Salah A, Hassen KS.** Evaluation of some properties of four silicon based soft denture reliner materials. J Bagh College of Dentistry Vol 23(2), 2011:36-42.
[36]. **Anip K Roy, Dennis Mohan, M Sunith,Rashmi B Mandokar,S Suprasidh, SoumyaRajan.** Journal of contemporary dental practice, Oct 2017;18(10):881- 886.

Sree Varun M, Ramakrishnan H "Comparative Evaluation of the Effect of Different Surface Treatments on Shear Bond Strength between Silicone Soft Liner and Denture Base Resin – Three Dimensional Study." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 11, 2019, 24-34.