Journal of Applied Dental and Medical Sciences
NLM ID: 101671413 ISSN:2454-2288
Volume 2 Issue4 October- December 2016

Original Article

The effect of surface pretreatments on the bond strength of Soft denture lining materials to heat polymerized Polymethyl methacrylate (PMMA) denture base resin- an in vitro study

S.K.Vishwanath [1], D.R.Prithviraj [2] , K.Sounder Raj [3] , Akash Patel [4], Shruti Saraswat[5]

[1] *Associate professor, Department of Prosthodontics, Government Dental College and Research Institute, Bangalore.*
[2] *Dean cum Director,Government Dental College and Research Institute, Bangalore*
[3] *Head of Department ,Department of Prosthodontics,Government Dental College and Research Institute, Bangalore*
[4] *Post graduate trainee, Department of Prosthodontics,Government Dental College and Research Institute, Bangalore*

ARTICLE INFO

Keywords:
soft liner, poly methyl methacrylate(PMMA), tensile bond strength, air abrasion, acid etching.

ABSTRACT

Background and objectives: This in vitro study was undertaken to evaluate the effect of air abrasion and acid etch surface pretreatment of denture base resin on tensile bond strength of two long term resilient liners.
Method: A total of 120 heat cure PMMA resin blocks were prepared for producing 60 PMMA specimens with soft liner in between two blocks. The study comprised of 60 specimens divided into 3 groups. Each group containing 20 specimens. GROUP I- air abrasion with 50-µm Al_2O_3 particles (Abrasion group). GROUP II- 36% phosphoric acid etching (acid group). GROUP III-Control Group. Each group was divided into two subgroups. Subgroup A was relined by Molloplast B and Subgroup B was relined by Ufi Gel P. Tensile bond strength was tested using universal testing machine.
Results and conclusions: Among the soft liners tested for tensile bond strength, it was found that tensile bond strength was highest for acid etching and lowest for air abrasion group. Mean bond strength of Molloplast B was significantly higher than Ufi Gel P in various surface treatment groups.

Introduction

Soft denture lining material is defined as a polymeric material that is placed on the tissue-contacting surface of a denture base to absorb some of the mastication impact energy by acting as a type of "shock absorber" between the occlusal surfaces of a denture and the underlying oral tissues. A denture soft liner also may be used to engage natural or prosthetic undercuts so as to provide retention, stability and support. As masticatory forces are directly transmitted to the underlying tissues through the denture, the residual ridge becomes burdened with increasing years of edentulism, diminishing the shock absorbing capacity of the mucosa. A soft liner is suggested to compensate for the lost thickness and function of the mucosa.[1,2] These liners are most commonly indicated in patients who are unable to tolerate the pressure transmitted by the prostheses because of thin mucosa or severe alveolar ridge resorption. Additional applications have emerged in the past few years viz. fabrication of obturators, for

* *Corresponding author:* ***Dr.Akash Patel,12/harivilla bunglows, Nr J.K.park,Gota road, chandlodia, Ahmedabad. Gujarat-382481.E-mail: akash25490@gmail.com, Mobile no: 9904523067, 8105695858.***

Groups	Sample size	Sum	mean	Variance
Air abrasion	10	12.955	1.2955	0.0001
Acid etching	10	15.281	1.5281	0.0016
control	10	14.757	1.4757	0.0007

Table 1: Mean tensile bond strength and variance of Group A1, Group B1 and Group C1

Mean values of tensile bond strength was highest for acid etching group and lowest for air abrasion group.

Groups	Sample size	Sum	mean	Variance
Air Abrasion	10	4.431	0.4431	0.0026
Acid etching	10	7.511	0.7511	0.0013
Control	10	6.282	0.6282	0.0025

Table 2: Mean tensile bond strength and variance of Group A2, Group B2 and Group C2

Mean values of tensile bond strength was highest for acid etching group and lowest for air abrasion group.

transitional prostheses during the healing phase of osseointegration and for retention of implant-supported overdentures.[2]

Tensile and shear forces during function affect the longevity of soft liner. They can cause debonding of softliner from denture base. Factors which can affect the bond strength between lining material and acrylic resin include geometry of bond surface whether it is surface pretreatment of denture base resin, thickness of the lining material, water absorption, use of bonding agents and denture base composition.[3]

Lammie and Storer classified the processed resilient materials as follows.

1. natural rubber, 2. polyvinylchloride, 3. polyvinylacetate, 4. methyl methacrylate copolymer, and 5. silicone.[4]

Silicone soft liners basically consist of polydimethylsiloxane polymer to which fillers are added to obtain the correct consistency. The material hardens by cross linking process. Being a polymer, this cross linking can be achieved either by heat, using benzoyl peroxide or at room temperature using tetraethyl silicate. Silicone materials remain resilient for longer time when compared to acrylic liners as they are devoid of plasticizers. In addition they have greater cross linking and higher bonding capacity to the fillers. Silicone soft lining materials have the advantage of being inherently soft over a long period of time. Moreover with the development of polyvinylsiloxanes similar to those used in dental impression materials the application procedures have been simplified.

Silicone-based soft denture liners have little or no chemical adhesion to denture base resin so, an adhesive primer is used to aid bonding to the denture base resin. Bond strength can be altered by various methods, namely mechanical roughening, chemical treatments and chemico-mechanical treatment. Adequate literature is available regarding mechanical surface roughening of denture bases. But, there is paucity of information about the chemical treatment particularly acid etching.[9,10]

The purpose of present study was to evaluate the effect of mechanical and chemical surface pre treatments on the bond strength of heat polymerized and auto polymerized silicone based

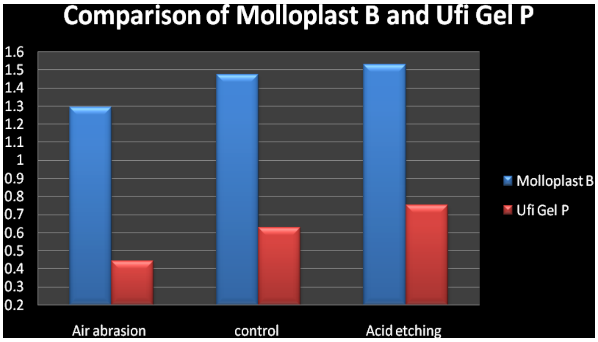

Figure 1: Comparison of tensile bond strength of test specimens in between Molloplast B and Ufi Gel P for all the subgroups.

soft liners to poly methyl methacrylate (PMMA) denture base resin.

Methodology

A heat activated poly methyl methacrylate (PMMA) resin (Trevalon, India); and two resilient liners, Ufi Gel P (Voco, Cuxhaven, Germany) and Molloplast-B (Detax GmbH & Co KG, Germany), were used in this study. Molloplast B is a heat polymerized silicone based resilient liner whereas Ufi Gel P is auto polymerized silicone based liner.

To standardize fabrication of specimens, a machine cut stainless steel master die was prepared and utilized to fabricate a rubber base mold. The dimension of master die was 10×10×40 mm. Four machine cut stainless steel spacers of 10×10×3 mm dimension were prepared. Conventional flasking and compression molding procedure was used to fabricate the resin samples. A total of 120 heat cure PMMA resin blocks were prepared for producing 60 PMMA specimens with soft liner in between two blocks. Samples were randomly divided into 3 groups, each group containing 40 blocks (to fabricate 20 test specimens per group), which were followed by their surface treatment as follows. Group A- airborne-particle abrasion with 50-µm Al_2O_3 for 30 seconds at a pressure of 0.62 MPa from a distance of 1.0 mm (abrasion group); Group B- 36% phosphoric acid (AMD labs, Bangalore) etching for 30 seconds, washed with water under pressure for 30 seconds with an air/water spray, with each surface dried for 20 seconds with an air spray (acid group) and Group C- no surface treatment (control group).

Each surface treated group was divided into two subgroups containing 10 specimens and was lined by Molloplast-B (Subgroup 1) and Ufi Gel P (Subgroup 2). Molloplast B lined specimens were prepared by investing two acrylic resin blocks, separated by a metal spacer of dimension 10×10×3 mm (to standardize the thickness of liner), in a dental flask. Adhesive Primer, supplied with the soft liner, was applied uniformly on surfaces to be bonded and allowed to dry. Molloplast B was then packed into the space generated by the stainless steel spacer using a clean spatula, and the curing was done according to the manufacturers' instructions. Ufi Gel P lined specimens were prepared by investing two acrylic resin blocks, separated by a metal spacer of dimension 10×10×3 mm (to standardize the thickness of liner), in a rubber base material. Adhesive Primer, supplied with the soft liner, was applied uniformly on surfaces to be bonded and allowed to dry. Ufi Gel P was mixed according to the manufacturer's instructions and then placed in between the blocks using a clean spatula. It was allowed to set for 10 minutes and then removed from the mold.

The specimens were subjected to tensile stress on a Universal Testing Machine and deformed using a cross head speed of 5 mm per minute. The load at which failure occurred was recorded. The maximum tensile stress before failure divided by cross sectional area of interface would produce the tensile strength value for the specimen.

$$\text{Tensile bond strength (MPa)} = \frac{\text{Load in Newton}}{\text{Surface area in mm}}$$

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS, V 21) package.

Results

Significant differences were found for the resilient lining materials (P<.01), surface treatments (P<.01), and their interactions (P<.01). A plot of interaction effects is presented in Figure 1, and the mean and variance of the tensile bond strength for each of the experimental groups are presented in Table 1 and Table 2. The tensile bond strength of Molloplast B was significantly higher (P<.01) than that of Ufi Gel P. Significant differences were found among the control, acid etching, and abrasion groups (P<.01). The specimens that were surface treated with abrasion showed a significant decrease in tensile bond strength compared with the control and acid etching groups (P<.01).The highest bond strengths were observed in the acid etching group, and the lowest were observed in the abrasion group.

Discussion

Resilient lining materials must have excellent adhesion to the acrylic resin denture base. Poor adhesion between these two materials can lead to functional and hygiene problems if they detach from each other during use. Even though soft lining materials have been in dentistry for several years, they are still not extensively used, due to the lack of optimal properties.[18] Silicone materials are being extensively used when compared to acrylic liners due to its superior properties. But poor bonding with acrylic denture base is an inherent disadvantage of silicone liners. Thus the present investigation was carried out in search of factors affecting the bonding and methods to improve the bond strength.

An adhesive primer is supplied to aid in bonding to denture base resin because silicone soft liner has little or no chemical adhesion to PMMA denture base resin. Adhesive is MMA / EMA based and act as a solvent that dissolves the PMMA surface. These bonding agents interact with the surface layer of the denture base polymer and the soft liner.

Craig and Gibbons[7] assessed the Tensile Bond Strength (TBS) of resilient lining materials and claimed that 0.45 MPa is an adequate adhesive value for an optimal bond. According to Kawano et al,[14] a bond strength of 0.44 MPa is acceptable for the clinical use of resilient lining materials. Khan *et al.* reported that soft denture liners should have a minimum of 0.44 MPa (4.5 kg/cm^2) bond strength to be acceptable for clinical use.[17]The mean bond strength values recorded for different materials used in the present study are as follows: **Molloplast B 1.433 MPa, Ufi Gel P 0.608 MPa.** Considering the above mentioned criteria, the results of the present investigation indicate that both the soft lining materials used in this study have got satisfactory bond strength for clinical application.

In the present investigation, Molloplast B had higher bond strength than Ufi Gel P. This result is in agreement with those of other authors who reported that heat-polymerized silicone-based resilient lining materials have the greater bond strength compare to auto-polymerized silicone-based resilient lining materials to acrylic resin denture base.[5,8,11,12,13]

Craig and Gibbons[7] reported that a roughened surface enhanced the bond strength and that the adhesive values obtained with a roughened surface were approximately double that of a smooth surface. Usumezet al[20] found that the bond strength of airborne-particle abrasion with 50-µm Al_2O_3 specimens was greater than in a control group, although the difference was not statistically significant. On the contrary, Amin et al[16] and Akin et al[21] reported that roughening the acrylic resin base with airborne-particle abrasion before applying a resilient lining material weakened the bond. They proposed that the lower bond strengths were due to stresses that occurred at the interface of the PMMA/resilient liner junction or that the size of the irregularities created by airborne-particle abrasion medium might not be sufficient to allow the resilient lining material to flow into it. These different results may also be a result of the different particle sizes used.

Jacobsen *et al*[6].have considered the ability of soft lining material to penetrate into the irregularities of the PMMA. The penetration coefficient for liquids into a space is given by:

Penetration coefficient (PC) = $\gamma\cos\theta/2\eta$

Where γ= surface tension, θ= contact angle, η= viscosity.

If this logic is applied to penetration of liners into the irregularities produced by air abrasion, increasing the viscosity of resilient liners for a given contact angle and surface tension reduces the penetration of the liner.[6]This could explain the lower tensile bond strength of sandblasted specimens observed in this study.

Phosphoric acid reactively dissolves hydrocarbons in the polar phosphoric acid phase of hydrocarbon depending on the carbon number and properties of the alkyl group. Hydrocarbons, whether they are aliphatic or aromatic, are quite apolar compared to the very polar phosphoric acid phase. Hydrocarbons may be absorbed by dissolving in the phosphoric acid phase or may react with phosphoric acid in a way to chemisorptions.[24] Since phosphoric acid also increases polarity of hydrocarbon chains of PMMA, adhesion between soft liner and PMMA was increased. The treatment by phosphoric acid introduces surface roughness at the molecular level also. This could explain the higher tensile strengths of the acid etched test specimens observed in this study.

The testing condition could not exactly simulate the clinical condition and oral environment as intra oral salivary composition and quantity may differ from person to person, The effect of saliva on the bond strength of Resilient liner to PMMA was not be evaluated in this study and it requires further studies.

Conclusion

Within the limitations of this study, the following conclusions were obtained:

1. Acid etch treatment (chemical surface pretreatment) of the resin surface enhanced the bonding between the resilient liner and PMMA resin

2. Air abrasion treatment (mechanical surface treatment) of the resin surface reduced the bonding between the resilient liner and PMMA resin
3. Mean bond strength of Molloplast B was significantly higher than Ufi Gel P in various surface treatment groups.
4. Both the materials tested had mean bond strength values greater than the minimum acceptable standard (0.44 MPa) for clinical application.

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