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EFFECTS OF VARIOUS SURFACE TREATMENTS OF HEAT CURE POLYMETHYL METHACRYLATE DENTURE BASES ON THE TENSILE BOND STRENGTH OF SOFT LINERS

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ABSTRACT

Aim: The aim of this study was to determine the bond strength of two soft liners to Heat cure poly methyl methacrylate denture base resins by various surface preparation of resin. **Materials and Methods:** GC Reline soft and soft liner (GC Corporation, Tokyo, Japan) a permanent self cure denture soft lining materials were used in this study. Specimens were prepared by stainless steel dies of 40 mm length, 10 mm wide, 10 mm and a cross sectional area of 10mm x 10mm. The specimen categorized in 2 groups along with 5 subgroups. **Results:** Statistical analysis done was ANOVA and Student 't' test. Bond strength was measured by universal testing machine. Significant difference was found in bond strength of silicon and acrylic including its subgroups. **Conclusion:** From the above study it can be concluded that highest bond strength was seen in the Acrylic group. In matter of best physical surface treatment Silicone group showed Sand papering was better than Sand blasting. In respect to chemical surface treatment, silicone group showed that application of Acetone was better than Methyl Methacrylate. Best combination was seen in the Polymethyl methacrylate to Acrylic soft liner after the Polymethyl methacrylate was treated with Methyl Methacrylate.

KEYWORDS: Methyl Methacrylate; heat cure; soft liner; denture

INTRODUCTION

Soft liners have known to be clinically beneficial in the prosthetic management of atrophic ridge bony undercuts, bruxism and complete denture opposing natural dentition. There are also several disadvantages to the use of the resilient liners, including poor tear strength and poor bond strength with the underlying denture base material. Debonding of soft liners from the denture base is a common clinical occurrence which results in localized unhygienic conditions at the debonded regions.[1] Different tests are developed to evaluate the strength of the material which include tensile strength, shear strength, fatigue, creep, and impact strength. In this study tensile bond strength was used to study the bond of soft liner to denture base resin. The aim of this study was to determine the bond strength of two soft liners to Heat cure poly methyl methacrylate denture base resins by various surface preparation of resin blocks.[2,3] The aim of this study was to determine the bond strength of two soft liners to Heat cure poly methyl methacrylate denture base resins by various surface preparation of resin. The objective was to evaluate the bond strength of 2 soft liners applied on heat cure Polymethyl methacrylate denture base treated by two different physical surface treatments i.e., 80 grit sandpaper, 250 micrometer aluminium oxide sand particles, to evaluate the bond strength of 2 soft liners applied on Heat cure cure Polymethyl methacrylate denture base treated by two different chemical surface treatment i.e., pure acetone, Methyl methacrylate solution and to compare the bond strength of two soft liners applied on Heat cure Polymethyl methacrylate denture base treated by two different physical surface treatment along with determination of bond strength of two soft liners applied on Heat cure Polymethyl methacrylate denture base treated by

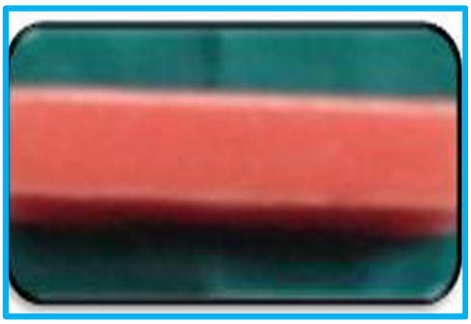

Fig. 1: Wax Block after duplicating in Silicone mould

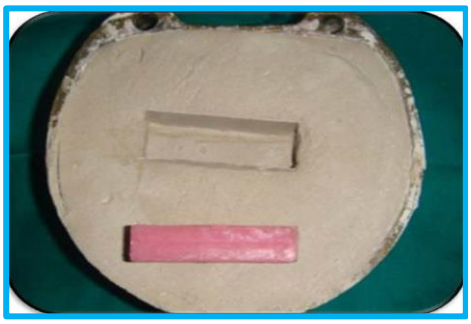

Fig. 2: Heat cure polymethyl methacrylate specimen

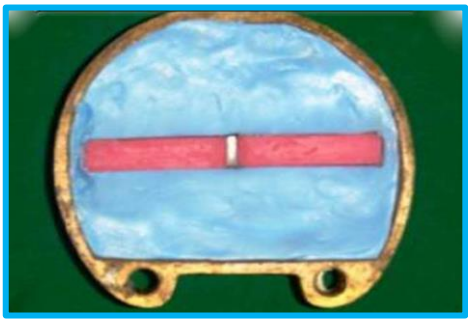

Fig. 3: Acrylic specimen in silicone mold with 3mm metal spacer

two different chemical surface treatment. i.e Pure acetone, Methyl methacrylate solution. Also, to compare and evaluate the efficacy of the surface treatment methods of denture base for obtaining the best bond strength between the denture base and the two soft liners.

MATERIALS & METHODS

GC Reline soft and GC Soft liner (GC Corporation, Tokyo, Japan) a permanent self cure denture soft lining materials were used in this study. GC Reline soft was supplied as gun with automixing tips with GC Reline bonder, a bonding liquid. GC Soft liner was supplied in the form of powder and liquid. All the specimens were prepared by stainless steel dies measuring 40 mm in length, 10 mm in width and 10 mm in height (40 mm x 10 mm x10 mm) and a cross sectional area of 10 mm x 10 mm. A 3 mm thick spacer was also prepared in stainless steel. The dies were duplicated in a flask using silicone based duplicating material (Degufoam). The dies were removed from the flask after the duplicating material hadset. Modeling wax No. 2 (Deepti, India) was melted and poured into the silicone duplicating mold. The wax specimens (Fig.1) were removed from the mold and were flasked. The flask was kept in boiling water for 10 minutes for dewaxing. The flask was separated and all the wax was removed by pouring boiling water over the mould. Separating Medium was applied, (Dental Products of India, India) and was allowed to dry. A second layer of separating medium substitute was applied and allowed to dry. Heat polymerizing polymethyl methacrylate (DPI-RR Heat Cure India) denture base resin was mixed according to the manufacturer's instructions using a powder - liquid ratio of 3:1 by volume in a clean mixing jar and trial packed into the flask. The excess flash was removed after the trial closure was done. The flask was processed using the slow curing cycle method at 165°F (74°C) for 8 hours in a Acrylizing Bath (Unident). After completion of the polymerization, the flask was cooled to room temperature. The specimens were deflasked, trimmed and polished (Fig. 2). The specimens were stored in distilled water for 24 hours until surface pretreatment and application of soft liner.

The specimens were grouped into two categories as:

1. Group I (GC Reline soft – Acrylic based)
2. Group II (GC Soft liner – Silicone based).

Each group were further subdivided into 5 Subgroups:

The subgroup I: Control with no surface treatment, Soft liner was thus applied.

The subgroup II: Surface treated using 80 grit sand paper kept on revolving abrader machine, using 5 revolutions of the sandpaper abrader machine. Soft liner was thus applied.

Subgroup III: Test surface were sandblasted using 250 micrometer aluminium oxide particles at a pressure of 0.62 MPa spaced 10 mm from the acrylic resin plate . Soft liner was then applied.

Subgroup IV: Test surface were treated with chemical etchant methylmethacrylate by scrubbing the testing area with a cotton tipped applicator saturated with liquid methyl methacrylate monomer and then the testing surface was dipped in methyl methacrylate solution for 180 seconds and it was left to dry for

Table 1: Bond strength by sand blasting and sand papering of silicon group

Parameters	**Sand Blasting**	***Sand Papering***	**t Value**	**P Value**
	Mean ± SD (n=8)	***Mean ± SD (n=8)***		
Bond strength (mpa)	0.056 ± 0.01	0.086 ± 0.001	8.17	<0.0001

Table 2: Bond strength of acetone between silicon and acrylic group

Acetone	**Silicon**	**Acrylic**	**t Value**	**P Value**
	Mean ± SD (n=8)	**Mean ± SD (n=8)**		
Bond strength (mpa)	0.073 ± 0.013	0.10 ± 0.015	3.97	<0.001

Table 3 showing groupwise comparison of bond strength in silicone group, control Vs sand Blasting, control Vs Methyl Methacrylate, Sand Blasting Vs Sand Papering, Sand Blasting Vs Methyl Methacrylate, Sand Papering Vs Methyl Methacrylate and Acetone Vs Methyl Methacrylate

Parameter	**n**	Bond strength (mpa)	**F Value**	**P Value**
		Mean ± SD		
Control	8	0.095 ± 0.014	45.56	<0.0001
Sand Blasting	8	0.056 ± 0.01		
Sand Papering	8	0.086 ± 0.006		
Acetone	8	0.073 ± 0.013		
Methyl Methacrylate	8	0.032 ± 0.01		

2 minutes after surface pretreatment . Soft liner was then applied.

Subgroup V: Test surfaces which were treated with chemical etchant pure acetone by scrubbing the testing area with a cotton tipped applicator saturated with pure acetone and then by dipping it in acetone for 45 seconds and it was left to dry for 2 mins after surface pretreatment. Soft liner was then applied.

The prepared 80 pairs of poly methyl methacrylate specimens were flasked along with 3mm stainless steel spacer invested in silicon rubber to allow for easy removal of the die and later provide space for the soft liners (Fig. 3). The GC Soft liner, silicone soft denture lining material, which was provided as powder & liquid, was mixed according to the manufacturer's instructions and was packed in between the two specimens. Separating medium was applied surrounding the specimen, allowed to dry and for 10 minutes. As it was a self cure soft liner, processing was not carried out. Another set of specimens were prepared in the same manner and GC Reline (Acrylic) soft denture lining material was packed between the specimens and according to the manufacturer's instructions, separating medium was applied surrounding the specimen, allowed to dry for 10 minutes. As it was a self cure soft liner, processing was not carried out. All the specimens were placed under tension, until failure, in a Star Universal Testing Machine using a cross head speed of 2 cm/min. Comparative study of the adhesive bond strength was done between the two soft lining materials. The bond strength was calculated as stress at failure divided by the cross sectional area of the sample.

DISCUSSION

A Soft Denture Liner should bond well to Heat Cure Polymethyl Methacrylate denture base resin to avoid failure of the interface while the prosthesis is in use. The bond strength between the soft linerand denture base resin is weak and detachment of lining material is seen even before the material has lost its elasticity. In such situations soft denture liner has to be replaced because the rough area after detachment which is left behind encourages bacterial growth.[5] Craig and Gibbons advocated a roughened surface to improve the adhesive bond . They reported that adhesive values obtained with the roughened surface were higher than those of the smooth surface. Strorer sandblasted the acrylic resin surface before placing a resilient lining material and concluded that a slightly irregular surface provided mechanical locking for the soft material thereby increasing the strength of the bond.[5] To the contrary, Amin et al reported that roughening the acrylic resin base by sandblasting before applying a lining material had a weakening effect on the bond . Researchers have attempted to identify other methods to improve the Polymethyl Methacrylate / Resilient liner bond. Recently,

Sandpapering and Chemical etchants like Acetone, Methyl methacrylate have been shown to provide a relatively safe and easy means of altering the surface of materials.[9] The purpose of this study was to evaluate the effects of specific sandblasting , sandpapering, etching with pure acetone and methyl methacylate chemicals on the interfacial bonding of PMMA and two types of resilient liners (a Silicone and an Acrylic based). The null hypothesis states that the bond strength was higher in the Acrylic liner as compared to Silicone liner. In this study, the bond strength of self cure soft denture liners to heat polymerized denture base resins was determined by a tensile test. This test differs from the forces that soft denture lining materials are subjected to clinically. The stress exerted on the interface of two materials is more of shear and tear.[17] However, the tensile test was effective in evaluating the bond strength and in ranking the materials. It was noted in this study that all the subgroups of Acrylic Group (Group II) had a higher bond strength than the subgroups of Silicone Group (Group I). The bond strength of Acrylic Group (Group II) was 0.10 Mpa and that of Silicone group was 0.068 Mpa. The result showed significant difference. This means the bond strength was higher in the Acrylic Group. The reason for such a result could be that, as acrylic soft liner and PMMA denture base materials are similar in chemical structure so the bonding between them is more than that of Silicone to Polymethyl methacrylate.[30] The results of this aspect of study are similar to the research carried out by Thomas .J Emmer *et al*.[30] When comparing the physical treatments within Silicone Group (Group I) i.e. Sand Blasting Vs Sand Papering of Group I, Sand Papering showed a mean of 0.086 Mpa which was higher than Sand blasting which showed a mean of 0.056 Mpa. Therefore, there was significant difference in bond strength between sand blasting and sand papering of silicone group, This means bond strength was higher in Sandpapering than Sandblasting of Silicone group. The reason for such a result could be that be that the size of the irregularities created by the sandpapering would be more than for Sandblasting which increase the mechanical interlocking between the soft liner and polymethyl methacrylate.[34] The results of this aspect of study are similar to the research carried out by Nancy Jacobsen *et al*., in 1997.[34] When comparing the physical treatments within Acrylic Group (Group II) i.e Sand Blasting Vs Sand Papering of Group II, Sand Blasting showed a mean of 0.10 Mpa which was higher than SP which showed a mean of 0.09 Mpa. Therefore, there was a significant difference in bond strength between sand blasting and sand papering of acrylic group , This means bond strength was higher in Sandblasting than Sand papering of acrylic group. The reason for such a result could be that lower bond strengths were due to stresses that occurred at the interface of the PMMA/soft liner junction. Another possibility may be thatthe size of the irregularities created by the sandpapering medium may not be sufficient to allow flow of the resilient lining material into it.[8] The results of this aspect of study are similar to the research carried out by Dugyu Sarac *et al*.[50] When comparing Sand Blasting (Subgroup III) of Silicone Group (Group I) which showed a mean of 0.05 Mpa Vs Sand Blasting (Subgroup III) of Acrylic Group showed a mean of 0.10. Therefore, there was a high significant difference in bond strength of sand blasting between silicon and acrylic group . This means Bond strength was higher in acrylic than silicone group. Reason could be that Silicone liner has a structurally different chemistry when compared with Polymethyl methacrylate denture base resin. No chemical bond occurs between them. The Polymethyl methacrylate/silicone bond relies on the primer to act as an adhesive between two materials.[27] The results of this aspect of study are similar to the research carried out by Dugyu Sarac *et al*.[28] When comparing Sandpaper (Subgroup IV) of Silicone Group (Group I) which showed a mean of 0.085 Mpa Vs SP (Subgroup IV) of Acrylic Group showed a mean of 0.089 Mpa. Therefore, there was no significant difference in bond strength of sand papering between silicone and acrylic group. This means Bond strength was higher in acrylic than silicone group. The reason for such a result could be the same logic which may be applicable to the penetration of the soft lining materials into the irregularities produced by the sandpapering method. Increasing the viscosity of the resilient lining materials for a given contact angle and surface tension reduces the penetration of material into the irregularities on the polymethyl

methacrylate surface because the penetration coefficient is inversely dependent on viscosity. The results of this aspect of study are similar to the research carried out by Ayse Mese *et al*. When comparing within the chemical treatments within Silicone Group, Acetone showed a mean of 0.073 Mpa which was higher than MMA which showed a mean of 0.032 Mpa. Therefore, there is significant difference in bond strength between Acetone and Methyl methacrylate of Silicone group, which means bond strength was higher in Acetone than Methyl methacrylate in Silicone group. The results of this study support the hypothesis that the duration of the application or the type of chemical etchants would have different effects on the bond strength of the silicone-based resilient liner to denture base resin and on the amount of microleakage between the two materials. The results of this aspect of study are similar to the research carried out by Ayse Mese *et al*.[27] The results of this study support the hypothesis that the polyethyl methacrylate (acrylic) resilient liner and the hard polymethyl methacrylate denture base can chemically combined through the application of the monomer to the denture base before application of the soft liner. Silicone, on the other hand, has a structurally different chemistry when compared with Polymethyl methacrylate denture base resin. No chemical bond occurs between them. The PMMA/silicone bondrelies on the primer acts as an adhesive between the two materials. The results of this aspect of study are similar to the research carried out by Nancy Jacobsen *et al*. When comparing A (Subgroup V) of Silicone Group (Group I) which showed a mean of 0.073 Mpa Vs A (Subgroup V) of Acrylic Group showed a mean of 0.10 Mpa. Therefore, there was highly significant difference in bond strength of acetone between silicone and acrylic This means Bond strength was higher in acrylic group than silicone group. The reason for such a result could be that Silicone, on the other hand, has a structurally different chemistry when compared with the Polymethyl methacrylate denture base resin. No chemical bond occurs between them. The Polymethyl methacrylate/silicone bond relies on the primer to act as an adhesive between thetwo materials. The results of this aspect of study are similar to the research carried out by Dugyu Sarac *et al*. When comparing MMA (Subgroup VI) of Silicone Group (Group I) which showed a mean of 0.032 Mpa Vs A (Subgroup VI) of Acrylic Group showed a mean of 0.12. Therefore, there is highly significant difference in bond strength of Methyl methacrylate between silicone and acrylic group. This means Bond strength was higher in acrylic group than silicone group. The reason for such a result could be same that Silicone, has a structurally different chemistry when compared with the Polymethyl methacrylate denture base resin. No chemical bond occurs between them. The Polymethyl methacrylate/silicone bond relies on the primer to act as an adhesive between the two materials.The results of this aspect of study are similar to the research carried out by Thomas J Emmer *et al*.[30] Theoretically, all manipulations (increased surface area and mechanical locks) should benefit the bond strength.[30] However, surface treating the PMMA before applying resilientmaterial (polyethyl methacrylate or silicone) application always resulted in lower mean peel strengths when compared with the control specimens. Amin proposed that lower bond strengths were due to stresses that occurred at the interface of the Polymethyl methacrylate/soft liner junction. When the mean bond strengths of the two resilient lining materials used in this research were compared, the Polymethyl methacrylate/polyethyl methacrylate combinations were significantly stronger than the Polymethyl methacrylate /silicone combinations.

CONCLUSION

From the above study it can be concluded that highest bond strength was seen in the Acrylic group. In matter of best physical surface treatment Silicone group showed Sand papering was better than Sand blasting and in Acrylic group showed that Sand blasting was better than sand papering. In respect to chemical surface treatment, silicone group showed that application of Acetone was better than Methyl Methacrylate and in Acrylic group showed that application of Methyl Methacrylate was better than Acetone. Best combination was seen in the Polymethyl methacrylate to Acrylic soft liner after the Polymethyl methacrylate was treated with Methyl Methacrylate.

CONFLICT OF INTEREST & SOURCE OF FUNDING

The author declares that there is no source of

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BIBLIOGRAPHY

1. Jose RRP, Marcello FM. Evaluation of varying amounts of thermal cycling on bond strength and permanent deformation of two resilient denture liners. J Prosthet Dent 2004; 92:288-93.
2. Carlos NE, Flavio QH. Effect of thermocycling on the tensile and shear bond strengths of three soft liners to a denture base resin. J Appl Oral Sci 2007; 15(10):18-23.
3. Samir Q, Alan H, Robin H. Soft lining materials in Prosthetic Dentistry: A Review. Int. J Prosthodont 1990; 3: 447-83.
4. Aydin AK, Terzioglu H, Akinay AE, U1ubayram K, Hasirci N. Bond strength and failure analysis of lining materials to denture resin. Dent Mater 1999; 15:211-18.
5. Robert GC. Restorative Dental Materials. 8th Ed. St. Louis. Mosby Co. 1989; 542-44.
6. Combe EC. Notes on Dental Materials. 6th Ed. Churchill Livingstone, London. 1992; 164 – 67
7. Anusavice. Phillip's Science of Dental Materials. 10th Ed. 1998; W. B. Saunders Company USA. 263-66.
8. Council on Dental Materials: Revised ADA specification No. 12 for denture base Polymers J.Am.Dent.Assoc. 1975; 90: 145
9. Amin WM, Fletcher AM, Ritche GM. The nature of the interface between polymethyl methacrylate denture base materials and soft lining materials. J Dent 1981; 9:336-46
10. Hayakawa.I, Kawae.M, Tsuji.Y, Masuhara.E: Soft denture liner of fluoroethylene Copolymer and its clinical evaluation J.Prosthet.Dent 1984; 51:310.
11. Ducan JD. Clark LL. The use of a soft denture liner for chronic residual ridge oreness. J.Am.Dent.Assoc. 1985;111:64
12. David R. Burns, Donna A. Burns, Guirard J. Di Pietro, Richard LG. Response of processed resilient denture liners to Candida albicans: J Prosthet Dent 1987;57: 507-12.
13. David. MD, Robert PC. The plasticizing effect of temporary soft lining materials on polymerized acrylic resins: J Prosthet Dent: 1987; 60: 463-66.
14. Bunch J, Johnson GH, Burdvik JS. Evaluation of hard direct reline resins. J Prosthet Dent 1987;57; 512-19.
15. Roy MM, Gordon EK. Evaluation of primers used for bonding silicone to denture base material J Prosthet Dent 1989;61: 636-39
16. Ramin R, Zafrulla K, Von Fraunhofer JA. The bond strength of a visible light-cured reline resin to acrylic resin denture base material J Prosthet Dent 1990; 63: 485-7.
17. lwao H, Masanori N, Takeo M, Eiichi M. Properties of a new light polymerized relining material: Int J. Prosthodont 1990; 3:278-84.
18. Raleigh AH, Christian GZ, Manville GD. Force versus time profiles of selected heat processed denture liners. Int J. Prosthodont 1991;4:164-68
19. James ER. Twenty-five years of clinical application of a heat-cured silicone rubber. J Prosthet Dent. 1991; 65:658-61
20. Fumiaki K, Edward RD, Andrew K, Robert GC. Comparison of bond strength of six soft denture / liners to denture base resin. J Prosthet Dent 1992; 68:368-71.
21. John C. Assessment of a recently introduced Fluoro elastomeric soft lining material. lnt J Prosthodont. 1993; 6: 440-45.
22. Dootz ER, Koran A, Robert GC. Physical property comparison of 11 soft denture lining materials as a function of accelerated aging. J Prosthet Dent 1993; 69: 114-9.
23. Fumiaki K, Edward RD. Andrew K, Robert GC. Sorption & solubility of 12 soft denture liners. J Prosthet Dent. 1994; 72: 393-98.
24. lwao H, Shoji K, Eiichi M. The creep behavior of denture supporting tissues and soft lining materials. Int J. Prosthodont 1994;7: 339-47.
25. Robert. WL, Brent MM, Corrine HH. Finishing and polishing of a poly (fluoroalkoxyphosphazene) resilient denture liner. Int J Prosthodont 1994 ;7: 362-67.
26. Anthony VF, William JS. Characterization of the physical properties of resilient denture lines. Int J Prosthodont 1994;7: 120-1.
27. Kawano F, Kon M, Koran A, Matsumoto N. :Shock-absorbing behavior of four processed soft denture liners.J Prosthet Dent. 1994 Dec;72(6):599-605.

28. Von Fraunhofer JA, Sichina WJ. Characterization of the physical properties of resilient denture liners. Int J Prosthodont 1994;7(2):120-8.
29. Kutay O. Comparison of tensile and peel bond strengths of resilient liners.J Prosthet Dent. 1994; 71(5):525-31.
30. Thomas JE Jr, Thomas JE Sr, Vaidyanathan J, Vaidyanathan TK. Bond strength of permanent soft denture liners bonded to the denture base. J Prosthet Dent. 1995; 74: 595-601.