RESEARCH PAPER

Assessing The Influence of Three Aluminium Oxide Particle Variants in Sand Blasting on Tensile Bond Strength Between Soft Resilient Liner and Polymethyl Methacrylate Denture Base - An In Vitro Study

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ABSTRACT

STATEMENT OF THE PROBLEM: Adhesion failure between silicone resilient denture lining materials and denture base resin is commonly encountered in clinical practice.

PURPOSE: To investigate the bond strength and adhesion of commercially available soft denture liner to alumina-abraded polymethyl methacrylate denture base resin.

METHODOLOGY: The specimens were prepared using heat-cure denture base material (ACRYTON- 'H' Heat cure) in the moulds in denture flasks, and divided into four groups, one being control group. 3 mm of the material was cut from the thin midsection. Bonding surfaces of specimens were sandblasted at a distance of 10 mm between the surface of the specimen and the blasting tip, with different size (50, 110, 250 µm) of aluminium oxide particles (SAFE PLUS BLASTER SAND) at 2 bar for 10 seconds. Specimens were secured in the gypsum moulds, and the specimens and relining material (ACRYTON soft liner) was polymerized, were then stored in distilled water at 37ºC for 1 week. The maximum tensile stress before failure was recorded for each specimen. Bond strength (in megapascal) was calculated using the following formula: Bond strength (N/mm2) = F/A {Where F is maximum force (N), and A is cross sectional area (mm2)}. The mean for different readings was tested using Analysis of Variance (ANOVA) for tensile strength. Tukey post hoc was applied to find significant difference within groups.

RESULTS: The mean tensile bond strength was highest in Group II (50 µm aluminium oxide particles) (0.41 ± 0.09 MPa), followed by Group III (110 µm) (0.39 ± 0.07 MPa). The control group (0.35 ± 0.08 MPa) and Group IV (250 µm) (0.34 ± 0.05 MPa) demonstrated comparatively lower mean values. The 50 µm aluminium oxide group (Group II) demonstrated the highest percentage increase in tensile bond strength (+17.1%) compared to the control group

CONCLUSIONS: findings suggest that moderate surface roughening (50 µm) enhances interfacial bonding, while larger particle size (250 µm) may adversely affect bonding efficiency.

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INTRODUCTION

Gradual changes of oral tissues require that complete or partial dentures should be relined to enhance their adaptation to the supporting tissue.[1] Soft lining materials are broadly used as a cushion on the fitting surface of dentures where the denture-bearing tissues are less able to withstand masticatory stresses, the use of soft lining materials may promote the success of complete dentures. [2] Number of materials have been used as resilient liners since the velum rubber was introduced. Many were successfully used, but cleansability, hardness, volumetric change due to water absorption, and abrasion resistance were the limitations that came across generally.

Wright concluded that the most common reason for failure of a soft-lined denture was the failure of "adhesion" between the liner and denture base. He explained the importance of the bond strength between liner and denture base. 4 Hence, the reason which is most common for failure of soft-lined dentures is the basic structural difference between the two materials. [1]

Multiple studies have been carried out to enhance the bond strength between acrylics and liners. Craig and Gibbons are of the view that a roughened surface improves the adhesive bond.

Sandblasting is the preferred method of choice in general, aimed at roughening of surfaces, thus making materials more bondable. Such conditioning procedures can be applied both at the laboratory and by the chairside, utilizing larger as well as smaller sized particles.

Hence, the primary objective of this study was investigating the effects of sandblasting with different sizes of aluminium oxide particles on tensile bond strength of resilient liner to acrylic denture base.[6]

MATERIALS AND METHODOLOGY:

MATERIALS

1. Gypsum type III (ZOODENTA STONE PLASTER)
2. Separating media (ACRYTON)
3. Heat- cured poly methyl meth acrylate as denture base material (ACRYTON- 'H' Heat cure cross linked denture base material)
4. Aluminium oxide particles (SAFE PLUS BLASTER SAND)
5. Silicone based material as soft liner (GC Soft Liner)
6. Distilled water

ARMAMENTARIUM:

1. Dental clamp and flask (VARSITY FLASK)
2. Mixing bowl
3. Straight spatula
4. Metal die (stainless steel)
5. Metal Hooks
6. Silicone jar
7. Acrylizing unit (UNIDENT ACRYLIZER)
8. Motor handpiece (MARATHON)
9. Diamond edge saw
10. Sand blasting machine (DELTA TWIN BLASTER)
11. Universal testing machine (MODEL NO. UNITEST 10)

In this study, 44 specimens were fabricated for each group using a die (40 x 10 x 10mm) as a mould. The heat-cured specimens were prepared in the moulds in denture flasks and cured in a manner similar to that used in conventional denture construction. After finishing, 3 mm of the material was cut from the thin midsection using a water-cooled diamond edge saw. Bonding surfaces of specimens were sandblasted at a distance of 10 mm between the surface of the specimen and the blasting tip, with different size of aluminium oxide particles. The groups were divided as follows:

Group1— untreated (control): No treatment will be applied to the acrylic resin specimen surface, this group will serve as a control.

Group 2— 50 µm Al_2O_3 at 2 bar for 10s.

Group 3— 110 µm Al_2O_3 at 2 bar for 10s.

Group 4— 250 µm Al_2O_3 at 2 bar for 10s.

INCLUSION CRITERIA • Samples of same dimensions • Samples without any defects/ distortion

EXCLUSION CRITERIA • Samples with any distortion

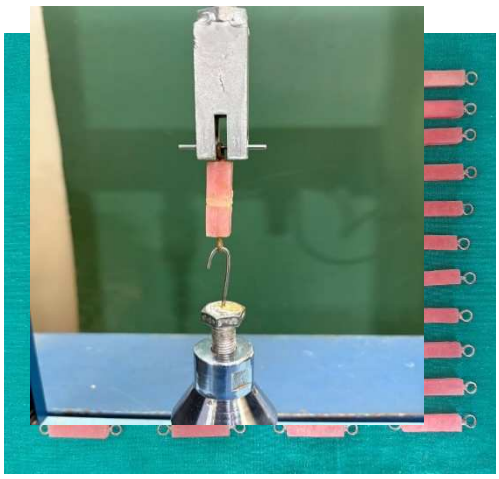
After rinsing and drying, specimens were secured in the gypsum moulds, and the specimens and relining material was polymerized according to manufacturer's instruction. The processed moulds were left to cool at room temperature for 20 min, and then placed under running tap water for 10 min. Specimens were then stored in distilled water at 37oC for 1 week.

Testing for tensile strength

Testing of sample was done at Praj Dental Laboratory, Pune. All specimens were placed on Universal testing machine under tension until failure in a universal testing machine at a crosshead speed of 5 mm/min. The maximum tensile stress before failure was recorded for each specimen. Bond strength (in megapascal) was calculated using the following formula: Bond strength (N/mm2) = F/A {Where F is maximum force (N), and A is cross sectional area (mm2)}

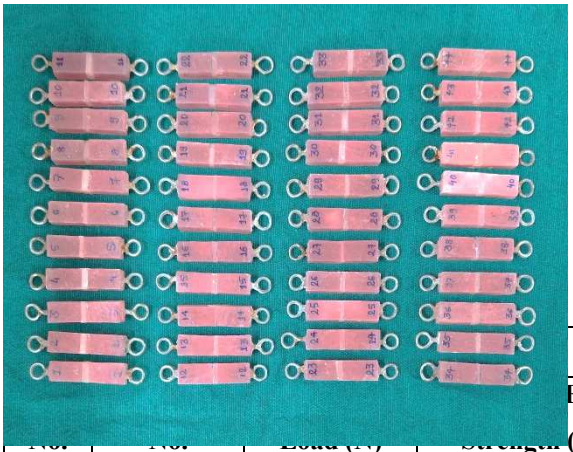
Statistics

The mean for different readings was tested using Analysis of Variance (ANOVA) for tensile strength. Tukey post hoc was applied to find significant difference within groups



A. Prepared

B. Amples With The Layer Of Soft Liner In The Cross- Section Area



			Bond Strength (MPa)
1	No.12	38.50	0.38
2	No.13	49.50	0.49
3	No14	42.00	0.42
4	No.15	30.50	0.30
5	No.16	38.00	0.38
6	No.17	48.50	0.48
7	No.18	56.50	0.56
8	No.19	33.00	0.33
9	No.20	40.50	0.40
10	No.21	29.50	0.29
11	No.22	47.50	0.47
MEAN			**0.41**

C. Sample Placed Under Tension Until Failure In A Universal Testing Machine At A Crosshead Speed Of 5 Mm/Min.

OBSERVATIONS AND RESULTS

Table No. 1: Readings for maximum tensile stress before failure and tensile bond strength for group I

Group I			
Sr. No.	**Sample No.**	**Tensile Load (N)**	**Tensile Bond Strength (MPa)**
1	No.1	27.50	0.27
2	No.2	45.00	0.45
3	No.3	34.50	0.34
4	No.4	40.50	0.40
5	No.5	32.00	0.32
6	No.6	48.00	0.48
7	No.7	36.50	0.36
8	No.8	40.00	0.40
9	No.9	31.00	0.31
10	No.10	20.50	0.20
11	No.11	30.50	0.30
MEAN			**0.35**

Table No.2: Readings for maximum tensile stress before failure and tensile bond strength for group II

Table No. 3: Readings for maximum tensile stress before failure and tensile bond strength for group III

Group III			
Sr. No.	**Sample No.**	**Tensile Load (N)**	**Tensile Bond Strength (MPa)**
1	No.23	42.00	0.42
2	No.24	53.00	0.53
3	No.25	46.50	0.46
4	No.26	37.00	0.37
5	No.27	37.00	0.37
6	No.28	29.00	0.29
7	No.29	44.50	0.44
8	No.30	41.00	0.41
9	No.31	36.50	0.36

10	No.32	39.50	0.39
11	No.33	29.00	0.29
MEAN			**0.40**

Table No. 4: Readings for maximum tensile stress before failure and tensile bond strength for group IV

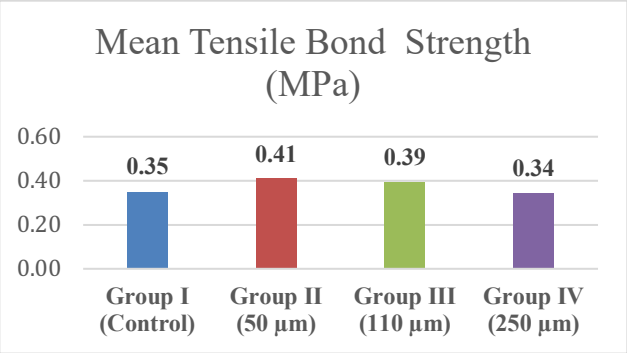
Group IV			
Sr. No.	**Sample No.**	**Tensile Load (N)**	**Tensile Bond Strength (MPa)**
1	No.34	35.00	0.35
2	No.35	33.50	0.33
3	No.36	29.00	0.29
4	No.37	25.50	0.25
5	No.38	34.50	0.34
6	No.39	37.50	0.37
7	No.40	34.00	0.34
8	No.14	30.00	0.30
9	No.42	37.00	0.37
10	No.43	46.50	0.46
11	No.44	35.50	0.35
MEAN			**0.34**

STATISTICAL ANALYSIS

Descriptive Statistics of Tensile Bond Strength among Study Groups

Bond Strength (MPa)								
Group	**N**	**Mean (MPa)**	**SD**	**Std. Error**	**95% Confidence Interval for Mean**		**Minimum**	**Maximum**
					Lower Bound	**Upper Bound**		
Group I (Control)	11	0.35	0.08	0.02	0.29	0.40	0.20	0.48
Group II (50 µm)	11	0.41	0.09	0.03	0.35	0.47	0.29	0.56
Group III (110 µm)	11	0.39	0.07	0.02	0.35	0.44	0.29	0.53
Group IV (250 µm)	11	0.34	0.05	0.02	0.30	0.38	0.25	0.46
Total	44	0.37	0.08	0.01	0.35	0.40	0.20	0.56

Graph 1: Mean Tensile Bond Strength (MPa) of Soft Liner–PMMA Interface across Different Surface Treatment Groups



(400 MHz, Bruker, CD3OD, TMS reference), 13C NMR (125.8 MHz, 1024 scans, proton-decoupled) and mass spectrometry (electron impact for rutin; electrospray, negative mode for EANP-2 and positive mode for EANN-2) [29].

RESULTS

Macroscopy and microscopy

The macroscopic characters of the two flowers are summarised in Table 1 and shown in Figure The mean tensile bond strength was highest in Group II (50 µm aluminium oxide particles) (0.41 ± 0.09 MPa), followed by Group III (110 µm) (0.39 ± 0.07 MPa). The control group (0.35 ± 0.08 MPa) and Group IV (250 µm) (0.34 ± 0.05 MPa) demonstrated comparatively lower mean values.

DISCUSSION

The findings of this study provide valuable insight into the optimal degree of surface roughening required to enhance bonding without compromising the structural integrity of the substrate.

The results of the present study demonstrated that the highest tensile bond strength was observed in Group II (50 µm) (0.41 ± 0.09 MPa), followed by Group III (110 µm) (0.39 ± 0.07 MPa), while comparatively lower values were recorded for the control group (0.35 ± 0.08 MPa) and Group IV (250 µm) (0.34 ± 0.05 MPa). This clearly indicates that moderate surface treatment using 50 µm aluminium oxide particles produces superior bonding compared to both untreated and excessively treated surfaces.

A consistent gradient pattern was observed across the groups: 50 µm > 110 µm > Control ≈ 250 µm, suggesting that increasing particle size initially enhances bond strength, but beyond an optimal threshold, further increase leads to deterioration in bonding performance. This trend is strongly supported by the percentage change analysis, where the 50 µm group showed a +17.1% increase, the 110 µm group showed +11.4% improvement, and the 250 µm group demonstrated a −2.9% decrease relative to the control group.

Mechanism of Surface Roughening and Bond Enhancement

The improved bond strength observed with 50 µm particles can be attributed to the creation of a uniform micro-roughened surface that enhances mechanical interlocking, increases surface energy, and improves wettability. This facilitates better penetration of the soft liner into the irregularities of the denture base surface, resulting in improved adhesion.

This concept aligns with the findings of Kern M. (1993)[3], who reported that sandblasting alters surface morphology and enhances micromechanical retention. Similarly, Al-Taweel S. M. (2021)[4] and Gibreel M. (2024)[5] demonstrated that airborne-particle abrasion and mechanical roughening significantly improve bond strength. However, excessive roughening, as observed with 250 µm particles in the present study, may lead to the formation of surface defects, microcracks, and irregular deep grooves, which negatively affect bonding. This finding is in strong agreement with Jacobsen N. L. (1997)[6], who reported that sandblasting with 250 µm aluminium oxide particles reduced bond strength.

Comparison with Previous Studies on Particle Size

The concept of optimal particle size has been explored in earlier studies. Akin H. (2011)[6] reported that 120 µm aluminium oxide particles produced the highest bond strength, which partially contrasts with the present study where 50 µm yielded the best results. This variation may be attributed to differences in material composition, testing methods, and surface characteristics.

Influence of Material Composition and Adhesive Systems

Bond strength is not solely dependent on surface treatment but is also influenced by material composition and adhesive systems. Pinto et al. (2002)[7] and Kulak-Ozkan Y (2003)[8] demonstrated that bond strength varies significantly based on the chemical composition of soft liners. Similarly, Mutluay M. M. (2007)[9] reported variability in bonding performance among newly developed materials.

Further evidence from Botega D. M. (2007)[10] and Salloum A. M. (2013)[11] indicates that thermocycling and exposure to saliva reduce bond strength. These findings suggest that in vitro results may not fully replicate clinical conditions, and long-term studies are required to assess durability.

Role of Alternative Surface Treatments

Apart from sandblasting, other surface treatment methods have also been explored. Zhang H. (2010)[12] demonstrated that oxygen plasma treatment significantly enhances bond strength, while Gundogdu M. (2014)[13] reported improved bonding with phosphoric acid etching. These findings indicate that multiple techniques are available to enhance bonding, each with its own advantages and limitations.

Clinical Implications

The findings of the present study have important clinical implications. The use of 50 µm aluminium oxide particles for surface treatment appears to provide the best balance between improved bond strength and preservation of surface integrity. The 110 µm particle size may be considered an acceptable alternative, while the use of larger particles such as 250 µm should be avoided due to their potential to compromise bonding.

The study also reinforces the importance of controlled surface modification, highlighting that excessive treatment may be detrimental rather than beneficial.

The present study contributes to the existing literature by providing a direct comparison of three different particle sizes under standardized conditions. It clearly demonstrates that moderate surface roughening enhances bonding, while excessive roughening has a negative effect. This adds valuable evidence to the concept of optimal surface treatment and helps refine clinical protocols.

CONCLUSION

Within the limitations of this in vitro study, it can be concluded that surface treatment of PMMA denture base resin using aluminium oxide particles influences the tensile bond strength of soft liner materials. The results demonstrated that sandblasting with 50 µm aluminium oxide particles produced the highest bond strength, followed by the 110 µm group, while the 250 µm group showed a slight reduction compared to the control. Although the differences among groups were not statistically significant, a consistent trend was observed indicating that moderate surface roughening enhances bonding, whereas excessive roughening may adversely affect the interface. The findings suggest that 50 µm particle size provides an optimal balance between surface roughness and structural integrity, thereby improving micromechanical retention. Clinically, controlled surface treatment should be preferred to achieve better adhesion and longevity of soft liners. Further long-term and in vivo studies are recommended to validate these findings.

REFERENCES

1. Aydın AK, Terzioğlu H, Akınay AE, Ulubayram K, Hasırcı N. Bond strength and failure analysis of lining materials to denture resin. Dental materials. 1999 May 1;15(3):211-8.
2. Usumez A, Inan O, Aykent F. Bond strength of a silicone lining material to alumina-abraded and lased denture resin. Journal of Biomedical Materials Research Part B: Applied Biomaterials: An Official Journal of The Society for Biomaterials, The Japanese Society for Biomaterials, and The Australian Society for Biomaterials and the Korean Society for Biomaterials. 2004 Oct 15;71(1):196-200.
3. Kern M, Thompson VP. Sandblasting and silica-coating of dental alloys: volume loss, morphology and changes in the surface composition. Dental Materials. 1993 May 1;9(3):155-61.
4. Al Taweel SM, Al-Otaibi HN, Labban N, AlFouzan A, Shehri HA. Soft denture liner adhesion to conventional and CAD/CAM processed poly (methyl methacrylate) acrylic denture resins-an in-vitro study. Materials. 2021 Nov 3;14(21):6614.
5. Botega DM, Sanchez JL, Mesquita MF, Henriques GE, Consani RL. Effects of thermocycling on the tensile bond strength of three permanent soft denture liners. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry. 2008 Oct;17(7):550-4.
6. Jacobsen NL, Mitchell DL, Johnson DL, Holt RA. Lased and sandblasted denture base surface preparations affecting resilient liner bonding. The Journal of prosthetic dentistry. 1997 Aug 1;78(2):153-8.
7. Pinto JR, Mesquita MF, Henriques GE, de Arruda Nóbilo MA. Effect of thermocycling on bond strength and elasticity of 4 long-term soft denture liners. The Journal of prosthetic dentistry. 2002 Nov 1;88(5):516-21.
8. Kulak-Ozkan Y, Sertgoz A, Gedik H. Effect of thermocycling on tensile bond strength of six silicone-based, resilient denture liners. The Journal of prosthetic dentistry. 2003 Mar 1;89(3):303-10.
9. Mutluay MM, Ruyter IE. Evaluation of bond strength of soft relining materials to denture base polymers. dental materials. 2007 Nov 1;23(11):1373-81.
10. Botega DM, Sanchez JL, Mesquita MF, Henriques GE, Consani RL. Effects of thermocycling on the tensile bond strength of three permanent soft denture liners. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry. 2008 Oct;17(7):550-4.
11. Salloum AA. Effect of aging on bond strength of two soft lining materials to a denture base polymer. The Journal of Indian Prosthodontic Society. 2014 Dec;14(Suppl 1):155-60.
12. Zhang H, Fang J, Hu Z, Ma J, Han Y, Bian J. Effect of oxygen plasma treatment on the bonding of a

soft liner to an acrylic resin denture material. Dental Materials Journal. 2010;29(4):398-402.

13. Gundogdu M, Duymus ZY, Alkurt M. Effect of surface treatments on the bond strength of soft denture lining materials to an acrylic resin denture base. The Journal of prosthetic dentistry. 2014 Oct 1;112(4):964-71.