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Shear Bond Strength of Hard Chairside Reline Material to Denture Base Material

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ABSTRACT

Aims: To evaluate the effect of different surface treatment on shear bond strength (SBS) of a hard chairside reline material to denture base resin. **Materials and methods:** Cylindric columns of denture reline material were bonded to columns of denture base resin. Fifty specimens were prepared and divided into 5 groups according to the surface treatment used. Group I: Untreated; group II: Wetting with denture base resin monomer (180 s); group III: Wetting with Kooliner monomer (180 s); group IV: Wetting with acetone (10 s); and group V: Wetting with chloroform (5 s). The strength at which the bond failed under shear was recorded and fracture site on the specimens was tested by visual examination and reflecting light microscope. The data were statistically analyzed using one–way analysis of variance (ANOVA), Duncan's Multiple Range Test and Chi–square test. **Results:** All surface treatments caused significantly increase ($p \leq 0.0001$) in SBS. Chloroform caused significantly higher SBS, and untreated group showed significantly lower SBS. Mixed failure mode was predominant in groups with higher SBS, while adhesive failure mode was predominant in groups with lower SBS. **Conclusions:** All surface treatments (Monomer, Kooliner monomer, acetone, chloroform) achieved significantly higher SBS.

Key Words: Shear strength, reline resin, denture base resin, bond strength.

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INTRODUCTION

A removable prosthesis may require relining of the intaglio surface as a result of tissue changes over time. Hard chairside relining is easier, faster and more convenient than the use of laboratory relining system[1] and has been used to reproduce the morphological features of oral soft tissues directly on the ill–fitting prosthesis and regain its adaptation to the residual ridge;[2, 3] however, unpleasant odour, potential for irritation to oral soft tissue by the monomer, heat generation during polymerization and poor chemical bond between the reline material and denture base resin are areas of clinical concern. This chemical bond has been evaluated by many authors,[4–8] showing that adhesive failure and weak bond strength are common problems.

Recent hard chairside reline resins contain a variety of methacrylate monomers with relatively greater molecular weight than methyl methacrylate. This may influence the extent of penetration of monomer from reline resins into the denture base resin, which is essential to form an interwoven polymer network,[9–11] and compromise the bond strength between the two materials.

On the other hand, studies showed that newly developed highly cross–linked denture base resin may restrict the availability of monomers to form the interwoven polymer between denture base resin and reline resin and thus compromise the bond strength.[12–14]

The aim of this study was to evaluate the effect of different surface treatments on shear bond strength (SBS) of a hard chairside reline material to highly cross–linked denture base resin.

MATERIALS AND METHODS

Hard chairside reline resin (Kooliner, Coe Laboratories, Chicago, Ill, USA) and highly cross–linked heat cured denture base resin (RESPAL NF, Salmoiraghi Produzione Dentaria, s.r.l. Italy) were selected for this study.

In order to prepare cylindrical columns of the denture base resin with dimensions 10 mm in height and 8 mm in diameter,[15] a “splite” metal mold was designed and prepared especially for this study.

By using thermostatically controlled water bath, (T.P Regular, Major Prodotti Dentari, Italy) wax was melted and poured into the metal mold, and left for cooling for 20 minutes, then the screws were loosened. The two parts of the mold were separated and the wax pattern (10 mm height, 8 mm diameter) was removed. These wax patterns were invested in flasks (Ash, England) using type IV dental stone (Micromod Zeus Seri Loc. {GR} Italy). After elimination of the wax, denture base resin was mixed, packed into the flask using hydraulic press (Bego–Hydrofix, W. Germany) and polymerized according to manufacturer’s instructions.

The acrylic specimens were removed from the flask and stored in distilled water at 37 ± 1 ºC for 50 ± 2 hours [16] .The total number of specimens prepared by this method was fifty.

To facilitate holding of the specimens onto testing machine, each specimen was embedded into plastic tube with autopoly merizing acrylic resin [9, 15] . The denture base resin surface to be bonded was smoothed on silicon carbide paper to simulate clinical relief of the denture base for bonding of the reline resins.[17]

The specimens were divided into 5 groups, 10 specimens for each group:

1)Group I: Untreated as control group.

2)Group II: Wetting with denture base resin monomer (methyl methacrylate) (MMA) for 180 s.

3)Group III: Wetting with Kooliner monomer (isobutyl methacrylate) (IBMA) for 180 s.

4)Group IV: Wetting with acetone for 10 s, followed by rinsing with distilled water and soft air drying.[18]

5)Group V: Wetting with chloroform for 5 s followed by rinsing with distilled water and soft air drying.[18]

Masking tape with 6 mm diameter hole was placed on the denture base surface to provide a uniform bonding area, and Teflon tube with a 5 mm internal diameter and 5 mm height was positioned in the hole.[9, 15]

The self curing reline material was then mixed according to the manufacturer’s instruction (powder/liquid ratio= 2.1 g/1.5 mL) and inserted into the Teflon tube. An acetate sheet was placed over the material, and pressure was applied,[17] and left 10 minutes for polymerization at room temperature (according to manufacturer’s instruction), then Teflon tube and masking tape were removed (Figure 1).

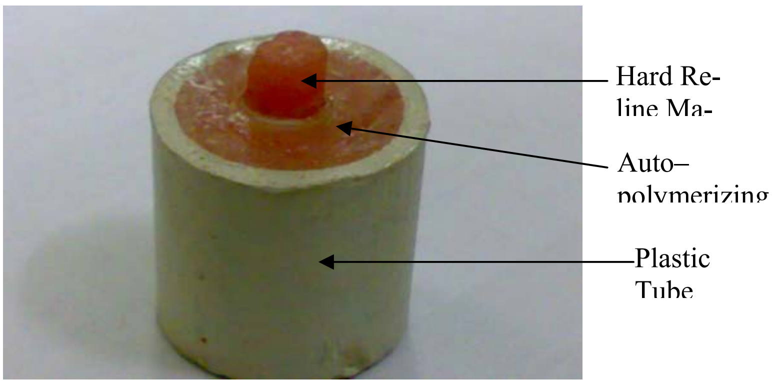


Figure (1): Sample of the study

Then, all specimens were stored in distilled water at 37 $\pm$ 1 ºC for 50 $\pm$ 2 hours.[19]

At cross–head speed of 1 mm/minute, the compressive load was applied with a knife–edge blade placed parallel to the material interface[9,15] (Figure 2) on the unconfined compression testing machine (Model CN 472, EVANSTON, Ill, USA).

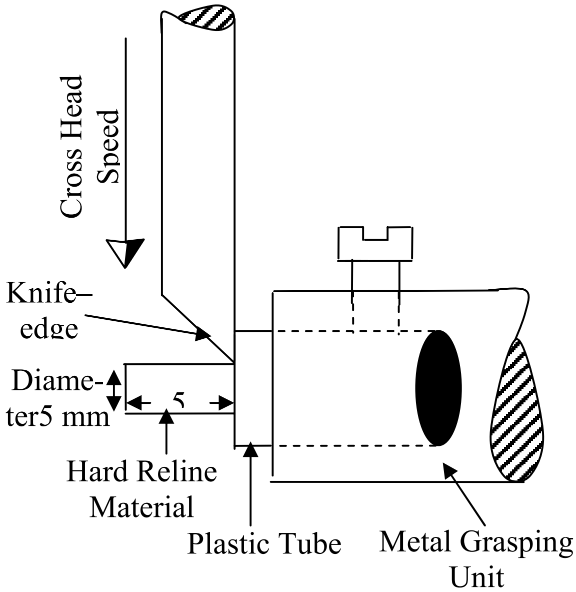


Figure (2): Holding and loading arrangement

After shear bond testing, the detached surfaces of specimens were examined by visual examination and reflecting light microscope (Carl Zeiss, Germany) at magnification ×40 to evaluate reline material–denture base resin bonding failure mode.

Failures occurring at the reline–denture base resin interface were recorded as adhesive failure (Figure 3), while presence of any trace of denture base resin on the surface of denture reline material or remnants of the denture reline material on the denture base resin were recorded as mixed failures (Figure 4).

Figure (3): Samples with adhesive failures

Figure(4): samples with mixed failures

Data from shear test were statistically analyzed by one way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test to compare between significantly different groups. Also data from mode of failure test were statistically analyzed using Chi–square test.

RESULTS

Means and standard deviations for all groups were showed in Figure (5).

One way ANOVA showed that there was significant difference among 5 groups ($p < 0.0001$) (Table 1).

Duncan's Multiple Range Test (Table 2) showed that Group V (chloroform) had significantly higher SBS (23.950 MPa) followed by Group II (monomer), Group III

(Kooliner monomer) and Group IV (acetone) where there was no significant difference among them, while Group I (untreated, control) showed significantly lower SBS (13.950 MPa).

Modes of failure and their percentages for all groups were showed in Figure (6). Chi–square test (Figure 6) showed that there was significant difference between adhesive and mixed modes of failures ($p < 0.0001$).

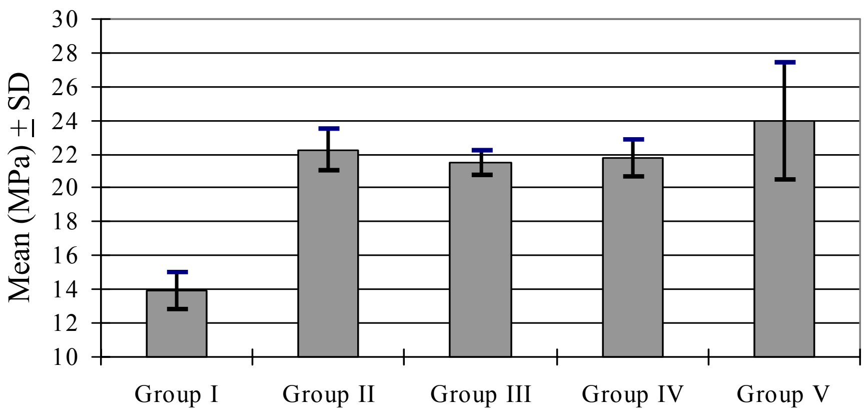


Figure (5): Means and standard deviation of shear bond strength for all groups

Table (1): Analysis of variance (ANOVA) for all groups

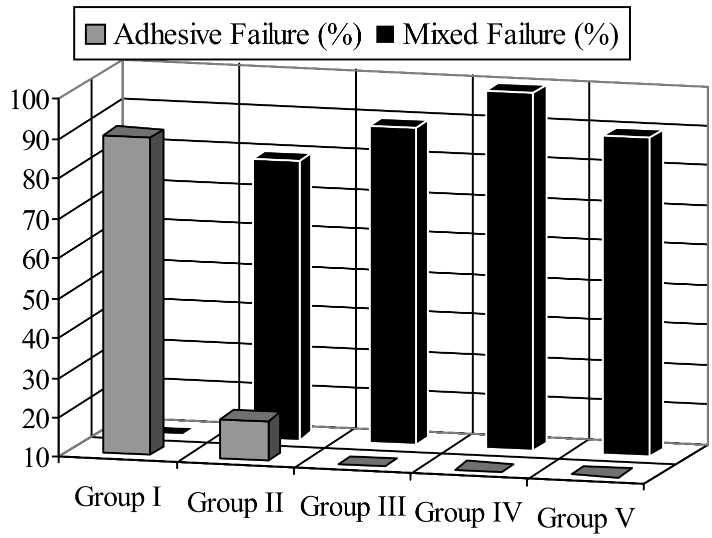
	SS	Df	MS	F–value	*p*–value
Between Groups	602.680	4	150.670	45.443	0.000*
Within Groups	149.200	45	3.316		
Total	751.880	49			

*Significant difference existed at $p \leq 0.001$; SS: Sum of Squares, df: Degree of freedom, MS: Mean Square.

Table (2): Duncan's Multiple Range Test for all groups

Groups	Number	Mean (MPa)	$\pm$ Standard Deviation	Duncan's Grouping*
Group I, Untreated	10	13.950	1.0916	A
Group II, Monomer	10	22.250	1.2304	B
Group III, Kooliner Monomer	10	21.500	0.7454	B
Group IV, Acetone	10	21.750	1.0865	B
Group V, Chloroform	10	23.950	3.4837	C

*Means with same letters were statistically not significant ($p > 0.05$).



* Chi–square test between adhesive and mixed failure modes:
χ^2= 27.651; df= 4, *p*–value= 0.000 (significant).

Figure (6): Modes of failure and their percentages for all groups

DISCUSSION

Adequate bond strength between the hard chairside reline material and the denture base resin is essential to prevent proliferation of microorganisms at their junction, staining and failure at the bond site which may result in delamination of the reline material [3, 20–22].

The most important finding in this study was that treatment of the denture base resin surface with different chemicals (Kooliner monomer, denture base monomer, acetone, chloroform) cause significantly increase in SBS when compared with that of untreated control group (Table 2).

Researches found that these chemicals cause etching of the resin surface by changing its morphology and chemical properties. Normally this etching is caused by wetting the resin surfaces with monomer.[4, 23, 24] As poly methyl–methacrylate (PMMA) soluble in organic solvents such as acetone or chloroform, these chemicals can also be used as etchers and increase the bond strength.[26] Other researches stated that these solvents (acetone, chloroform) produce softening of the denture base resin allowing the Kooliner monomer to penetrate the denture base resin[18].

This study showed the wetting bonding side of denture base resin with Kooliner monomer cause significantly improvement in SBS, as the basic composition of Kooliner monomer is isobutyl methacrylate (IBMA) (according to manufacturer's leaflet) which could affect denture base resin as monomer of denture resin (MMA)[18].

Arima *et al.*[21] stated that wetting bonding site with Kooliner monomer did not improve bond strength. Direct comparison of these results with those of the present study could not accomplished due to differences in protocol of both studies.

Successful bonding between reline material and denture base resin relies on the effective penetration of monomer emanating from the polymerizing reline material into the denture base resin[24, 27]. An adequate amount of monomer has to be available to interact with the denture base resin to form an inter–penetrating polymer network to improve the bond strength[27].

Vallittue *et al.*[4] stated that when denture base resin is dissolved by MMA, the bonding is based on the formation of new polymer chains between the acrylic resin materials. They observed that wetting the acrylic surface with MMA for 180 seconds diminished the number of adhesive failure. The results of the present study were in accordance with those reported by the authors.

The results of this study revealed that wetting bonding site with acetone for 10 seconds significantly improve bond strength. Studies showed that the dissolving effect of acetone on the denture base resin thus promoting a mechanical interlocking associated with the reline monomer penetration and polymerization along the reline–denture base resin interface,[21] and this was in agreement with the findings of Rached and Cury[28].

Leles *et al.*[18] concluded that wetting of bonding site with acetone did not improve the bond strength of reline material and denture base resin. Scientific explanation for such differences in the result could be related to the time of acetone application; in the present study acetone applied to the bonding surface for 10 seconds which allow sufficient time for softening of denture base resin, while in the first study acetone applied for 5 seconds only.

On the other hand, significant improvement was observed in this study when chloroform was used for wetting of bonding site for 5 seconds. According to the result from other study, wetting the bonding sits with chloroform creates a cleaner and more efficient site for bonding, increasing the bond strength,[26] and this was in accordance with the results of other studies[18, 28].

Regarding mode of failure, the results of this study showed that adhesive failures mode were predominant in group that display weaker SBS (Group I, untreated) versus mixed failure mode were predominant in groups with higher SBS (Groups II, III, IV and V) (Figure 6). This was in accordance with the results of other studies which revealed that a weak bond strength has been observed between Kooliner reline resin and the denture base material in absence of surface treatment[22, 29, 30].

CONCLUSIONS

All surface treatment (MMA, Kooliner monomer, acetone, chloroform) achieved significantly higher SBS when compared with untreated group.

Chloroform wetting for 5 seconds achieved significantly higher SBS when compared with other surface treatments.

Mixed failure mode was predominant in groups with higher SBS (Groups II, III, IV and V), while adhesive failure mode was predominant in group with lower SBS (Group I, untreated).

REFERENCES

1. Arima T, Murata H, Hamada T. Analysis of composition and structure of hard autopolymerizing reline resins. *J Oral Rehabil*. 1996; 23: 346-352.
2. Matsumura H, Tanoue N, Kawasaki K. Clinical evaluation of a chemically cured hard denture relining material. *J Oral Rehabil*. 2001; 28: 640-644.
3. Haywood J, Basker RM, Watson CJ. A comparison of three hard chairside denture reline materials. Part I. Clinical evaluation. *Eur J Prosthodont Restor Dent*. 2003; 11(4): 157-163.
4. Vallittu PK, Lassila VP, Lappalainen R. Wetting the repair surface with methyl methacrylate affects the transverse strength of repaired heat–polymerized resin. *J Prosthet Dent*. 1994; 72(6): 639-643.
5. Ward JE, Moon PC, Levine RA, Behrendt CL. Effect of repair surface design, repair material and processing method on the transverse strength of repaired acrylic denture resin. *J Prosthet Dent*. 1992; 67: 815.
6. Leong A, Grant AA. The transverse strength repairs in polymethyl methacrylate. *Aust Dent J*. 1971; 16: 232.
7. Woelfel JB, Paffenbarger GC, Sweeney WT. Some physical properties of organic denture base materials. *J Am Dent Assoc*. 1963; 67: 489.
8. Stanford JW, Burns CL, Paffenbarger GC. Self curing resins for repairing dentures: Some physical properties. *J Am Dent Assoc*. 1955; 51: 307.
9. Takahashi Y, Chai J. Shear bond strength of denture reline polymers to denture base polymers. *Int J Prosthodont*. 2001; 14(3): 271-275.
10. Minami H, Suzuki S, Minesaki Y, Kuroshige H, Tanaka T. *In vitro* evaluation of the influence of repairing condition of denture base resin on the bonding of autopolymerizing resins. *J Prosthet Dent*. 2001; 28(7): 640-644.
11. Jerolimov V, Brooks SC, Huggett R, Bates JF. Rapid curing of acrylic denture base materials. *Dent Mater*. 1989; 5(1): 18-22.
12. Takahashi Y, Chai J, Takahashi T, Habu T. Bond strength of denture teeth to denture base resins. *Int J Prosth-odont*. 2000; 13: 59-65.
13. Takahashi Y, Chai J, Kawaguchi M. Equilibrium strengths of denture polymers subjected to long–term water immersion. *Int J Prosthodont*. 1999; 12: 348-352.
14. Chai J, Takahashi Y, Takahashi T, Habu T. Bonding durability of conventional resinous denture teeth and highly cross–linked denture teeth to a pour type denture base resin. *Int J Prosthodont*. 2000; 13: 112-116.
15. Takahashi Y, Chai J. Assessment of shear bond strength between three denture reline materials and a denture base acrylic resin. *Int J Prosthodont*. 2001; 14: 531-535.
16. Takahashi Y, Chai J, Kawaguchi M. Effect of water sorption on the resistance to plastic deformation of a denture base material relined with four different denture reline materials. *Int J Prosthodont*. 1998; 11(1): 49-54.
17. Neppelenbroek KH, Pavarina AC, Gomes MN, Machado AL, Vergani CE. Bond strength of hard chairside reline resins to a rapid polymerizing denture base resin before and after thermal cycling. *J Appl Oral Sci*. 2006; 14(6): 436-442
18. Leles CR, Machado AL, Vergani CE, Giampaolo ET, Pavarina AC. Bonding strength between a hard chairside reline resin and a denture base material as influenced by surface treatment. *J Oral Rehabil*. 2001; 28: 1153-1157.
19. Revised American Dental Association Specification No. 12 for Denture Base polymers. *J Am Dent Assoc*. 2001; 28(4): 370-375.
20. Lamb DJ, Ellis B, Priestley D. The effects of process variables on levels of residual monomer in autopolymerizing dental acrylic resin. *J Dent*. 1983; 11(1): 80-88.
21. Arima T, Nikawa H, Hamada T, Harsi NI. Composition and effect of denture base resin surface primers for reline acrylic resins. *J Prosthet Dent*. 1996; 75(4): 457-462.
22. Arena CA, Evans DB, Hilton TJ. A comparison of bond strength among chairside hard reline materials. *J Prosthet Dent*. 1993; 70(2): 126-131.

23. Grajower R, Goultschin J. The transverse strength of acrylic resin strips and of repaired acrylic samples. *J Oral Rehabil*. 1984; 11: 237.
24. Curtis DA, Eggleston TL, Marshall SJ, Watanabe LG. Shear bond strength of visible–light cured resin relative to heat–cured resin. *Dent Mater*. 1989; 5(5): 314-318.
25. Anusavice JK. Philip's Science of Dental Materials. 10th ed. WB Saunders Co. Philadelphia. 1996; p: 233.
26. Shen C, Colaizzi FA, Bradley B. Strength of repairs as influenced by surface treatment. *J Prosthet Dent*. 1984; 52: 844.
27. Takahashi Y, Chai J, Kawaguchi M. Strength of relined denture base poly-mers subjected to long–term water immersion. *Int J Prosthodont*. 2000; 13: 205-208.
28. Rached RN, Cury AA. Heat–cured acrylic resin repaired with microwave–cured one: Bond strength and surface texture. *J Oral Rehabil*. 2001; 28: 370-375.
29. Bunch J, Johnson GH, Brudvik JS. Evaluation of hard direct reline resins. *J Prosthet Dent*. 1987; 57: 512.
30. Cucci ALM, Vergani CE, Giampaolo ET, Afonso MCSF. Water sorption, solubility and bond strength of two autopolymerizing acrylic resin and one heat–polymerizing acrylic resin. *J Prosthet Dent*. 1998; 80: 434.