ORIGINAL ARTICLE

EFFECT OF MECHANICAL MODIFICATION OF ACRYLIC RESIN DENTURE TEETH BONDED TO ACRYLIC DENTURE BASE

[1]AZAD ALI AZAD, BDS, MCPS, FCPS
[2]ADEL ZIA SIDDIQUI, BDS, MSc
[3]ATIF JAWAD, BDS, FCPS
[4]MAJID ZIA, BDS, FCPS
[5]TAHIR ALI, BDS

ABSTRACT

Techniques for bonding denture teeth to acrylic resin denture base remains empirical, with little consensus from the literature, among clinicians or among dental laboratories. Despite of this great variation, the data available regarding effectiveness of various methods used are sparse.

The study was carried out to compare the effect of different surface treatments of ridge lap area of acrylic resin denture teeth on bond strength of acrylic resin denture teeth with acrylic resin denture base.

180 Maxillary central incisors were divided into 6 groups of 30 each according to surface preparations. First group served as the control with no surface preparation; other groups included horizontal grooves, vertical grooves, diatorics, sand blasting and roughened surfaces. Compressive shear force was applied to incisal edge of each tooth until fracture occurred, the force recorded and teeth visually inspected to determine adhesive or cohesive failure.

Significant increase in failure load ranged for diatoric 274±78N. Significant decrease in failure mode was observed after sand blasting 157±79N. Remaining groups showed non-significant increase in force required for bond failure.

Key words: *Bond strength, Acrylic teeth, Denture base, Mechanical preparation*

INTRODUCTION

Resin teeth are preferred as functional portions with acrylic denture base.[1,2] Acrylic resin teeth are one of the most popular artificial teeth used for denture construction but high number still fracture away at the tooth-denture interface.[3] Studies conducted[4] have found tooth de-bonding as the most frequent repair for conventional prosthodontics.

Adequate bonding of acrylic resin teeth to acrylic denture base increases stiffness and strength of prosthesis. Since the teeth become integral part of the prosthesis, in most instances the bonding seems satisfactory although fracture can occur.[5] Two processes affect the achievement of chemical bond between teeth and denture base resin. First the polymerizing denture base resin must come into physical contact with denture tooth, and second, the polymer network of the denture base resin must react chemically with the denture tooth.[2]

Besides contamination,[6] variables that effect bond strength between acrylic teeth and denture base resin

[1] Professor, Prosthodontic, AFID, Rawalpindi
[2] Asst Prof, Baqai Dental College, Karachi
[3] Asst Prof, Bhitai Dental and Medical College, Mirpurkhas, Sindh, Email: atif_jawad@hotmail.com Tel: 0300-8544867
[4] Asst Prof , Women Dental College, Abbottabad
[5] Lecturer, Baqai Dental College, Karachi

include the effects of resin dough time, tooth surface, tooth surface conditioning, processing variables, monomer cementation and acrylic resign cement, temperature of curing, degree of cross linking in the material and the available monomer during processing.[5-8]

Techniques for bonding denture teeth to an acrylic resin denture base remain empirical, with little consensus from literature, among clinicians, or among dental laboratories.[4] Chemical or mechanical preparation of tooth surface prior to bonding has mixed results on bond strengths. Treating tooth surface with the monomer of denture resin i.e. methyl meth acrylate (MMA) either compromised or had no effect on the bond strength of heat cured denture resins. Monomer application to denture teeth also compromised bonding to an autopolymerizing resin. Conversely, monomer application improved the bonding between denture teeth and microwave cured acrylic resin. Applying (MMA) liquid, dichloromethane or trichloromethane, with the anticipation that the solvent would enhance the monomer diffusion and polymer network formation, have controversial results in different researches.[2]

Improve bond strength by mechanical preparation of denture teeth can either increase or have no effect. Vertical grooves placed on anterior denture teeth enhance their bonding yet the advantage of horizontal grooves is unclear.[2]

With increased use of dental implants and the commensurate increase in forces applied to prosthetic components, tooth de-bonding will become even greater clinical problem.[4] The optimal combination of acrylic resin denture tooth, denture base material, and processing method is not known.[9] Systematic studies to compare commonly used bonding techniques are lacking. Collection of data will improve our understanding in manipulating materials and using them to their best without any extra effort and cost.

METHODOLOGY

180 cross-linked abrasion-resistant acrylic resin maxillary central incisors (Super Resin Teeth manufactured by Hatakeyama Dental Mfg. Co., Osaka, Japan) were included in this study. They were divided into 6 groups of 30 each.

Group 1 No surface modifications done.

Group 2 Horizontal grooves 2mm deep and 2mm wide made on ridge lap surfaces of teeth with a cylindrical fissure bur.

Group 3 Vertical grooves 2mm deep and 2mm wide cut into the ridge lap surfaces of teeth with a cylindrical fissure bur.

Group 4 Ridge lap surfaces prepared for a diatoric, 2mm deep and 3mm wide, drilled on the palatal surfaces of teeth.

Group 5 Ridge lap surfaces sand blasted with 250micron grit in sand blasting machine. (Provomomatic, manufactured by BEGO Inc Germany).

Group 6 Ridge lap surfaces roughened with bur (Goldies, Titanium Nitride coated Carbide bur No 8011 shape 47-XC manufactured by Dedeco international, Inc. USA.)

All groups of teeth were cured at 74°C for 8 hours in an electric curing unit (EVL 5520 manufactured by Kavo Inc. West Germany).

Teeth representing each of the 6 groups were manually positioned into prefabricated wax blocks. Teeth were visibly inspected under magnification to confirm complete seal between denture teeth and wax block. Wax blocks were made of standard dimensions, roughly the long axes of teeth about 45° with base of block. Eighteen (18) blocks were made with 10 teeth on each block. One wax pattern was sealed in one flask and invested in hard plaster (Shofu Inc). Flasks were boiled in water for 10 minutes and after opening, rinsed with boiling water for one minute to remove any residual wax. Flasks were allowed to cool at room temperature. Than separating agent (Cold Mould Seal, manufacture by PSP dental, UK) was applied with the help of a brush, avoiding contact with exposed tooth surfaces, and allowed to dry. Heat cured acrylic resin (Stellon C manufactured by BD Inc. England) was mixed and packed according to manufacturer's instructions in molds at dough stage. Trial packing was done and excess material was removed after placing it in a bench press. Curing was carried out in water bath at 74°C for 8 hours.

After curing, acrylic blocks were removed from the flasks, finished and polished and were checked for any

defects. Specimen with any porosity, damaged or cracked specimen, teeth damaged during processing, cracked or chipped teeth, any break at tooth-acrylic resin interface were excluded form study. If found satisfactory, they were selected for testing.

Compressive shear load was applied on incisal edge with a 5mm tip by universal testing machine (Instron model 1122, manufactured by Instron Co., Massachusetts) at 45° from the long axis of each tooth. For all specimens, the interface where failure occurred was inspected to determine adhesive or a cohesive failure.

Statistical Package for Social Sciences (SPSS) version 10 was used to analyze the data. Mean and standard deviation was computed. Statistical significance was identified by applying One Way ANOVA and Chi-square tests at 95% confidence interval.

RESULTS

Mean force required for bond failure is given in Table 1.

Group 4 (diatoric) and Group 5 (sand blasting) showed statistically significant difference in bond failure ($P<0.05$) while all the other groups did not show any statistically significant difference.

The mean lowest force required for bond failure was seen in group 5 (157±79 N) while the mean highest force required for bond failure was of group 4 (374±78 N).

Distribution of mode of failure according to different groups is given in Table 2. 63.3% teeth failed adhesively i.e. at tooth-denture base resin interface and 31.7% teeth failed cohesively.

TABLE 1: THE MEAN FORCE REQUIRED UP TO BOND FAILURE

Groups	Force (N)	P-value
Group 1	231 ± 44	0.341
Group 2	247 ± 19	0.341
Group 3	235 ± 50	0.791
Group 4	374 ± 78	0.000*
Group 5	157 ± 79	0.000*
Group 6	225 ± 9	0.747

Key: Given in column 2 are mean and standard deviation.

*Shows the statistical significance between the groups.

TABLE 2: DISTRIBUTION OF MODE OF FAILURE ACCORDING TO DIFFERENT GROUPS

Groups	Adhesive Failure	Cohesive Failure
Group 1	90%	10%
Group 2	63.3%	36.7%
Group 3	50%	50%
Group 4	3.3%	96.7%
Group 5	93.3%	6.7%
Group 6	96.7%	3.3%

The lowest number of adhesive failure was seen in group 4 (96.7%). All adhesive failures were at the tooth-denture base resin interface; there was a clean separation.

Approximately all the teeth for cohesive failure fractured at tooth surface. The lowest number of cohesive failure was found in group 6.

DISCUSSION

This study showed that denture tooth modifications can result in significant differences in the failure load when highly cross-linked teeth are processed with conventional heat cured acrylic resin.

Failure loads were significantly higher with diatoric, although vertical grooves also displayed increased bond failures as compared to controls.

Comparing our results to other investigators poses difficulties, because of method differences and the difficulty in isolating the variables in each of the 5 treatment groups, yet some comparisons show interesting similarities.

Takahashi et al[2] worked on 3 different denture base resins and 3 different types of denture teeth, the ridge lap surfaces of denture teeth were treated with chemical solvents, dichloromethane or prepared for a diatoric. Their results showed that conventional acrylic resin denture base material bonds better with conventional resin denture teeth as compared to highly cross-linked denture teeth. They also showed increase in bond strength if diatroic was placed with no difference of debonding force between conventional and highly cross-linked teeth. Results of this study regarding diatorics were consistent with the above mentioned study where

diatoric had higher bond strength than the controls and nearly all the failures were cohesive.

Comparing effects of different types of horizontal grooves i.e. prepared with inverted cone bur, round bur and fissure bur found no statistically significant difference between test groups and controls. This is also in consistence with the present study.[10]

Cardash et al[9] in another study compared the effects of vertical and horizontal grooves on ridge lap surface of denture teeth bonded with standard and high impact acrylic resin for central incisor, lateral incisor and canine. They found that vertical grooves showed superior retention in all tooth types than the horizontal grooves, suggesting that vertical grooves are closer to the point of application of the force and a short lever arm requires a greater force to separate the tooth from denture base.[4] This finding is also consistent with this study although we failed to find statistically significant for the vertical and horizontal groove groups.

Barpal[8] et al compared two different type of acrylic resin bonded to highly cross-linked teeth and found that diatoric increases the bond strength with one type of resin and decreased with other type of resin. Showing consistency with results of present study.

Cunningham et al[11] investigated number of different variables and found vertical grooves to be of no significant value, however teeth prepared with burs showed mean increase in bond strength but it was not significant. These findings are consistent with this study as it was found that mean force required was higher than the controls. Moreover, mean failure load for vertical groove was higher than horizontal groove which was in turn better than unmodified tooth surface, but not statistically significant. One of the reasons for increase in failure load might be the increase in surface area by formation of grooves.

Effects of retention grooves made on ridge lap surfaces were studied by Can G and Kansu G[1] found that retention grooves provided mechanical retention and greater amount of force was required for bond failure which was cohesive in nature i.e. with indenture base. This finding is consistent with the present study, as teeth diatorics failed cohesively and teeth with vertical and horizontal grooves required higher but non-significant force for debonding.

Schneider and colleagues[6] used tensile test to compare bond strength between denture bases made of heat and microwave cured acrylic resin with four different types of denture teeth. Their result suggested better bond between heat cured denture base resin and with all types of teeth similar to a study performed by Clancy and Boyer.[7]

Morrow et al[12] in a similar study compared effects of bonding between high impact and conventional denture base resin with plastic teeth and found high impact resin to have greater values of bond failure. Suzuki et al[13] concluded that as the hardness of denture teeth increased, the bond strength decreased.

Saavedra and colleagues[14] compared the effects of sand blasting of ridge lap surface with 110 micron Aluminium oxide particles on two different types of teeth and three types of acrylic resins and found it to be insignificant. This is in contrast with our study in which bond strength actually decreased after sand blasting. This difference can be explained by time of sand blasting as it was done before dewaxing in this study, leaving residual wax on rough surface which made efficient dewaxing difficult.

Barpal[8] et al found that sandblasting the ridgelap surface have improved failure load when used with Lucitone but did not have any effect on Ivocap. That is not in accordance with the present study in which failure load has decreased significantly.

Civjin et al[10] found that grinding of tooth surface increased bond strength with self cured acrylic. The increased bond strength was not statistically significant in this study.

Huggett et al[15] compared bond strength between three different types of surface treatments, grinding, and making a retention groove and found that there was no improvement in bond strength between these groups. This finding is in general agreement with the present study.

Chung et al[16] used roughening the ridge lap surface with sandblasting and burs and found that both increased bond between denture base and acrylic teeth with sandblasting showing higher failure loads which is in contrast to this study.

Saavedra G17 in a study compared different surface modifications and found sand blasting better than no

surface modification in tensile test in contrast to the present study, he found chemical + mechanical modification provide maximum adhesion.

It has been found by reviewing literature and comparing our results to the present date studies that a wide variety of denture base materials and artificial teeth are available. The best possible combination must be identified between denture teeth and denture base resins. There is lack of information regarding the use of reinforced denture base acrylics and their effects on bond between denture teeth and denture base resin.

Therefore, it is suggested that broad based survey with variety of different combinations of denture base resins, denture teeth and surface modifications must be carried out. It has also found that there is no universally accepted standard for bond strength evaluation. Hence, it is suggested that there should be uniformity in the evaluation system of bond failure. It was also observed that there is lack of sufficient data which can provide the dentist and the technician the knowledge that can be used best in the favor of the profession. Further research work needs to be carried out to this end.

CONCLUSION

This investigation tested the shear compressive bond strength of heart cured acrylic with cross-linked resin teeth with different ridge lap surface modifications. We have identified a positive relation between diatorics, vertical grooves, horizontal grooves on the ridge lap areas of denture teeth in terms of improving their bond strength to acrylic resin denture bases. It has also been found that sand blasting, if performed, must be carried out after dewaxing although it appeared that this procedure failed to improve the bond strength of denture teeth. It seems that these procedures are time consuming and difficult, but a little extra effort during denture processing can save the dentist and the technician valuable time otherwise spent on denture repairs.

REFERENCES

1 Can G, Kansu G. An evaluation of bond strength of plastic teeth to acrylic denture base material. Ankara Univ Hekim Fak Derg 1990;17:97-101.

2 Takashi Y, Chai J, Takashi T, Habu T. Bond strength of denture teeth to denture based resin. Int J Prosthodont 2000;13:59-65.

3 Darba UR, Huggett R, Harrison A, Williams K. The tooth-denture base bond: stress analysis using the finite element method. Eur J Prosthodont Restor Dent 1993;1:177-20.

4 Kim JY, Pfeiffer P, Niedermeier W. Effect of laboratory procedure and thermocycling on the shear bond strength of resin-metal bonding system. J Prosthet Dent 2003;90:184-89.

5 Kawara M, Carter JM, Ogle RE, Jhonson RR. Bonding of plastic teeth to denture base resins. J Prosthet Dent 1991; 66:566-71.

6 Schneinder RL, Curtis ER, Clancy JMS. Tensile bond strength of acrylic resin denture teeth to microwave-or heat-processed denture base. J Prosthet Dent 2002;88:145-50.

7 Clancy JMS, Boyer DB. Comparative bond strengths of light-cured, heat-cured and auto polymerizing denture resins to denture teeth. J Prosthet Dent 1989;61:457-62.

8 Barpal D, Curtis DA, Finzen F, Pery J, Gansky SA. Failure load of acrylic resin denture teeth bonded to high impact acrylic resin. J Prosthet Dent 1998;80:666-71.

9 Cardash HS, Applebuam B, Liberrman R. Effects of retention grooves on tooth-denture based bond strength. J Prosthet Dent 1990;64:492-96.

10 52 Civjan S, Huget EF, de Simon LB. Modiofications of fluid resin technique. J Am dent Assoc 1972;85:109-12.

11 Cunningham JL, Benington IC. An investigation of the variables which may affect the bond between plastic teeth and denture base resin. J Dent 1999;27:129-35.

12 54 Morrow RM, Matvias FM, Windeler AS, Fuchs RJ. Bonding of plastic teeth to two heat-cured denture base resins. J Prosthet Dent 1978;39:565-68.

13 55 Suzuki S, Sakoh M, Shiba A. Adhesive bonding of denture base resins to plastic denture teeth. J Biomed Mater Res 1990;24:1091-1103.

14 42 Saavedra G, Neisser MP, Sinhorti MA, Machado C. Evaluation of bond strength of denture teeth bonded to heat polymerized acrylic resin denture bases. Braz J Oral Sci 2004;3:458-62.

15 57 Huggett R, John G, Jagger RG, Bates JF. Strength of acrylic denture base tooth bond. Br Dent J 1982;153:187-90.

16 Chung KH, Chung CY, Chan DC. J Oral Rehabil 2008;35: 268-75.

17 Saavedra G, Valandro LF, Leite FP, Amaral R, Ozcan M, Bottino MA, Kimpara Et. Int J Prosthodont. 2007;2:199-201.