

EFFECT OF DIFFERENT MECHANICAL SURFACE TREATMENTS ON BOND STRENGTH OF ACRYLIC TEETH TO POLYAMIDE DENTURE BASE

Alaa Aaser Soliman ^{*}, Mohamed Nabeel Elgendy ^{**} and Mohamed M. El-Sheikh ^{***}

ABSTRACT

Purpose: To compare the effects of three surface treatments on bond strength between acrylic teeth and polyamide denture base.

Material and Methods: 60 specimens, each composed of maxillary central acrylic cross-linked incisor tooth processed onto thermoplastic polyamide denture base according to the Japanese Standards Association 6506. Test specimens were divided according to the experimental design: Surface treatments (sandblasting, T-shape diatoric holes, or both). The specimens were then subjected to shear load with the Universal Testing Machine. Load was applied till denture teeth separated from the base resin. The resulting debonding forces were recorded and statistically analyzed by using T student-test and ANOVA test followed by Tukey HSD test. The interface where failure occurred was inspected to determine the type of failure whether adhesive or cohesive.

Results: Statistical significant differences were found in bond strength among the different surface treatment groups ($P < 0.05$).

Conclusion: Within the limitations of this in-vitro study, under normal storage condition, it can be concluded that sandblasting of the diatoric holed teeth give the highest bond strength.

KEY WORDS: Bond strength, Diatoric hole, Sandblasting, polyamide denture

INTRODUCTION

The integrity of removable dentures depends mainly on the bond strength between denture teeth and denture base ¹; however, debonding of denture teeth from denture base is a common mode of failure in prosthetic dentistry. Schnoover et al., were

the first to study bond strength of teeth and denture base resins.² Since then; studies have been made to evaluate bonding of acrylic teeth to denture base resins.³

Bond strength of denture teeth to denture base is mainly related to the properties of both

* Demonstrator, Department of Prosthetic Dentistry, Faculty of Dentistry, University of Tanta, Egypt.

** Lecturer, Department of Prosthetic Dentistry, Faculty of Dentistry, University of Tanta, Egypt.

*** Professor, Department of Prosthetic Dentistry, Faculty of Dentistry, University of Tanta, Egypt.

materials.⁴Acrylic cross-linked teeth have poor bonding to denture base resin because of their crystalline structure as well as less available unlinked polymer chains for creation of interwoven polymer network between the teeth and denture base.⁵

Bond strength of teeth to heat cure acrylic base is greater than their bond to thermoplastic base³ because the bond to thermoplastic base resin is purely mechanical, so the problem of teeth detachment which was already present with heat cure acrylic base is increased with thermoplastic polyamide.⁶

Several studies have been done to enhance the bond strength of acrylic teeth to denture base which can be categorized into: Mechanical and Chemical modification of ridge lap or combination of both.⁸ Mechanical modification include micromechanical or macromechanical treatment⁵ as grinding, cutting retention grooves and diatorics^{8,9} and high-energy abrasion¹⁰.

This study was carried out to evaluate the effect of 3 different types of mechanical surface treatments on the bond strength between acrylic cross-linked teeth to thermoplastic polyamide denture base.

The null hypothesis was that there is no difference in bond strength among different surface treatments of acrylic teeth.

MATERIALS AND METHODS

A total of 60 acrylic cross-linked maxillary central incisor denture teeth (Acry Rock V teeth; Ruthenium group; mould size S67) were used with thermoplastic polyamide denture base (breflex 2nd edition, Bredent) were used as the denture base material.

60 wax test specimens were prepared and divided into: 3 subgroups, 20 each, according to the experimental design illustrated in Table 1.

TABLE (1): The experimental design

Groups	Surface treatment	Number of specimens
G I	Sandblasting	20
G II	T-shape diatoric holes	20
G III	T-shape diatoric holes with sand blasting	20

Test specimens were prepared simulating clinical condition, as described in Japanese Standards Association No.6506.⁹ Master specimen was prepared by aligning the teeth long axis at 45 degree to the base of a wax block, of size (10mmX10mmX30mm) with ridge lap contacting the base (Fig.1). A metal die was fabricated by using the master specimen. Silicone mold was fabricated by taking impression of the metal die. The cross-linked acrylic teeth of same brand and size were placed in the mold and molten wax was flown into it to form the specimen base. Angulation was measured with a profile projector to rule out any alignment discrepancy.

The waxed patterns were flaked in metal flasks. After dewaxing, flasks were allowed to cool at room temperature (Fig.2) then separating medium was applied to the stone and let to dry.

Surface treatments:

- *Group I* : 20 specimens were sandblasted with sandblasting machine (Renfert, Basic eco).
- *Group II*: 20 specimens were prepared with T-shape diatoric holes at ridge lap.
- *Group III* : 20 specimens were prepared with T-shape diatoric holes then sandblasted as in group I.

Diatoric holes preparation and standardization

One tooth was used to create a jig as described by Olive to ensure that all teeth had diatorics in exactly the same position, thus eliminating variables during testing.¹¹

Storage of the specimens

All finished specimens were stored in distilled water for 50 hours (h) at 37°C in digital incubator (Biotech company) according to the revised A.D.A specification no.12 for denture base polymers.¹²

Testing method

Each specimen was held securely in a stainless steel jig of the Universal Testing Machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) to avoid any change in position. The specimens were then subjected to shear load at 45 degree from the tooth long axis on the palatal surface (Fig.3) with cross head speed of 1mm/minute. All tests were done under uniform atmospheric conditions of $23\pm 10^\circ\text{C}$ temperature. Load was applied till the teeth separated from the base. The resulting debonding forces were recorded in newton (N) and statistically analyzed.

The failure interface was inspected and classified into 2 categories: Adhesive: if fracture occurred at tooth resin interface, Cohesive: if fracture occurred within resin or tooth.

Statistical analysis:

Data were collected, tabulated and statistically analyzed using T student-test and ANOVA test followed by Tukey HSD test if P value ≤ 0.05 , (SPSS 20; Inc. Chicago, USA). P values ≤ 0.05 were considered to be statistically significant in all tests.



Fig. (1): Test specimen

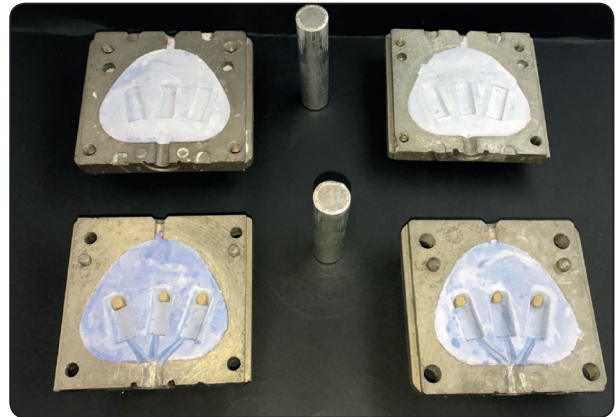


Fig. (2): Flasks after dewaxing

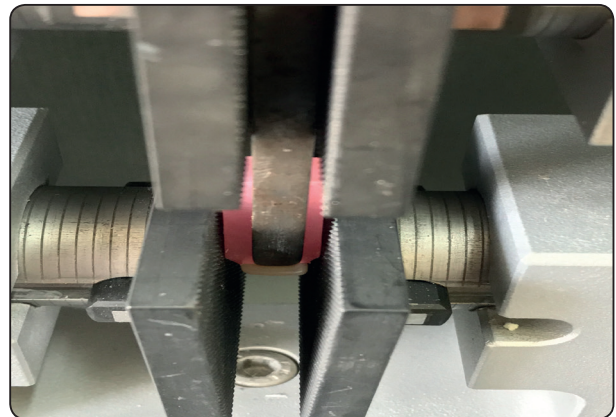


Fig. (3): Universal testing machine

RESULTS

Effect of surface treatments

Mean debonding forces and standard deviation \pm SD are listed in Table 2.

Mean debonding force for G II was significantly higher than GI, ($P \leq 0.05$). Mean debonding force for G III was significantly higher than G I and GII ($P \leq 0.05$).

Mode of failure

Distribution of mode of failure in different groups is given in Table 3. It showed that the failure mode was adhesive failure in all the experimental groups.

TABLE (2): Mean debonding force in different surface treatments

	Range			Mean	±	(SD)*	F. test	p. value		
		–								
G I (sand blasting)	21.49	–	35.91	29.36	±	(5.91)	149.56	.001*	P1	0.001†
G II (T-shape diatoric holes)	35.74	–	45.79	39.72	±	(3.96)				
G III (T-shape diatoric holes with sand blasting)	58.04	–	65.76	61.47	±	(2.67)				

*: *Standard deviation*

†: *statistical significant differences*

TABLE (3): Distribution of mode of failure according to different groups

Groups	Adhesive failure	Cohesive failure
G I (Sand blasting)	100%	0%
G II (T-shape diatoric holes)	100%	0%
G III (T-shape diatoric holes with sand blasting)	100%	0%

DISCUSSION

The null hypothesis was rejected as the bond strength was different among different mechanical surface treatments of acrylic teeth.

The Japanese standard JIS T No.6506 was followed as it is much more clinically acceptable because it involves the true shape of anterior teeth and simulates the direction of shear and compressive loads more accurately.^{9,13}

Mechanical surface treatment was done after wax elimination because if the T-shape diatorics

are drilled during setup and in case of faulty de-waxing, some wax may remain in the diatorics, causing incomplete flow of the molten polyamide. A weakened three-finger design will result as found by Singh et al. and Yunus et al.¹⁴

All specimens were stored in distilled water at 37 ± 1 °C for 50 ± 2 h before testing according to the revised A.D.A Specification No.12 for denture base polymers.¹²

Regarding the effect of mechanical surface treatment, the highest debonding force was recorded in group III (diatorics with sandblasting). This is consistent with Bhochohibhoya et al.¹⁵ and Takahashi et al.,⁹ who found that diatoric preparation improved the bond strength to acrylic resin denture base. Also, Fletcher et al.,¹⁶ explained why surface roughening improves the bond strength, by the fact that the surface energy of newly exposed acrylic was different from that of unprepared acrylic.

However, Buyukyilmaz et al.,¹⁷ did not find any significant advance in bond strength with diatoric preparation. Bragaglia et al.,¹³ explained acrylic base material failure in the diatorics by the borders sharpness that might cause stresses concentration.

CONCLUSION

Within the limitations of this in-vitro study it can be concluded that Sandblasting of the acrylic teeth gives the lowest bond strength; on the other hand, sandblasting of teeth having t-shape diatoric holes gives the highest bond strength.

REFERENCES

1. Saavedra G, Valandro LF, Leite FPP, et al. Bond strength of acrylic teeth to denture base resin after various surface conditioning methods before and after thermocycling. *Int J Prosthodont.* 2007;20(2):199-201.
2. Schoonover IC, Fischer TE, Serio AF, Sweeney WT. Bonding of plastic teeth to heat-cured denture base resins. *J Am Dent Assoc.* 1952;44(3):285-287.
3. Abass SM, Abdulsahib AJ, Khalaf BS. Bond strength of acrylic teeth to heat cure acrylic resin and thermoplastic denture base materials. *J Kerbala Univ.* 2011;9(4):35-44.
4. Kawara M, Carter JM, Ogle RE, Johnson RR. Bonding of plastic teeth to denture base resins. *J Prosthet Dent.* 1991;66(4):566-571.
5. Shankar YR, Krishna P SS, Srinivas K. Evaluation of bond strength of acrylic teeth to the denture base resins with chemical surface treatment and mechanical modification-an in-vitro comparative study. *Baba Farid Univ Dent J.* 2014;5(1):169-178.
6. Ditolla M. Flexible, esthetic partial dentures. *Chairside Perspect Mag.* 2004;5(1).
7. 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(2):129-135.
8. Barpal D, Curtis DA, Finzen F, Perry J, Gansky SA. Failure load of acrylic resin denture teeth bonded to high impact acrylic resins. *J Prosthet Dent.* 1998;80(6):666-671.
9. Takahashi Y, Chai J, Takahashi T, Habu T. Bond strength of denture teeth to denture base resins. *Int J Prosthodont.* 2000;13(1):59-65.
10. Moffa JP, Jenkins WA, Weaver RG. Silane bonding of porcelain denture teeth to acrylic resin denture bases. *J Prosthet Dent.* 1975;33(6):620-627.
11. Olive Van Der N. Mechanical retention of acrylic teeth onto a pure nylon base. 2014.
12. Amaral R, Ozcan M, Bottino MA, Valandro LF. Micro-tensile bond strength of a resin cement to glass infiltrated zirconia-reinforced ceramic: the effect of surface conditioning. *Dent Mater.* 2006;22(3):283-290.
13. Bragaglia LE, Prates LHM, Calvo MC. The role of surface treatments on the bond between acrylic denture base and teeth. *Braz Dent J.* 2009;20(2):156-161.
14. Singh JP, Dhiman RK, Bedi RP, Girish SH. Flexible denture base material: A viable alternative to conventional acrylic denture base material. *Contemp Clin Dent.* 2011; 2(4):313-317.
15. Bhoohhibhoya A, Mathema S, Maskey B. An evaluation on effect of surface treatment and mechanical modifications on shear bond strength between acrylic denture teeth and heat cure acrylic denture base resin. *EC Dent Sci.* 2016;6(6):1450-1462.
16. Fletcher AM, Al-Mulla MA, Amin WM, Dodd AW, Ritchie GM. A method of improving the bonding between artificial teeth and PMMA. *J Dent.* 1985;13(2):102-108.
17. Buyukyilmaz S, Ruyter IE. The effects of polymerization temperature on the acrylic resin denture base-tooth bond. *Int J Prosthodont.* 1997;10(1):49-54.