

Tensile Bond Strength of Acrylic Resin Teeth to Denture Base Repair Resin

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Abstract— The aim of this study is to evaluate the effect of different surface treatments of the artificial acrylic teeth on the bond strength to Denture Base Repair Resin.

Fifty acrylic cylinders were milled from large size acrylic molars. The cylinders were then randomly assigned to five experimental groups, each containing ten cylinders. The flat surfaces were considered as bonding areas. The surface treatment regimens were:

Group 1: polished (control group), Group 2: polished+methyl methacrylate, Group 3: sandblasting + methyl methacrylate, Group 4: sandblasting+universal repairing adhesive (Clearfil Repair-Kuraray), Group 5: polished+dichloromethane. All sandblasting procedures were realized using 50 µm alumina (30 seconds), from a distance of 10 mm. A self-cured denture base repair resin (Duracryl – Spofa Dental) was used for manufacturing the bonding test specimens, according to the ADA specification No. 15. After 30 days of water storage, each specimen was tested in tensile at a speed of 1 mm/min. Tensile bond strength mean values were statistically significant among groups, ranging from 13,5 MPa (group 4) to 35,9 MPa, the latter pertaining to group 5. Dichloromethane treatment leads to enhanced bond strength to the artificial teeth and may be considered as a laboratory and clinical procedure as well, in order to improve the quality of bonding.

Keywords - acrylic teeth, chemical treatment, denture base resin, dichloromethane, tensile strength.

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I. INTRODUCTION

Complete dentures acrylic teeth detachment, even if it does not generate a physical suffering similar to the loss of a natural tooth, surely, from the psychological point of view, could be considered a tragedy for the patient, whatever his age or social position are. Acrylic teeth adhesion to denture base resin generates the longevity of the complete denture, for this reason the acrylic tooth becomes part of the whole: the complete denture. The detachment of acrylic teeth from complete denture bases, especially those that restore the complete denture frontal area, achieves values between 20%-30%. [1], [2].

The main directions of investigation of the interfaces between artificial teeth and denture base resin were aimed at determining the factors that are generating negative or positive influences to the adherence of the teeth to the denture base, factors such as: 1. Teeth and denture base resin manufacturing technology, 2. Factors involved in the laboratory technological steps of samples manufacturing: wax impurities [3]. or gypsum impurities [4], 3. Physical or chemical ridge lap area treatment agents (such as organic solvents, curing agents, monomers adhesives) [5] [6] [7] [8]. 4. The action time of physical and chemical agents on the acrylic tooth ridge lap area; 5. Technological methods for dough stage denture base acrylic resin preparation (the amount of monomer and polymer in accordance with the manufacturer's indications) 6. Acrylic resin denture base polymerization method (auto polymerization, heat polymerization, baropolymerization, microwave polymerization) [9] [10] [11]. Last but not least in terms of importance, some of the factors that may change the adhesion of acrylic teeth to denture base resin occur after the samples were made, namely water storage parameters. This paper aims to assess through tensile strength test, the effect of different treatment methods of the acrylic teeth ridge lap area on the adhesion to a self cured acrylic denture base resin.

II. MATERIALS AND METHODS

The null hypothesis is based on the idea that physical or chemical treatment of the "ridge lap area" does not improve the adhesion of acrylic teeth to denture base resin.

The samples were made so that their material, size and design to subscribe ADA specification No. 15.

A. As a first step

50 artificial acrylic first upper and lower molars (Spora Dental) were used for milling 6 mm diameter base and 5 mm height cylinders.

This method uses a keys milling device, JMA Dakar, Alexandro Altun, SA which allows milling in perpendicular planes.

To generate the 6 mm diameter and lateral surface of the cylinder, a 6 mm internal diameter trepan bur was mounted in the mandrels milling machine.

After the trepan bur was fixed to the mandrels JMA Dakar, and the artificial molars with the axial sides milled as parallel planes were clamped in to the jaws of the machine, the movement in vertical plane of the bur, at a minimum length of 7 mm inside the molars, under cooling water jet realized the lateral surface of the cylinder (Fig 1,2).

Maintaining the artificial molars clamped in the same position to the jaws of the machine and replacing the trepan bur with a diamond disc (Fig. 2), and moving it in a horizontal plane, perpendicular to the cervico-occlusal axis of the molars in mesio distal direction, at minimum 1 mm distance below the mucosal surface of the acrylic teeth, the first base of the cylinder was made.



Fig.1 JMA Dakar device (clamping jaws, trepan bur, acrylic tooth).



Fig.2. Acrylic molar flat milled ridge lap area.

The acrylic tooth with the milled lateral surfaces of the cylinder was removed from the clamping jaws of Dakar JMA. That allowed the removal of the acrylic tooth axial walls surrounding the lateral surface of the cylinder with a

cylindrical shaped bur. A solid cylindrical shape with 6 mm height and diameter, a flat base, the other base being still represented by the occlusal surface, was obtained (Fig. 3.).



Fig.3 The lateral surface of the cylinder

The cylindrical solid shape is fixed again in the clamping jaws of the milling machine, this time with the occlusal surface directed to the disc fixed in the Dakar s JMA mandrel. Moving the disc in mesio-distal way in a plane perpendicular to the cervico-occlusal axis of the cylindrical solid shaped body, to a predetermined length of 5 mm from the previously obtained, the second base of the cylinder was made (Fig. 4).



Fig.4. The flat milling of the second base of the cylinder



Fig.5. The final shape of the milled cylinders.

The final shape corresponds to a cylinder with a diameter of 6 mm and length 5 mm, subscribing the ANSI/ADA No. 15 (Fig. 6).

B. The second step

of the sample manufacturing, involves wax models preparation for the extremities of the samples.

The silicone putty impression of a metallic object generated the wax sample. The metallic object corresponds in shape and size of half wax sample. (Fig. 7a.). After casting, solidification and removal of the wax from the silicone putty impression, half of the wax samples were obtained, wax sample dimensions being equal to those of the imprinted metallic object (Fig. 7b.). By bonding two wax half models at the 6 mm diameter bases, a wax model of a whole sample was made at the size specifications set by ANSI/ADA No.15



Fig. 6a. The metallic object.



Fig.6b. Wax model of the metallic object

C. In the third step

patterns for future samples were made. 10 mould patterns suitable in size and design for the proper alignment of the 5 wax samples were used. Class four (IV) gypsum was chosen for the pattern manufacturing stage (Fig.7.). The manufacturing of the pattern involved the alignment in horizontal position of the wax models after gypsum paste preparation.



Fig. 7. Wax samples removed from plaster models.

D. The fourth step

refers to the treatment of the two flat bases resulted after the milling procedure of the acrylic molars. They were divided into five groups 10 cylinders each. The flat surfaces were considered as bonding areas. The surface treatment regimens were: Group 1: polished (control group), Group 2: polished+methylmethacrylate, Group 3: sandblasting + methylmethacrylate, Group 4: sandblasting+universal repairing adhesive (Clearfil Repair-Kuraray), Group 5: polished+dichlormethane.

All sandblasting procedures were performed using 50 μm alumina (30 seconds), from a distance of 10 mm. After the flat surfaces treatment, each cylinder belonging to the 5 groups was placed one by one in the middle of each of the five patterns of a mould, so that the bases obtained after cylinder milling to be located at equal distances from the extremities of the patterns (Fig.8).



Fig.8. Cylinders aligned in the mould patterns.

E. The final step

consisted in preparation and mould stamping of self cured acrylic denture base resin in the dough stage phase (Duracryl SPOFA Plus Dental, Kerr Company). The polymerization followed in accordance to the manufacturer's directions. (Fig. 9).

After completion of polymerization and unpacking, the samples were kept in distilled water for 30 days at a temperature of 37 degrees Celsius (Fig. 10)

Subsequently, the samples were tensile tested, using Multitest 5i (Mecmesin) at a speed of 1 mm / min (Fig. 11)



Fig. Nr.9 Acrylic resin dough stage tamping in the mould patterns



Fig. Nr.10. The shape and size of the sample corresponding to specification ADA / ANSI No.15

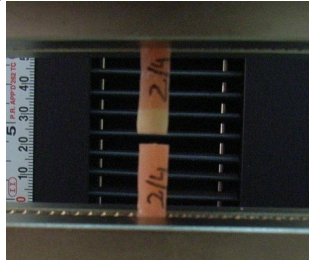


Fig. Nr.11. Sample fixed to the Mecmesin holding device before after the adhesive fracture

III. RESULTS

Tensile strength values to which one of the interfaces gives up are presented in Table I and are obtained by the formula $R = F / S$, where F = force and S = surface.

Table I

	Control Group I	Group II	Group III	Group IV	Group V
1	27,7MPa	29,3 MPa	29,8 MPa	11,1 MPa	35,4 MPa
2	26,4 MPa	26,8 MPa	27,9 MPa	16,8 MPa	32,8 MPa
3	27,2 Mpa	30,2 MPa	30,8 MPa	13,4 MPa	35,9 MPa
4	25,0 MPa	29,7 MPa	26,6 MPa	11,6 MPa	35,3 MPa
5	28,8 MPa	31,2 MPa	26,6 MPa	14,6 MPa	35,9 MPa
6	26,9 MPa	29,7 MPa	27,9 MPa	12,7 MPa	35,2 MPa
7	28,3MPa	30,7 MPa	30,0 MPa	13,8 MPa	35,5 MPa
8	27,5 MPa	30,4 MPa	28,6 MPa	14,5 MPa	34,3MPa
9	28,6 MPa	30,6 MPa	29,7 MPa	12,4 MPa	35,7 MPa
10	27,1 MPa	29,5 MPa	29,0 MPa	15,0 MPa	34,9 MPa

After statistical analysis of results (One-Way ANOVA) significant differences were found between group five and four, insignificant differences between group one, two and

three, and significant differences between group five and group one.

Table II

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2561,07	4	640,27	370,71	,000 ^s
Within Groups	77,72	45	1,73		Within Groups

In order to compare two by two the five groups, the option Post Hoc multiple comparisons, ANOVA test, was chosen, as follows:

Multiple Comparisons - Post Hoc "Scheffe" Test.

Significant differences between the five groups, with $\alpha = 0.001$.

Legend: s = significant differences

ns = not significant differences

Only groups I, II compared with III give insignificant differences.

Table III

(I) GROUP	(J) GROUP	Sig.	IV. SIG.LEVEL (α)
control	polished + MMA	,004 ^s	0.01
	sandblasting + MMA	,285 ^{ns}	0.05
	sandblasting + Kuraray	,000 ^s	0.001
	polished + CH ₂ Cl ₂	,000 ^s	0.001
polished + MMA	sandblasting + MMA	,468 ^{ns}	0.05
	sandblasting + Kuraray	,000 ^s	0.001
	polished + CH ₂ Cl ₂	,000 ^s	0.001
sandblasted + MMA	sandblasting + Kuraray	,000 ^s	0.001
	polished + CH ₂ Cl ₂	,000 ^s	0.001
sandblasted + kuraray	polished + CH ₂ Cl ₂	,000 ^s	0.001

V. DISCUSSION

The present study demonstrates that the different treatment of the acrylic teeth ridge lap area generates differences more or less significant in terms of acrylic resin denture base acrylic teeth tensile strength, differences that are in direct causal relationship with the type of treatment.

The results of this study showed that the tensile strength values are significantly different between group I (control) and group II (polished + MMA (methyl methacrylate)) ($\alpha = 0.01$), the group II (polished + MMA (methyl methacrylate)) being associated to higher values of tensile strength than group I (control). The explanation could be the one chosen by [12]. According to this the MMA (methylmethacrylate) treatment dissolves the PMMA (polymethyl methacrylate) structure and improves the adhesion between acrylic teeth and self cured acrylic denture base resin. Authors such as [13]-[14] found that, after there following studies, methyl methacrylate improves adhesion of acrylic teeth to denture bases, while, authors such as [15] support lower values of adhesion after methyl methacrylate treatment.

Comparing the control group (I) to the group V (polished + dichloromethane) it was found that the values of group V are significantly higher than those of the group I ($\alpha = 0.001$). Dichloromethane is a volatile organic solvent that applied to the ridge lap area of the acrylic teeth dissolves the superficial layer of the prefabricated high cross-linked polymer network, penetrating through polymer chains, expanding them, creating in this manner the premises to the presence of spaces between the polymers chains were MMA could penetrate. High values of tensile strength of acrylic teeth and denture base resin are obtained and explained by [16] based on the softening and "penetration" capacity of the solvent in the PMMA layer, practical the ability to achieve a new polymer intertwined network. Authors such as [17]-[18] have found an improvement in adhesion after treatment with dichloromethane

Lowest values of tensile strength were recorded in the Group IV (micro sandblasted + adhesive Kuraray). All these low values can be explained by the complex mechanism of adhesion. The low efficiency of Al_2O_3 micro sandblasting associated with the Clearfil Kuraray adhesive chemical treatment could find an explanation by the type of the monomer from the adhesive system, monomer represented by 10-methacrylate-oil-dihydrogen-phosphate-oxidecil. His monomer has a molecular structure represented by a hydrophobic $(CH_2)_{10}$ chain at whose extremities could be found a methacrylate group and a hydrophilic phosphate group represented by the radical $O = P(OH)$ responsible for performing a chemical bond between bivalent Ca^{2+} ions from the enamel structure and also with the bivalent ions from the composition of alloys used in prosthetic restorations. The polymeric structure of the acrylic teeth does not offer the potential to make new chemical bonds with 10-methacrylate-oil-oxidecil-dihydrogen-phosphate, fact which could explain the low values of adhesion for the group IV.

Reporting the group II (polished + MMA) to the group III (sandblasted + MMA) significant differences were found between the values of tensile strength of the two groups ($\alpha = 0.05$). These facts indicate that Al_2O_3 micro sandblasting associated to methyl methacrylate treatment do not improves significantly the adhesion of acrylic teeth to the denture base resin.

Within the limitations of this study related to the research methodology the increased adhesion of acrylic teeth treated with dichloromethane to denture base resin was demonstrated.

VI. CONCLUSIONS

A. Dichloromethane significantly improves the adhesion of acrylic teeth to denture base resin, tensile strength values recorded in the group V (polished + dichloromethane), being significantly higher than the amount stipulated by the ANSI/ADANr.15 (31 MPa), the acrylic teeth ridge lap area treatment with dichloromethane being considered as a leading treatment.

B. Micro sandblasting associated to MMA treatment do not cause statistically significant superior results compared to polishing.

C. The adhesive system Clearfil Kuraray is not indicated for complete denture repairs.

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