ARTIGO ORIGINAL

EVALUATION OF THE ADHESION OF SELF- AND HEAT-POLYMERIZED ACRYLIC RESINS TO ZANTEX AS A BAR FRAMEWORK FOR FULL-ARCH IMPLANT-SUPPORTED PROSTHESES

Avaliação da adesão de resinas acrílicas autopolimerizáveis e termopolimerizáveis ao Zantex como estrutura de suporte para próteses de arco total implantossuportadas

ISSN: 2178-7514

Vol. 18 | Nº. 1 | Ano 2026

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ABSTRACT

This study was conducted with the aim of analyzing the bond strength of self- and heat-polymerized acrylic resins to a fiberglass-reinforced material (Zantex) used as bar frameworks for full-arch implant-supported prostheses. Self-polymerized Vipi Flash, heat-polymerized VipiCril Plus, heat-polymerized Clássico, and self-polymerized Jet acrylic resins were evaluated. The study compared the effectiveness of adhesion in specimens that received surface treatment (aluminum oxide sandblasting) with those that did not receive any treatment. The shear bond strength test, performed after thermocycling, allowed the assessment of whether surface treatment and resin type influenced bond strength. The results demonstrated that surface treatment by sandblasting significantly increased bond strength values ($p < 0.001$), regardless of the acrylic resin used. In addition, the type of resin also had a statistically significant effect on bond strength ($p = 0.004$). Significantly higher bond strength values were obtained with Vipi Flash (self-polymerized), VipiCril Plus (heat-polymerized), and Jet (self-polymerized) resins compared with the Clássico (heat-polymerized) resin.

Keywords: Acrylic resins; adhesion; dental prosthesis.

RESUMO

Este estudo foi conduzido com o objetivo de analisar a resistência de união de resinas acrílicas autopolimerizáveis e termopolimerizáveis a um material reforçado com fibra de vidro (Zantex) utilizado como estrutura de barras para próteses totais implantossuportadas. Foram avaliadas as resinas acrílicas autopolimerizáveis Vipi Flash, termopolimerizáveis VipiCril Plus, termopolimerizáveis Clássico e autopolimerizáveis Jet. O estudo comparou a eficácia da adesão em espécimes que receberam tratamento de superfície (jateamento com óxido de alumínio) com aqueles que não receberam nenhum tratamento. O teste de resistência de união ao cisalhamento, realizado após termociclagem, permitiu avaliar se o tratamento de superfície e o tipo de resina influenciaram a resistência de união. Os resultados demonstraram que o tratamento de superfície por jateamento aumentou significativamente os valores de resistência de união ($p < 0,001$), independentemente da resina acrílica utilizada. Além disso, o tipo de resina também apresentou efeito estatisticamente significativo na resistência de união ($p = 0,004$). Valores de resistência de união significativamente maiores foram obtidos com as resinas Vipi Flash (autopolimerizável), VipiCril Plus (polimerizável a quente) e Jet (autopolimerizável) em comparação com a resina Clássico (polimerizável a quente).

Palavras-chave: Resinas acrílicas; adesão; prótese dentária.

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INTRODUCTION

For full-arch oral rehabilitations, implant-supported full-arch prostheses are currently the most commonly used. Traditionally, these prostheses are fabricated with a metal alloy framework, such as Co-Cr and Ni-Cr, veneered with an esthetic material. However, these materials present disadvantages, including high rigidity, which hinders the dissipation and absorption of stresses generated by the implants, potentially resulting in mechanical failures, such as screw loosening, or biological complications, such as peri-implant bone loss[1]. In order to minimize these effects, several authors have investigated alternative metal-free materials to replace metal alloys as the primary framework material for this type of procedure[2].

The most commonly used esthetic material to veneer these frameworks is polymethyl methacrylate (PMMA) acrylic resin. Introduced in the 1940s, PMMA remains widely used in daily clinical practice because it meets prosthetic esthetic requirements, has simple processing, and low manufacturing cost[3]. It can be polymerized by different methods, including heat, light, chemical, and microwave energy[4]. However, the bond between the acrylic resin and the framework represents a clinical challenge. Differences in thermal expansion coefficients and polymerization shrinkage of the resin may generate stresses at the interface, resulting in inadequate adhesion, crack formation, and microleakage, which becomes a gateway for bacterial colonization and compromises treatment success[5].

In this context, the search for new framework materials aims not only to optimize biomechanical behavior but also to improve compatibility with veneering materials. Among the alternatives, high-performance polymers stand out. PEEK, a polymer from the polyetheretherketone family introduced into dentistry in 1992, exhibits high chemical and mechanical resistance, thermal stability, and biocompatibility. With favorable flexural properties and fracture resistance, it can be used in the fabrication of dental prostheses through CAD-CAM systems[6,2].

Another promising alternative is polymer matrix composites reinforced with fibers (FRCs). With more than 50 years of use in dentistry, the evolution of these materials aimed at improving their mechanical properties has made them an excellent alternative to metal frameworks. Their biomechanical performance is influenced by the type of fiber, volume fraction, architecture, orientation, and the quality of bonding with the resin matrix. FRCs may exhibit flexural strength comparable to or even higher than metals, with the advantage of a lower elastic modulus, which provides the ability to absorb energy from the masticatory cycle, resulting in improved stress distribution when compared with more rigid materials such as ceramics[7]. Recently, FRC blocks, such as Zantex, have been developed for

fabrication using CAD–CAM systems, allowing the production of frameworks with greater precision and reliability[8].

The success of an FRC framework, however, fundamentally depends on its microstructure. The manner in which fibers are arranged within the material determines its mechanical properties related to strength, toughness, and fatigue resistance. The incorporation of silanized filler particles increases hardness and strength, while fiber length and orientation define the effectiveness of reinforcement[9]. Unidirectional fibers, for example, provide an anisotropic effect with extremely high strength in a single direction, whereas bidirectional (woven) or multidirectional fibers offer more homogeneous properties, although with lower peak strength in a single direction when compared with unidirectional fibers[10]. Therefore, the choice of fiber architecture is crucial for the clinical performance of the prosthesis[11].

The purpose of this in vitro laboratory study was to evaluate and compare, by means of a shear bond strength test, the adhesion of four different types of acrylic resins to a fiberglass-reinforced composite CAD/CAM framework (Zantex).

MATERIALS AND METHODS

Experimental Design

In this study, the adhesion of self- and heat-polymerized acrylic resins to a fiberglass-reinforced material (Zantex Biofunctional Materials, FL, USA), used as bar frameworks for full-arch implant-supported prostheses, was evaluated.

The acrylic resins tested were VipiCril Plus (Toledo, Spain), Vipi Flash (Toledo, Spain), Clássico (Campo Limpo Paulista, São Paulo, Brazil), and Jet (São Paulo, São Paulo, Brazil).

The resins were divided into eight groups. For each group, ten specimens were used (n = 10), totaling 80 specimens. The sample size (n) of this study was determined based on a pilot study.

Fifty percent of the specimens underwent surface treatment by aluminum oxide sandblasting.

Specimen Preparation

The Zantex specimens were milled to dimensions of 5 × 10 × 10 mm and embedded in PVC tubes (Tigre, Castro, Brazil) with a height of 15 mm and a diameter of 0.5 inches, using high-viscosity epoxy resin (Redelease, São Paulo, Brazil), allowing the upper surface to remain with the Zantex area exposed.

All specimens were polished using a metallographic polishing machine (Aropol 2V, Arotec S.A. Indústria e Comércio, Cotia, SP, Brazil) to remove any excess acrylic resin remaining from the PVC tube embedding process. For polishing, a sequence of 3M wet silicon carbide abrasive papers (3M do Brasil, Sumaré, São Paulo, Brazil) was used in the

following grit sequence: 600, 800, 1200, and 1500 for 30 s each, at 300 rpm. To standardize this step, specimens from the same group were bundled together using two seals.

After embedding, the Zantex specimens were cleaned using a gentle stream of pressurized steam.

Group Allocation

The test groups were divided as follows:

Group 1: Self-polymerized Vipi Flash (Vipi, Polígono Industrial, Toledo, Spain) bonded to Zantex with surface treatment.

Group 2: Self-polymerized Vipi Flash (Vipi, Polígono Industrial, Toledo, Spain) bonded to Zantex without surface treatment.

Group 3: Heat-polymerized VipiCril Plus (Vipi, Polígono Industrial, Toledo, Spain) bonded to Zantex with surface treatment.

Group 4: Heat-polymerized VipiCril Plus (Vipi, Polígono Industrial, Toledo, Spain) bonded to Zantex without surface treatment.

Group 5: Heat-polymerized Clássico (Clássico, Campo Limpo Paulista, São Paulo, Brazil) bonded to Zantex with surface treatment.

Group 6: Heat-polymerized Clássico (Clássico, Campo Limpo Paulista, São Paulo, Brazil) bonded to Zantex without surface treatment.

Group 7: Self-polymerized Jet (Clássico, Campo Limpo Paulista, São Paulo, Brazil) bonded to Zantex with surface treatment.

Group 8: Self-polymerized Jet (Clássico, Campo Limpo Paulista, São Paulo, Brazil) bonded to Zantex without surface treatment.

Surface Treatment of the Specimens

Half of the samples were subjected to surface treatment, while the other half did not undergo any surface treatment. That is, groups 1, 3, 5, and 7 were subjected to surface treatment through sandblasting for 15 seconds with alumina powder ranging from 80–130 microns at a pressure of 2 bar, at a distance of 10 millimeters and an angle of 90°, as recommended by the manufacturer, ZANTEX. To ensure standardization, a 10mm rod was placed at the tip of the sandblaster nozzle to guarantee the same blasting distance for all samples.

Preparation of the acrylic resins

The self-curing resins to be tested were prepared using a standardized metal mold with dimensions of 5 mm in diameter by 3mm in thickness, which were manufactured on a mechanical lathe by the author of the study.

The heat-curing resins to be tested were prepared using the conventional flasking technique, by the lost-wax method, with standardized dimensions of 5 mm in diameter by 3 mm in thickness.

The flasking process consisted of placing the samples into the flask, followed by the application of a Zetalabor (Zhermack SpA-Via Bovo Bovazecchino, Badia Polesine, Rome,

Italy) wall. The flask was then subjected to curing using the lost-wax technique.

Thermocycling process

All specimens underwent thermocycling for 10,000 cycles using the MSCT-3 cycling equipment (Biopdi, São Paulo, Brazil) before being subjected to the shear test.

Shear test and failure mode

The specimens were subjected to the EMIC DL2000 universal testing machine (Instron Brasil Equipamentos Científicos Ltda, São José dos Pinhais, Brazil) for the shear test.

They were positioned perpendicular to the machine base for the shear test, with a force unit of 50 kgf and a crosshead speed of 0.5 mm/min.

The specimens were secured in a metal device measuring 40 mm in diameter, with a central square recess measuring 10 mm per side, and a transverse screw that holds a cylinder measuring 20 mm in length and 24 mm in diameter, which fit into the shear testing machine.

The mode of failure of the specimens was observed using a 40× stereoscopic magnifying glass and categorized as adhesive, cohesive, or mixed.

The collected data were recorded and subjected to the most appropriate statistical test.

Research location

The study was conducted in the materials testing laboratory at São Leopoldo Mandic College in Campinas, SP, Brazil.

Statistical Analysis

In verifying the assumptions of normal distribution and homoscedasticity, the presence of an outlier was identified in the group whose samples were heat-curing VIPICRIL PLUS acrylic resin bonded to Zantex without surface treatment. Excluding this data, which allowed for normal distribution, the comparison between the composite resins and the effect of Zantex surface treatment was performed using two-way analysis of variance. For multiple comparisons, Fisher's LSD test was employed. Statistical calculations were performed using SPSS 23 (SPSS Inc., Chicago, IL, USA) at a significance level of 5%.

RESULTS

Two-way analysis of variance indicated that there was no statistically significant interaction between the acrylic resin and the surface treatment of Zantex ($p = 0.478$).

Subsequently, a comparison between the acrylic resins was performed, revealing that they had a statistically significant effect on the shear bond strength with the glass fiber–based material (Zantex), regardless of whether it was subjected to surface treatment or not ($p = 0.004$).

Specifically, significantly higher shear bond strength values were obtained with the self-curing Vipi Flash and heat-curing Vipi Cril Plus and the self-curing Jet resins compared to the heat-curing Clássico resin (Table 1 and Graph 1).

With the surface treatment of the glass fiber–based material (Zantex), significantly higher shear bond strength values were observed for all the evaluated acrylic resins ($p < 0.001$; Table 1; Graph 1).

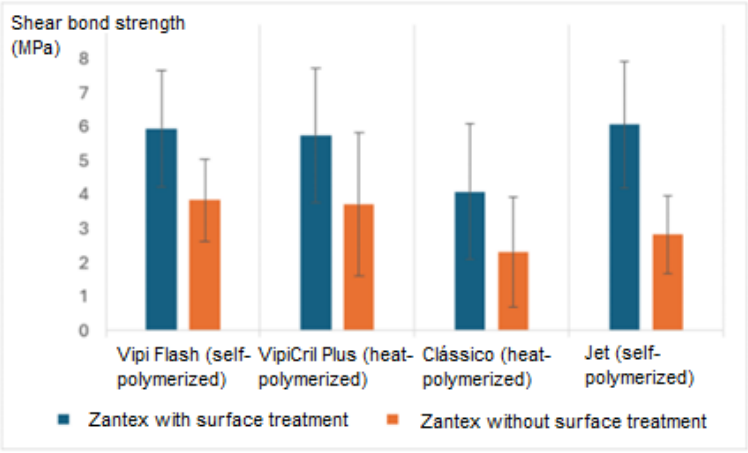
Table 1 - Means and standard deviations of shear bond strength (MPa) between acrylic resins and the fiberglass-reinforced material (Zantex) used as a bar framework for full-arch implant-supported prostheses, with or without surface treatment.

Acrylic resin	Surface treatment		Overall mean
	With	Without	
Vipi Flash (self-polymerized)	5.95 (1.71)	3.84 (1.22)	4.89 (1.81) A
VipiCril Plus (heat-polymerized)	5.76 (1.98)	3.73 (2.11)	4.79 (2.25) A
Clássico (heat-polymerized)	4.09 (1.99)	2.32 (1.62)	3.21 (1.99) B
Jet (self-polymerized)	6.06 (1.87)	2.83 (1.15)	4.45 (2.24) A
Overall mean	**5.47 (2.00) a**	**3.17 (1.64) b**	

Source: Authors' own elaboration.

Caption: Standard deviation is shown in parentheses. Overall means followed by different uppercase letters indicate a significant difference between resins, regardless of whether the Zantex surface was treated or not. Overall means followed by different lowercase letters indicate a significant difference between values obtained with and without Zantex surface treatment, regardless of the resin used.

Graph 1 - Bar chart of the mean shear bond strength values between acrylic resins and the fiberglass-reinforced material (Zantex) used as a bar framework for full-arch implant-supported prostheses, with or without surface treatment.



Source: Authors' own elaboration.

Caption: Standard deviation in parentheses. Overall means followed by different uppercase letters indicate a significant difference among resins, regardless of whether Zantex surface treatment was performed. Overall means followed by different lowercase letters indicate a significant difference between values obtained with and without Zantex surface treatment, regardless of the resin used.

CONCLUSION

Based on the methodology applied and the results obtained in this in vitro study, it can be concluded that:

Surface treatment with aluminum oxide sandblasting on the Zantex framework positively influenced adhesion, significantly increasing bond strength values for all four types of acrylic resins tested.

There was a statistically significant difference among the acrylic resins evaluated. VipiCril Plus (heat-polymerized), Vipi Flash (self-polymerized), and Jet (self-polymerized) resins demonstrated higher bond strength compared to the Clássico (heat-polymerized) resin.

Thus, null hypotheses 1 and 2 were rejected. Null hypothesis 3, related to the failure mode, was accepted, as there was no clear influence of the variables, with a predominance of adhesive and mixed failures.

Clinically, the results suggest that Zantex surface sandblasting is an indispensable step to optimize adhesion. In addition, they indicate that self-polymerized acrylic resins, when used on a properly treated surface, may exhibit reliable adhesive performance comparable to that of heat-polymerized resins for the fabrication of full-arch implant-supported prostheses.

REFERENCES

1. Delucchi F, De Giovanni E, Pesce P, Bagnasco F, Pera F, Baldi D et al. Framework Materials for Full-Arch Implant-Supported Rehabilitations: A Systematic Review of Clinical Studies. Materials (Basel). 2021 Jun 11;14(12):3251.
2-Tribst JPM, de Morais DC, de Matos JDM, Lopes GRS, Dal Piva AMdO, Borges ALS et al. Influence of Framework Material and Posterior Implant Angulation in Full-Arch All-on-4 Implant-Supported Prosthesis Stress Concentration. Dent J (Basel). 2022 Jan 14;10(1):12.
3-Urban VM, Machado AL, Vergani CE, Giampaolo ET, Pavarina AC, de Almeida FG et al. Comprehensive characterization of heat-polymerized and CAD-CAM acrylic resins for denture bases: A comparative study. Dent Mater. 2021 May;37(5):856-866.
4-Gad MM, Al-Harbi FA, Akhtar S, Fouda SM. Effect of polymerization technique on the properties of PMMA denture base materials: A comparative study of conventional, injection, and 3D printing methods. J Prosthet Dent. 2022 Dec;128(6):1378-1384.
5-Kanat-Ertürk B, Akarsu C, Tak Ö. Investigation of the effects of different denture base fabrication techniques and hard relining resin materials on the fixation of immediate provisional hybrid prosthesis to titanium cylinders. BMC Oral Health. 2025 May 9;25(1):697
6-Tardelli JD, dos Reis AC. How does the material used for overdenture bars influence the results? A systematic review. J Oral Biol Craniofac Res. 2024 Jan-Feb;14(1):97-103.
7-Pesce P, Pera F, Delucchi F, Menini M, Barabino M, Lagazzo A et al. Mechanical behavior of fiber-reinforced composite vs. titanium frameworks in full-arch implant-supported rehabilitations: A 3D finite element analysis. J Dent. 2022 Jan;116:103893.
8-Bergamo ETP, Lopes ACO, Napoleão Jr ES, Campos TMB, Coelho PG, Zahoui A et al. Confiabilidade e Modo de Falha de Próteses Parciais Fixas Implantossuportadas com Infraestrutura de Compósito Reforçado por Fibra de Vidro. PróteseNews. 2019;6:672-80.
9-Safwat EM, Khater AGA, Abd-Elsatar AG, Khater GA. Glass fiber-reinforced composites in dentistry. Bull Natl Res Cent. 2021 Nov 10;45(1):190.
10-Cetintas S, Karacaer O, Tokar E. Fiber Materials Used in Prosthetic Dentistry. The Journal of Dentists. 2017;5(1):36-46.
11-Zhang M, Matinlinna JP. E-Glass Fiber Reinforced Composites in Dental Applications. Silicon. 2012; 4(1):73-78.

Observação: os/(as) autores/(as) declaram não existir conflitos de interesses de qualquer natureza.