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Tensile Strength of Resin Cements Used with Base Metals in a Simulating Passive Cementation Technique for Implant-Supported Prostheses

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The aim of this study was to analyze the tensile strength of two different resin cements used in passive cementation technique for implant-supported prosthesis. Ninety-six plastic cylinders were waxed in standardized forms, cast in commercially pure titanium, nickel-chromium and nickel-chromium-titanium alloys. Specimens were cemented on titanium cylinders using self-adhesive resin cement or conventional dual-cured resin cement. Specimens were divided in 12 groups (n=8) in accordance to metal, cement and ageing process. Specimens were immersed in distilled water at 37 °C for 24 h and half of them was thermocycled for 5,000 cycles. Specimens were submitted to bond strength test in a universal test machine EMIC-DL2000 at 5 mm/min speed. Statistical analysis evidenced higher tensile strength for self-adhesive resin cement than conventional dual-cured resin cement, whatever the used metal. Self-adhesive resin cement presented higher tensile strength compared to conventional dual-cured resin cement. In conclusion, metal type and ageing process did not influence the tensile strength results.

Key Words: implant, implant-supported prosthesis, resin cement, tensile strength, self-adhesive cement, dual resin cement.

Introduction

The osseointegration has been studied for years, as well as some techniques for rehabilitation with implant-supported prostheses that have been developed and constantly improved. The implant reconstructions present excellent clinical survival rates (1).

One of the important decisions in implant prosthodontics is the choice of the connection type that can be either screw- or cement-retained. Both retention types have their advantages and limitations. The choice is based on ease of fabrication, precision, passivity of the framework, retention provided by cement and abutment occlusion, esthetics, accessibility, retrievability, complications and cost (2).

Cemented prosthesis appears to minimize pressure on the implants caused by the misfit of frameworks and absorbs a part of the load exerted on the implants (3). However, a possible technical problem associated with the cementation is the de-cementation failure of the prosthesis (1). The cemented cylinder technique is a form of rehabilitation with implants that allows complete or partial prosthesis supposedly passive fit to the implant restoration, keeping the advantage of retrievability inherent to screwed prosthesis (2).

Passive fit of implant-supported prosthesis seems to be a prerequisite for the prevention of mechanical complications (3) and enhances the quality of restorations (4). The cementation of titanium frameworks improves the passive fit because the cement space between abutment and titanium cylinder may compensate for fit discrepancies (3-6). The choice of luting agent is one of most important factors controlling the amount of retention and is critical to the passivity (6-8).

The used cement must have favorable biological and mechanical properties due to the sensitivity of the technique especially when performed for the immediate load technique. The choice of the cement is one the most important factors controlling the amount of retention to prevent dislodgement of the titanium cylinders. (6). As consequence, the dislodgement could cause deleterious micro movements and the concentration of loads in some implants may cause failures (4,9,10).

The aim of this study was evaluate the tensile strength of two different resin cements used to fix titanium cylinders in a passive cementation technique of implant-supported prosthesis.

Material and Methods

Micro Unit abutment analog (Conexão Sistemas de Prótese, Arujá, SP, Brazil) was fixed in the center of a polytetrafluoroethylene cylinder for waxing the samples. Over this analog space, ring (Conexão) and its respective plastic cylinder (Conexão) were positioned and screwed. Ninety-six specimens (9 mm high x 9 mm lower diameter x

11 mm upper diameter) were waxed and cast (n=32) using commercially pure titanium (cp Ti grid 2; Realum, São Paulo, SP, Brazil), nickel-chromium (NiCr,Verabond 2; Alba Dental, Cordelia, CA, USA) and nickel-chromium-titanium (NiCrTi, Tilite Omega; Talladium, Valencia, CA, USA).

Patterns were included with specific investments, Rematitan Plus (Dentaurum, Pforzheim, Germany) was used for commercially pure titanium (cp Ti) and Rema Exakt (Dentaurum) was used for nickel-chromium (NiCr) and nickel-chromium-titanium (NiCrTi) alloys. Investments were mixed in a vacuum machine (Turbomix; EDG, São Carlos, SP, Brazil) and inclusion made in stainless steel rings. After 40 min, rings were placed in a heating oven (10 P-S; EDG). Casting of cp Ti occurred when the temperature of the investment preheating reached 430 °C and for NiCr and NiCrTi alloys accomplished when temperature of 950 °C were reached. Castings were done in a Discovery Plasma (EDG) furnace that promotes fusion through voltaic arc current of the tungsten electrode, under vacuum and inert argon atmosphere.

After divesting, the samples were submitted to airborne-particle abrasion using 100 µm aluminum oxide particles at an emission pressure of 90 psi for 10 s at a standardized 45° incidence angle and ultrasonically cleaned (Ultrasonic Cleaner; Odontobras, Ribeirão Preto, SP, Brazil) with isopropyl alcohol (Labsynth, Diadema, SP, Brazil) for 10 min.

Titanium cylinder (Conexão) was placed on the Micro Unit abutment and screwed with 10 Ncm torque by a manual torquemeter (Conexão). Over this titanium cylinder samples (copings) were individually cemented with the aid of a surveyor in the central position of the Micro Unit abutment (Conexão).

Panavia F (Kuraray, Fujimoto, Japan) or RelyX U100 (3M ESPE, Seefeld, Germany) was applied in half the samples Alloy Primer (Kuraray) was used for conditioning the metal surface etching when Panavia F was employed. Cements were handled according to the guidelines of the manufacturers, inserted into samples and positioned over the titanium cylinders. After removing excess of cement, a 5 kg-load was applied over the samples for 10 min. Cements were cured with a halogen lamp (Ultralux; Dabi Atlante, Ribeirão Preto, SP, Brazil) at 450 mW/cm^2 for 20 s at each side (mesial, distal, buccal, lingual and occlusal) totaling 100 s for each sample, and maintained under a 5 kg load of for 10 min (4,8,11). The samples of Panavia F group were kept with an Oxyguard (Kuraray) layer at the margins during the same period.

After cementation, the samples were stored in distilled water at 37 °C for 24 h. Half he samples were submitted to tensile strength test in a universal test machine (EMIC DL2000; EMIC, São Carlos, Brazil) with a 5 mm/min speed (12,13) and 500 kgf load cell. The other half was thermocycled for 5,000 cycles with temperature bath of 5 and 55 °C, and next subjected to bond strength test (Table 1).

Statistical analysis was performed with SPSS for windows (SPSS/PC for Windows Inc., Chicago, IL, USA) and p values of less than 0.05 were considered significant. For the tested tensile strength variable, adhesion to the normal distribution and homogeneity of variances were analyzed by Kolmogorov-Smirnov and Levene tests, respectively.

The comparison was performed using three-way ANOVA (cement, metal and ageing factors). The interaction among factors (5%) was also investigated.

Results

Kolmogorov-Smirnov statistical test showed that the rate and tensile strength variables had a normal distribution and the Levene test showed homogeneity of variances, which allowed comparisons using parametric methods.

No statistically significant difference ($p>0.05$) was found for the metal and ageing process factors and their interactions.

The cementing agent factor showed a statistically significant difference between cements, regardless the type of metal and ageing process before or after thermocycling, and the highest values of tensile strength were for RelyX U100 cementing agent (Fig. 1).

Discussion

Resin cement showed different values for tensile strength. The self-adhesive resin cement (RelyX U100) presented higher tensile strength when used to fix titanium cylinders in passive cementing technique with values varying from 535.3±96 to 676.2±188 N after 24 h and from

Table 1. Experimental studied groups

Group	Cement	Metal	Ageing process
G1	Panavia F	NiCr	24 hours
G2	Panavia F	cp Ti	24 hours
G3	Panavia F	NiCrTi	24 hours
G4	Rely-X U100	NiCr	30 days
G5	Rely-X U100	cp Ti	30 days
G6	Rely-X U100	NiCrTi	30 days
G7	Panavia F	NiCr	24 hours
G8	Panavia F	cp Ti	24 hours
G9	Panavia F	NiCrTi	24 hours
G10	Rely-X U100	NiCr	30 days
G11	Rely-X U100	cp Ti	30 days
G12	Rely-X U100	NiCrTi	30 days

556.5±131 to 698.1±195 N after 30 days of ageing process.

In the present study, Panavia F cement, using a conditioner, showed mean values of tensile strength varying from 504±206 to 540.2±195 N after 24 h and from 377±120 to 516.5±109 N after 30 days of ageing process.

Panavia contains the organic ester 10-methacryloyloxidecyl-dihydrogen-phosphate (MDP) which has the property of bonding the primer monomer and metal oxides (4,14). Then, the results obtained with Panavia F can be justified by the presence of residual monomer or solvent like ethanol and acetone from conditioner primers (15). It is suggested that the negative influence of VBATDT monomer (6-(4-vinylbenzyl-η-propyl) amino-1,2,5-tiazine-2,4-dithione), in the Alloy Primer, disturbs the polymerization reaction of resin-based materials that contain the benzoyl peroxide-amine initiator system. This monomer may interfere in the reaction between the MDP of the primer and the cement and/or metal oxides (15).

Temperature range between 5 and 55 °C did not cause mechanical changes on the cohesive strength of resin cement to weaken metal/cement bond. The ageing process in distilled water (24 h) and thermocycling (30 days) may be unsufficient for the hydrolysis process, because lower sorption and solubility may avoid water diffusion (15).

RelyX U100, (methacrylate phosphoric acid esters) is classified by the manufacturer as self-adhesive resin cement and contains hydrophilic monomers and acids, demineralizing and infiltrating the enamel and dentin (16). Base metals provide a more reactive surface for bonding to the resin cement because they have higher free-surface energy and are more reactive than precious metal alloys, forming a thicker oxide layer that roughens the metal surface providing micromechanical retention (17).

RelyX U100 cementing agent showed a statistically greater average tensile strength (N) compared to Panavia F. The highest mean retention was obtained when a Tilite (NiCrTi) structure was cemented with RelyX U100 and subjected to thermocycling for 5,000 cycles (698.1±195 N). This result suggests further evaluation of this agent for cementation but offers a perspective with easy access and convenient use.

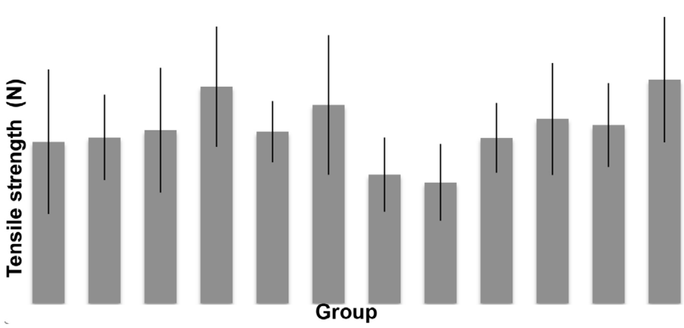

Figure 1. Mean and standard deviation of tensile strength of different studied groups (N).

The resin cements are materials composed of a Bis-GMA (bisphenol A-glycidyl methacrylate) or UDMA (urethane dimethacrylate) matrix and silane-treated small particles of inorganic load. A group of these cements has adhesive monomers in the composition of a system part, which chemically adhere to the metal. They are called adhesive cements and are able to efficiently join the oxides. The high reactivity of base metal alloys makes them more appropriate for the restoration of preparations with small surface area (16,18).

The chemical bond of resin cement can enhance the performance of conditioner primers, which, with bifunctional monomers with one end containing mercaptan or thiol groups (-SH), are able to optimize the metal alloys bond. Some types of adhesive monomers are the 10-MDP and VBATDT that are in the Alloy Primer, the conditioner of the Panavia F cement system.

The effectiveness of the primers for bonding resin cements to precious metal alloys and base metal alloys was confirmed in some studies (19-23). Self-adhesive cements are a nonhomogeneous group with regard to their bond values and chemical composition and differ significantly in their bonding to base metal alloys (24).

The oxide layer formed over cp titanium produces a firm oxide adherent layer that does not influence the bond strength of self-adhesive resin cements (25). However, the bond strength of the cements varies depending on the prosthodontic substrate, indicating that selection of these cements should be dictated by the substrate (26)

Certain properties of resin cements compared are superior to other types of cements, like greater fracture resistance (18,27,28), good adherence to dental structures and alloys provided by adhesive systems (29,30), low solubility in oral fluids, in addition to the reduced leakage in restorations (29), make the resin cements agents of choice for cementation. It is claimed that there is no established value of load considered ideal for clinical success of prosthesis retention (30).

The traditional system of building a metal framework by melting over mechanized pieces called cylinders was modified. The cylinders are joined to the metal framework by physicochemical bonding. A passive cementing technique is a viable alternative, as well as others whose main purpose is the ability to compensate possible distortions in the metal framework that could generate undesirable loads to the implants (8,11).

In this study, the standard form of preparation and use of segments of the framework allowed comparing only the efficiency of the physicochemical bond of the tested cementing agents, without change in any other factor. The substrate surfaces were similar due the airborne-particle abrasion applied to all samples.

The alloys behaved similarly despite the cp Ti providing a more stable oxidation layer (15). In this study, the tensile bond strength of cements was similar in all tested metals. This similarity between the metals was possibly due to the standardization of surface, cylinder form and samples.

The chemical bond occurred on all metals regardless of chemical composition of the oxide layer on the surface of samples. The MDP and VBTDT adhesive monomers of Panavia F system and the phosphoric acid esters of methacrylate of RelyX U100 provided good adhesion to different substrates used in this study.

Although the present results show no differences between the different alloys, it is important to choose the nature of the material to be used (7) in regard to other mechanical properties and biological action. Further studies should be conducted to evaluate other biological and mechanical properties of materials evaluated in this study.

According to the employed methodology, it may be concluded that the self-adhesive resin cement used to cement titanium cylinders on different metallic copings in passive cementation technique of implant-supported prosthesis presented higher tensile strength when compared to conventional dual-cured resin cement. Metal and ageing process do not influence tensile results at in the different studied situations.

Resumo

O objetivo deste estudo foi analisar a resistência à tração de dois diferentes cimentos resinosos usados na técnica de cimentação passiva de próteses implanto-suportadas. Noventa e seis cilindros plásticos foram encerados em formas padronizadas, fundidos em titânio grau 2 comercialmente puro e ligas de níquel-cromo e níquel-cromo-titânio. Amostras foram cimentadas sobre cilindros de titânio usando um cimento auto-adesivo ou um cimento convencional de dupla polimerização. Os espécimes foram divididos em 12 grupos (n=8) de acordo com o metal, cimento e processo de envelhecimento. Espécimes foram imersos em água destilada a 37 °C por 24 h e metade deles foi termociclado por 5,000 ciclos. Espécimes foram submetidos ao ensaio de tração numa máquina universal de ensaios (velocidade de 5 mm/min). Análise estatística evidenciou maior resistência à tração do cimento auto adesivo do que o cimento convencional de dupla polimerização, independente do metal utilizado. O cimento resinoso auto adesivo apresentou maior resistência à tração do que o cimento convencional de dupla polimerização. O tipo de metal e o processo de envelhecimento não tiveram influência nos resultados.

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