Original Article

Influence of calcinable cylinders cast in cobalt-chromium alloy on the passivity of implant-supported frameworks

Influência de cilindros calcináveis fundidos em cobalto-cromo na passividade de próteses implanto-suportadas

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Abstract

Purpose: This study aimed to determine the effect of using calcinable cylinders on the passivity of a framework that simulates a three-unit fixed partial prosthesis on two implants.

Methods: Two 3.75×10 mm external hex implants were used, with their abutments set on a steel base forming the master model. Ten cobalt-chromium alloy frameworks were manufactured by the induction casting technique. Two groups were established: Group 1 used premachined cylinders to cast five frameworks; Group 2 used plastic calcinable cylinders to cast five frameworks. Passivity evaluation was accomplished by using strain gauges placed in the cervical and occlusal regions of the framework pontics. The measurement was performed during screwing of the second prosthetic screw with a torque of 10 Ncm. Data were analyzed by Student's *t* test (α=0.05).

Results: The mean (standard deviation) values were 39.16 (24.74) mV/V for Group 1 and 43.76 (21.13) mV/V for Group 2. There was no statistically significant difference between groups (P=0.815).

Conclusion: The results suggest that the use of calcinable cylinders had a similar degree of passivity compared to the use of premachined prosthetic cylinders.

Key words: Adaptation; strain gauge; dental implant; passivity; calcinable cylinder

Resumo

Objetivo: Este trabalho avaliou a influência da utilização de cilindros calcináveis no grau de passividade de infra-estruturas que simulam uma prótese parcial fixa de três elementos sobre dois implantes.

Metodologia: Foram utilizados dois implantes de hexágono externo de 3,75 mm×10 mm, com seus respectivos pilares intermediários, fixados numa base de aço, formando o modelo-mestre. A partir disto, foram fabricadas dez infra-estruturas em liga de cobalto-cromo através da técnica de fundição por indução. Foram criados dois grupos: Grupo 1 utilizando cilindros pré-usinados para a fabricação de cinco infra-estruturas; Grupo 2 cinco infra-estruturas fundidas com cilindros de plástico calcináveis. Para avaliação da passividade foram utilizados extensômetros colados na região oclusal e cervical do pôntico das infra-estruturas. A medição foi realizada no momento do aperto do segundo parafuso protético com torque de 10Ncm. Os dados foram analisados pelo teste *t* de Student (α=0,05).

Resultados: As médias (desvio-padrão) dos grupos foram de 39,16 (24,74) mV/V no Grupo 1 e 43,76 (21,13) mV/V no Grupo 2. Não houve diferença estatisticamente significante entre os grupos (P=0,815).

Conclusão: Considerando-se as limitações deste trabalho, sugere-se que o uso de cilindros calcináveis obtém o mesmo grau de passividade que o uso de cilindros pré-usinados.

Palavras-chaves: Adaptação; extensometria; implante dentário; passividade; cilindro calcinável

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Introduction

At present the failure rates of dental implants are low, yet they still can occur in the surgical or prosthetic phases. With respect to the prosthetic part of the implant-based oral rehabilitation, the fit of the implant/prosthetic components is of great importance. This is due to the fact that fit influences the distribution of forces in the implant/components system and bone tissue, interfering in the passivity of the prosthetic structure on its support components. Thus, any lack of fit or misfit of the prosthetic framework will result in tensions, which may be transferred to the implants and bone tissue (1).

The adaptation of prosthetic components may be affected by a number of clinical and laboratory steps. Some changes in techniques have been adopted to reduce the costs of the laboratory procedures of implant-supported prostheses, particularly in Brazil and in other developing countries, where considerable social differences exist. These changes include the switch from noble to non-noble alloys and the utilization of simplified prosthetic components, such as calcinable plastic cylinders instead of premachined cylinders of noble metal alloys (2,3).

One way of determining the amount of forces generated by the degree of passivity of the components is by the use of electrical resistance extensometers or transducers. These apparatuses transform dimensional variations into variations in equivalent electrical current (4). Therefore, one can measure the tension produced on a body through the dimensional deformation it undergoes from the application of forces.

The aim of the present study using extensometers was to evaluate the passivity of cobalt-chrome frameworks on two implants, simulating a three-unit fixed partial prosthesis, as a function of the type of cylinder and laboratory procedure: premachined cylinder with cobalt-chrome collar (control) versus calcinable cylinder. The null hypothesis was that the framework produced with calcinable cylinders has the same degree of passivity of that fabricated with premachined cylinders.

Methods

Construction of the master model

A metal matrix was made of 8640 steel (Metalúrgica Cotrac Ltda., Porto Alegre, RS, Brazil), with dimensions of 10×20×25 mm, with two holes on the top for placement of two outer hexagonal implants (3.75×10 mm; Conexão Sistemas de Prótese Ltda., São Paulo, SP, Brazil). Two hex screws were used with a manual torque to fix the implants, which were located 18 mm apart, center to center of each implant. Two Micro-Unit abutments (Conexão Sistemas de Prótese Ltda., São Paulo, SP, Brazil) 4 mm-height were installed, with a tightening torque of 20 Ncm as recommended by the manufacturer (Fig. 1A).

Fabrication of frameworks

The transfers for open impression were installed on the Micro-Unit abutments and joined with acrylic resin (Pattern Resin, GC America, Chicago, IL, USA). After polymerization, it was sectioned with a diamond disk and joined again using the brush technique to minimize the resin contraction. After removing the transfers, Micro-Unit abutments of 4 mm-height were installed, which were identical to those of the master model; they were screwed in replicates of the implants and placed in a mold that was filled with type IV plaster. In this model, the first wax-up was carried out, and a silicon index (Star Gold, Sterngold Implant, Attleboro, USA) was made to standardize the framework waxing-up (Fig. 1 B).

The frameworks were divided into two groups:

- *Group 1*: This group consisted of 10 premachined cylinders of cobalt-chrome of the Micro-Unit abutment for the wax-up and subsequent induction casting (Neutrodyn-Easyti Manfred, Torino, Italy) of five cobalt-chrome frameworks, simulating a three-unit fixed partial prosthesis, with the first molar and first premolar as abutments, and the second premolar as a pontic. The framework was sectioned using a carburundum disk in the region of the connector and the segments were united with acrylic resin after screwed onto the master model. All frameworks were laser-welded (EV Laser V900, Casnigo, Italy).
- *Group 2*: Ten calcinable cylinders of the Micro-Unit abutment were cast to make five frameworks following the laboratory procedures described above.

Embedding and casting were carried out by the method of induction (Neutrodyn-Easyti Manfred, Torino, Italy) with cobalt-chrome alloy by a certified laboratory (Portodent, Porto Alegre, RS, Brazil).

Experimental setup and measurements

The preparation of the surface of the specimens followed the procedures: Finishing the upper and lower surfaces of the pontic with the use of a carburundum disk and 400-grit sandpaper; and cleaning these surfaces with a paper towel soaked with isopropyl alcohol.

Two extensometers were glued in the region of the pontic of each sample, placing one on the upper part and the other on the lower part, forming a half Wheatstone bridge (Fig. 2A). Two other extensometers were affixed to the base of the master model. The extensometers were glued using a small amount of cyanoacrylate adhesive (Loctite 406, Henkel Loctite Adesivos Ltda. Itapevi, SP, Brazil), positioning the extensometer carefully with the help of a piece of nonpolar plastic (Exel Engenharia de Sensores Ltda. Embu, SP, Brazil) and finger pressure to avoid the formation of air bubbles in the adhesive layer.

A customized device was assembled to perform the signal output reading of the extensometer channels (Fig. 2B). After positioning the master model in a vice, the sample was placed in position by tightening the prosthetic screw in the abutment corresponding to the molar, applying a torque of 10 Ncm using an electric motor torque control (Driller, São Paulo, SP, Brazil).

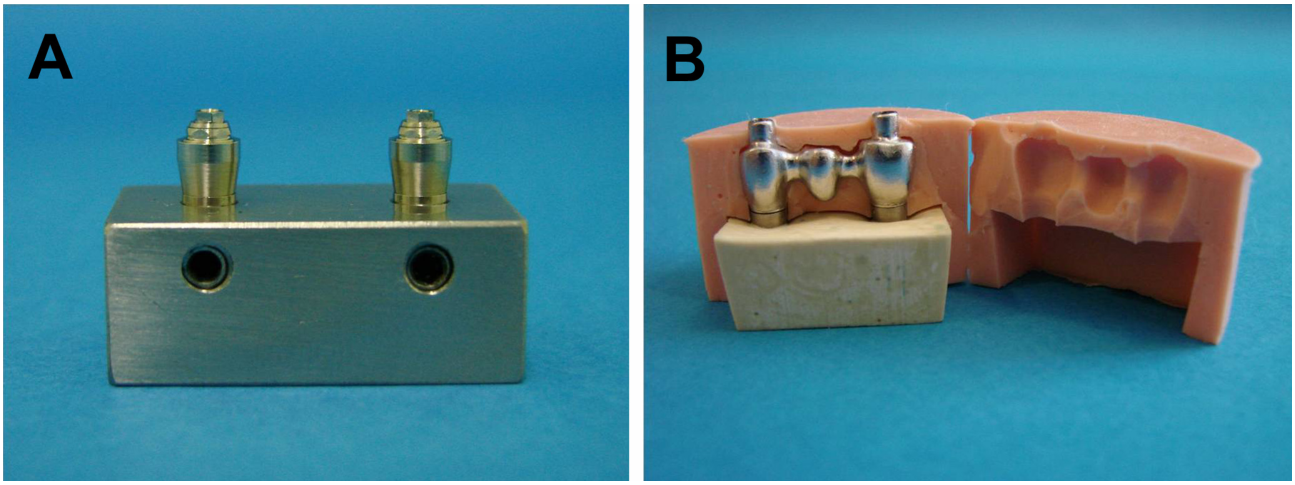

Fig. 1. Fabrication of the test specimens. **(A)** Implants installed on the metal base. **(B)** Silicon index utilized to standardize the framework waxing-up.

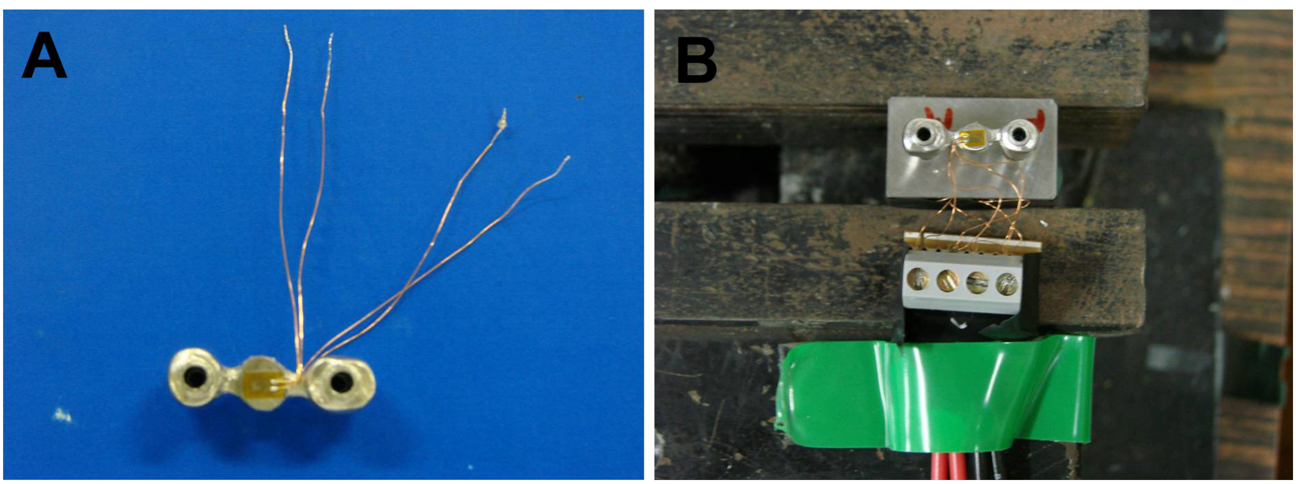

Fig. 2. Experimental setup with extensometers. **(A)** Extensometers glued to the upper and lower part of the pontic. **(B)** Extensometers wired to record the output signal during the tests.

At this time, a calibration was made of the signal-amplifying device of the extensometer. The measurement obtained after this calibration was defined as being the baseline or zero measurement, since the absolute difference between the initial and final measurements was the value taken as the amount of deformation undergone by each sample. To determine the final measurement, the prosthetic screw of the abutment corresponding to the premolar was tightened with a torque of 10 Ncm. After recording the final measurement shown in the amplifier display, the abutment screw of the premolar was loosened. This process was repeated five times for each sample, and two new prosthetic screws were used for each sample. The measurements were determined as milivolts per volt (mV/V). The mean of the variation between the baseline (initial) and final measurements was computed for each sample. After normality of the residuals and homogeneity of variance were verified, data were analyzed by Student's *t* test at the significance level of 5%.

Results

Table 1 shows the comparison of the means and standard deviation values of passivity between the groups of frameworks fabricated with calcinable cylinders and with premachined cylinders. There was no statistically significant difference between groups (P=0.815).

Table 1. Comparison of the passivity between the groups of frameworks fabricated with calcinable cylinders (Group 1) and with premachined cylinders (Group 2).

Group	n	Passivity (mV/V)		*P*
		Mean*	SD	
1	5	39.12^{a}	24.70	0.815
2	5	42.56^{a}	20.11	

* Same letters indicate no statistically significant difference between the groups (Student t test).

Discussion

The null hypothesis of the present study was not rejected, since no significant difference in the passivity of the frameworks was found between the groups with premachined cylinders and calcinable cylinders. The lack of a statistically significant difference can be explained by the induction casting technique, which provides accurate control of melting temperature of the metal alloy, resulting in less contraction of the metal during cooling. As a consequence, the dimensional alterations could be reduced in the calcinable cylinders. Also, all frameworks were laser-welded, which minimizes the distortion from casting.

Many clinical and laboratory steps can induce deformation and affect passivity of implant-supported prosthesis during its complex process of fabrication (5-7), such as impression procedures, fabrication of the master model, waxing-up or modeling of the framework, framework casting, application of esthetic material (composite or ceramics), etc. Consequently, a sum of sequential steps can contribute to the timely variations in the passivity of each framework constructed, causing heterogeneity among the samples of each group. Nonetheless, even premachined cylinders may present variation in their adaptation to abutments and affect framework passivity, since the machining process depends on several factors, such as different precision of the industrial milling machines used, quality control of the manufacturer, dimensional alteration of the premachined cylinders during the process of prosthesis fabrication. Also, machined surfaces are not completely polished and flat microscopically, which can hinder, more or less, the joining of two surfaces (7-9).

In relation to the comparison between prosthetic calcinable and premachined cylinders, a previous study (2) also reported not finding statistically significant differences between cylinders cast in palladium-silver or cobalt-chrome, since both showed a fit considered satisfactory. On the other hand, the present findings are in disagreement with other studies (10,11), which stated that the premachined components show better fit than their cast counterparts. However, the results of this work suggest that other discrepancies that occurred in the fabrication process of the frameworks may have a greater influence on final prosthesis passivity than the type of cylinder when induction casting is used.

In another study with the same specimens (12), scanning electron microscopy was used to evaluate the marginal gap between prosthetic cylinder and abutment comparing groups with calcinable and premachined cylinders. No statistical difference was found between groups, and the mean marginal gap after tightening of the screws was 8.53 µm for premachined cylinders and 11.81 µm for calcinable cylinders. The measurements of misfit vary substantially in the literature, which shows the difficulty in obtaining passive frameworks (13,14). Other study showed a misfit of 21 µm with a 10 Ncm torque of the prosthetic screws (15), while Jemt (16) found a misfit of 111 µm *in vivo* by examining the marginal gap in three dimensions by photogrammetry without the screwing of prosthetic cylinders. However, it is suggested that even the frameworks with a misfit of 10 µm or less are capable of producing internal stress transmitted directly to the prosthetic components, implants and bone interfaces (17-19). Moreover, the current cast technology to fabricate implant-supported prostheses cannot provide absolute passivity, which results in internal tensions when the frameworks are screwed (11).

A cut-off value for an acceptable degree of passivity has not yet been determined, and it is difficult to clinically verify the amount of fit and passivity of frameworks that can affect the success of implant-supported prostheses. Some methods for clinical evaluation include: finger pressure, direct vision and tactile sensation, radiography, single screw test, resistance to screw tightening test, and instruments and/or materials to measure the gap (thickness) between the implant system components (20).

In the present study, electrical resistance strain gauges (extensometers) were used to measure the degree of passivity of the frameworks, because these devices have great sensitivity in detecting small variations in surface size, which is generated from the deformation of the framework when it is screwed onto the respective abutments. Thus, the greater the degree of passivity, the lower the amount of deformation detected by the extensometer will be. Other methods also are used to determine fit and the passivity of an implant-supported prosthesis, such as light microscopy (2,3,5,10,14), scanning electron microscopy (12), photogrammometry (16), laser videography (18), photoelastic analysis (19), finite element analysis (6), the use of impression materials to measure the space between implant components (15), the use of Periotest equipment (18), standardized x-rays etc. However, the gold standard to assess passivity and other outcomes of success of prosthesis on implants still need consensus as long-term clinical studies on large samples may require simple and reproducible methods (21).

In summary, the present study suggests that the use of castable cylinders and non-noble alloys may reduce the cost of prostheses on implants with no significant loss of passivity of fit. As a possible limitation of this study, no consideration was given to the effect of sedimentation of the screwed union. The specific objective of the present experiment was to analyze the immediate degree of framework deformation upon torque, which would vary with passivity of fit according to the type of prosthetic cylinder used. As the results showed no effect of type of cylinder on framework passivity as measured by extensometry, the evaluation of sedimentation of the screwed union would be neglected. Nonetheless, the effect of sedimentation may be important in further studies on components or procedures that promote significant variation of fit and passivity and should be investigated.

Conclusions

Considering the limitations of this study, the results suggest that the use of calcinable cylinders with the induction casting technique produced frameworks with passivity similar to that of frameworks fabricated using premachined cylinders.

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