

Marginal fit of implant-supported fixed prosthesis frameworks with prefabricated and calcinable cylinders

Adaptação marginal de infra-estruturas de prótese fixa implanto-suportada com cilindros pré-usinados e calcináveis

Abstract

Purpose: The aim of this study was to evaluate the vertical marginal misfit of the metal framework of an implant-supported prosthesis.

Methods: Ten frameworks were made of cobalt-chromium alloy (Co-Cr), simulating a three-element fixed prosthesis on two implants. Five frameworks were constructed using prefabricated cylinders, and the other five were constructed using calcinable cylinders. All frameworks were cast by the induction technique and laser-welded. Marginal misfit was measured by means of scanning electron microscopy with the frameworks subjected to the single-screw test. Twenty-five measurements of marginal fit were recorded per abutment and averaged for statistical analysis (ANOVA, $\alpha=0.05$).

Results: There was no statistically significant difference in marginal fit between the groups tested. The only difference found was when comparing the abutments with and without screw.

Conclusion: It was concluded that there is no difference in marginal fit between frameworks cast in Co-Cr with calcinable and prefabricated cylinders using induction casting, laser-welding, and single-screw test.

Key words: Dental implants; passive fit; manual rectification

Resumo

Objetivo: O objetivo deste trabalho foi avaliar o desajuste marginal vertical de infra-estruturas metálicas de prótese fixa sobre implantes.

Metodologia: Foram confeccionadas 10 infra-estruturas em liga de cobalto-cromo (Co-Cr), simulando uma prótese fixa de três elementos sobre dois implantes, com o auxílio de uma matriz metálica. Cinco infra-estruturas foram confeccionadas com cilindros pré-usinados. Outras cinco foram confeccionadas com cilindros calcináveis. Todas as infra-estruturas foram fundidas pela técnica de indução e soldadas a laser. As leituras do desajuste marginal foram realizadas através de microscopia eletrônica de varredura, utilizando a técnica do parafuso único, totalizando 25 medições em cada cilindro. As médias de desajuste marginal de cada cilindro foram utilizadas para a análise estatística (ANOVA, $\alpha=0,05$).

Resultados: Não houve diferença estatística no grau de desajuste marginal entre os grupos testados. Apenas houve diferença quando comparados os cilindros com e sem parafuso.

Conclusão: Foi concluído que não há diferença de adaptação marginal entre as infra-estruturas fundidas em Co-Cr com cilindros calcináveis e pré-usinados, utilizando fundição por indução, soldagem a laser e teste do parafuso único.

Palavras-chave: Adaptação passiva; implantes dentários; desajuste marginal

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Introduction

The continuous development of osseointegration and implantology makes it possible today to perform prosthetic restorations that provide for the reestablishment of function, esthetics and phonetics, in a foreseeable manner. Thus, the use of dental implants for replacing absent teeth has become routine in oral rehabilitation, showing various positive features, because it prevents the wearing of entire teeth and lateral loads on tooth abutments of removable partial with distal extension (1). In order to assure this predictability of treatment, the seating of the prosthesis with total passivity to implants or temporary abutments is very important. On the contrary, a poorly fitted prosthesis can cause overload to the mechanical elements of the system, which can result in loosening or fracture of abutment screws, the temporary restoration and even the implant itself, which can also affect biological elements, leading to the loss of osseointegration (2).

To extend the population access to treatment with dental implants, plastic calcinable cylinders were developed, which are low-cost and have extensive clinical applicability (3). This contributed to the development of treatment concepts and fabrication techniques of prosthetic structure, with the aim of minimizing the effects of distortions inherent to clinical and laboratory steps (4,5). However, in the utilization of calcinable cylinders, castings with little precision can result in biological and mechanical complications, such as accumulation of biofilm, development of mucositis, loosening of screws, fracture of screws, and loss of osseointegration (6).

One of the main objectives in the fabrication of implant-supported prostheses is to achieve a passive fit between the temporary abutment and prosthetic cylinder, be it calcinable or prefabricated. The importance of this passivity and the search for alternatives to try to optimize it has been discussed in the literature (7-10), but there still is no precise definition for "passive fit." This fit was first defined as establishing the measure of 10 micrometers as the maximal distance between the base of the metal structure and abutments (1). However, passive fit was later defined as being that which does not cause clinical complications over time, suggesting that a misfit of up to 100 micrometer would be clinically acceptable (7).

Even though many studies have shown that poor fit between prosthetic components and implants can cause biomechanical problems, the majority of these works are laboratory studies (11-13). Some studies *in vivo* suggest that there is a biological tolerance for misfit. In one work with five years follow-up of implant-supported prostheses in the edentulous maxilla, measures of misfit of 111 and 91 μm were found, but without any alteration in marginal bone loss (8). In another study *in vivo*, the authors reported that a precise fit was rarely found, and they therefore concluded that considerable discrepancies exist between frameworks and abutments, but these were considered as an acceptable fit clinically (14). Based on a literature review, there are no longitudinal clinical studies reporting weaknesses in prostheses on implants specifically attributed to misfit of

the frameworks (15). On the other hand, laboratory studies suggest that the majority of complications with implant-supported prostheses can be directly connected to the lack of passive fit between the prosthetic framework and abutment (11,16,17), which would favor the accumulation of plaque and would increase the implant overload; the latter can accelerate bone loss and mechanical problems, such as weakening or fracture of the prosthetic screw and implant fracture (1,3).

Therefore, because of the importance of passive fit in multiple implant-supported prostheses, the aim of this study was to determine the vertical marginal misfit of frameworks made of cobalt-chrome on two implants, simulating the dimensions of a fixed partial prosthesis of three elements, utilizing the single-screw technique, according to the type of cylinder: prefabricated cobalt-chrome cylinder or calcinable cylinder.

Methods

A metal matrix (30x18x12mm) of steel was fabricated with two orifices in the upper part for the placement of implants. Two transverse hexagonal screws were placed to fix two implants of 4.0x10mm (Conexão Sistemas de Prótese Ltda., São Paulo, Brazil), with external hexagon 18mm from the center of each implant, providing sufficient space for the reconstruction of dental elements with mesial-distal and mesial-occlusal diameters compatible with the anatomy of the second pre-molar, first molar and second lower molar. Next, the transverse screws were tightened with manual torque for fixation of the implants. Two Micro-Unit abutments (Conexão Sistemas de Prótese Ltda., São Paulo, SP, Brazil), 4mm in height, were installed with a torque of 20Ncm in each implant (Fig. 1A).

The frameworks were made with the help of an index. 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, the resin was sectioned with diamond disk, and the segments were bound again utilizing the brush technique, to minimize the resin polymerization contraction. After complete resin polymerization, the transfers were removed from the master model. Micro-Unit abutments were installed in the transfers and taken into a mold that was filled with type IV stone (Durone – Dentsply Ind. Com. Ltda., Petropolis, RJ, Brazil). Using the resulting model, the first waxing of the framework was performed, and an index was made of dense addition silicone (Express, 3M ESPE, St. Paul, MN, USA), to standardize the waxing of all the other frameworks (Fig. 1B) (18). A straight cut was made in the region between the bridge and molar retainer for later laser-welding.

The frameworks were divided into two groups:

Group A: Ten prefabricated cylinders of cobalt-chrome of the Micro-Unit abutment were utilized for waxing and subsequent casting of five frameworks of cobalt-chrome, simulating a fixed prosthesis of three elements, with the first molar and first pre-molar as abutments, and the second pre-molar as a bridge.

Group B: Another 10 calcinable cylinders of plastic of the Micro-Unit abutment were cast according to the method described above to make the other five frameworks.

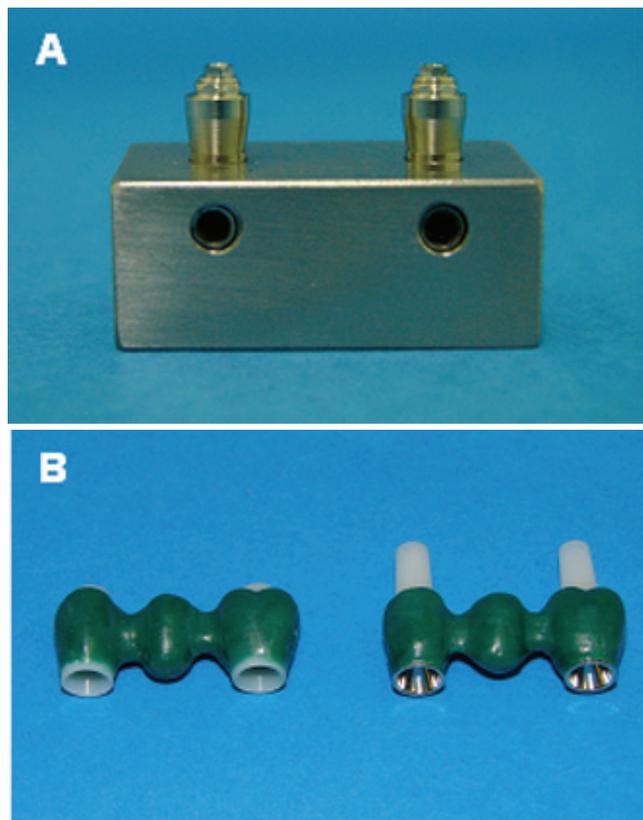


Fig. 1. (A) Metal matrix with implants and Micro-Unit abutments installed. (B) Frameworks waxed with calcinable (left) and prefabricated (right) cylinders.

The investing and casting were carried out according to the induction method (Neutrodyn Easyti, Manfredi, Torino, Italy), with cobalt-chrome bond (Wirobond C, Bremen, Germany) by a certified technician (Laboratório Portodent, Porto Alegre, RS, Brazil). After casting, each framework was laser-welded (EV LASER V900, Casnigo, Italy) using a pre-cast thread in the same bond in which the framework was cast.

A scanning electron microscope (SEM) (Philips, XL30, Eindhoven, Netherlands) was used to evaluate the marginal misfit. The evaluations were made after the connection of the framework onto the Micro-Unit abutments and tightening of the titanium screw in only one of the cylinders (first molar), with a torque of 10Ncm. Microscopic analysis was carried out on two cylinders screwed and in the cylinder without screw (first pre-molar). All frameworks were cleaned in an ultrasound bath of acetone (Unique, USC 700, São Paulo, SP, Brazil), before measurement with SEM.

For evaluation of the vertical misfit, measurements were made of the space between the Micro-Unit abutment and cylinder in five regions, with the distance between each region being

approximately 1000 micrometers, where points 1 and 5 were at the ends of the abutment (Fig. 2A). Five measurements were taken at each region at 500X magnification (Fig. 2B), totaling 25 measurements for each abutment-cylinder interface. The measurements were performed with the help of SEM software. Statistical analysis was carried out using two-way analysis of variance (cylinder group, with/without screw) considering the level of significance at 5%.

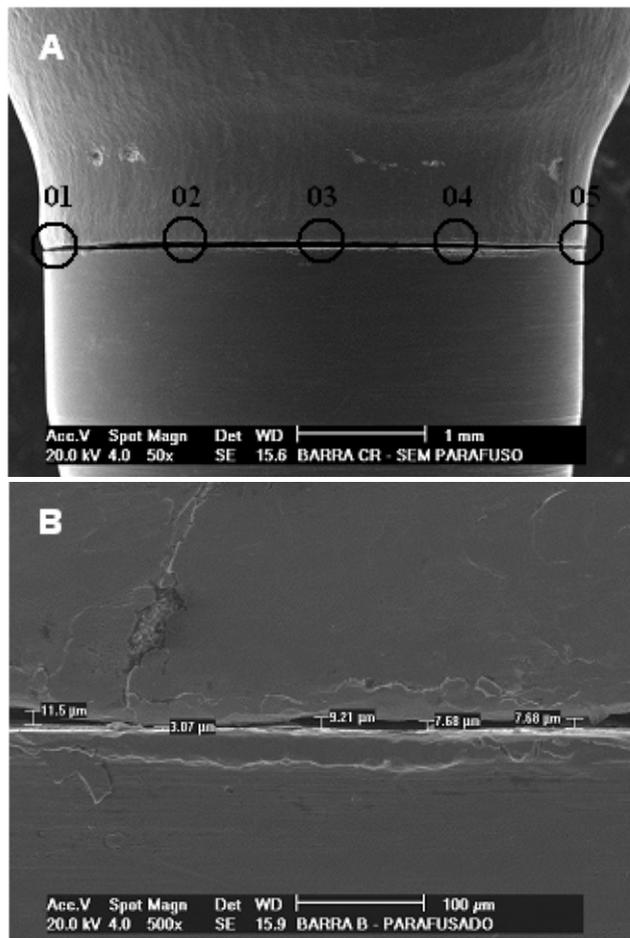


Fig. 2. (A) Photomicrography of the abutment/cylinder interface at 50x magnification illustrating the regions where measurements were taken. (B) Photomicrography of the abutment/cylinder interface at 500x magnification, illustrating the measures of marginal misfit.

Results

Table 1 shows the means and standard deviation of the vertical misfit of the two experimental groups, with and without tightening of the screw. There was no statistically significant difference in relation to the type of cylinder ($P=0.187$) or in their interaction with/without tightening of the screw ($P=0.646$). There was only a difference in the comparison of the cylinders with and without tightening of the screw ($P<0.001$), that is, the screwed cylinders showed a lower mean vertical misfit than those without screw.

Table 1. Mean and standard deviation (SD) (in micrometers) of the groups of frameworks with prefabricated and calcinable cylinders, tested with and without screw.

	Without screw		With screw	
	Mean	SD	Mean	SD
Prefabricated	23.51	9.62	8.53	6.50
Calcinable	30.16	10.31	11.81	4.27
Total	26.84 A	10.03	10.17 B	5.46

Means followed by different letters differ significantly by analysis of variance, at a level of significance of 5%.

Discussion

Based on the results of this study, there was no statistical difference in vertical marginal misfit between the Micro-Unit abutments and prefabricated and calcinable cylinders. The absence of statistically significant difference can be explained by the technique of casting by induction utilized in this work. This technique provides greater control of the melting point of the metal bond, allowing greater control of metal contraction during cooling. Consequently, the dimensional alterations resulting from the casting process can be minimized. However, with the aim of minimizing these distortions even more, all frameworks were laser-welded in this work, which improves the degree of passive fit of the metal frameworks (19,20).

Several methods for the evaluation of passive fit in frameworks on implants have been described in the literature. In one study with a photoelastic model, it was demonstrated that the fitted framework did not produce tensions around the implants, and, conversely, screw tightening of the piece not fitted produced a considerable concentration of tension around the implants (16). Another study utilized the 3-dimensional photogrammetric technique and found mean discrepancies of 90 μ m and 111 μ m *in vivo*, demonstrating that prostheses with considerable levels of misfit are considered clinically acceptable and are installed in the patient (21). Another work used the instrument Periostest to test the hypothesis that more negative values indicate precision of fit and more positive values correlate with lack of fit (9). However, the majority of these apparatuses are not available in the regular clinic, which makes it difficult to determine fit. On the other hand, there are many studies that use the single-screw test to determine the passivity of metal structures on implants, which is very simple to utilize in most clinical cases (18,22).

Therefore, the single-screw technique was utilized in this study to measure the degree of misfit of the screwed cylinder with a torque of 10Ncm, and also of the cylinder without screw. The measures of marginal misfit by SEM found in the screwed cylinders were 8.53 μ m and 11.81 μ m for the prefabricated and calcinable cylinders, respectively. There was no statistical difference between these values, which were close to those defined by Branemark (1) as representing

passive fit. For the cylinders without screw, the measures of misfit were 23.51 μ m and 30.16 μ m, respectively for the prefabricated and calcinable cylinders, without statistical difference between them. In this analysis, a significant difference was found only between screwed cylinders and cylinders without screw, showing that there was no absolute passive fit in any of the frameworks, corroborating earlier studies (8,15). Another similar study using cylinders prefabricated in gold-palladium and calcinable cylinders cast in cobalt-chrome, screwed with a torque of 10Ncm onto a Standard abutment (Conexão Sistema de Prótese Ltda., São Paulo, Brazil), also did not detect significant differences in fit between these types of cylinders using light microscopy (23). Besides, another study demonstrated that there was no difference in freedom of rotation between the external hexagon of the implant and the internal hexagon of the abutment comparing the prefabricated abutments and calcinable abutments of the UCLA type (24).

In view of these aspects and considering the limitations of this study, the results suggest that utilization of calcinable abutments can allow a reduction in costs without compromising the fit to the abutment. However, further studies should be carried out to try to optimize even more the fit of calcinable cylinders, utilizing other bonds and comparing casting and/or welding methods, as well as conducting a controlled longitudinal clinical trial to observe the effects of these techniques over time. Furthermore, it is necessary to evaluate the fit of implant-supported prosthesis after the application of esthetic materials as rotational freedom was shown to vary as a function of the stage of the manufacturing process depending on the all-ceramic system (25) and multiple ceramic firings may affect the ultimate adaptation of metallic frameworks.

Conclusions

Considering the results obtained and the limitations of this study, it can be concluded that there is no difference in vertical marginal misfit between prefabricated and calcinable cylinders, cast in Co-Cr, simulating a fixed prosthesis of three elements, utilizing induction casting, laser-welding, and single-screw test.

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