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EVALUATION OF THE SHEAR BOND STRENGTH OF THE UNION BETWEEN TWO CoCr-ALLOYS AND A DENTAL CERAMIC

AVALIAÇÃO DA RESISTÊNCIA AO CISALHAMENTO DA UNIÃO ENTRE DUAS LIGAS A BASE DE CoCr E UMA CERÂMICA

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ABSTRACT

INTRODUCTION: Based on the importance of the integrity of the metal/ceramic interface, the purpose of this work was to evaluate the shear bond strength of the metal-ceramic union of two Co-Cr alloys (Wirobond C, Bego; Remanium 2000, Dentaurum) combined with Omega 900 ceramic (Vita Zahnfabrik). MATERIAL and METHOD: Eleven cylindrical matrixes were made for each alloy, and the metallic portion was obtained with the lost wax casting technique with standardized waxing of 4mm of height and of 4mm of diameter. The ceramic was applied according to the manufacturer's recommendations with the aid of a teflon matrix that allowed its dimension to be standardized in the same size as the metallic portion. The specimens were submitted to the shear bond test in an universal testing machine (EMIC), with the aid of a device developed for such intention, and constant speed of 0.5mm/min. RESULTS and CONCLUSIONS: The mean resistance was 48.387MPa for Wirobond C alloy, with standard deviation of 17.718, and 55.956MPa for Remanium 2000, with standard deviation of 17.198. No statistically significant difference was observed between the shear strength of the two metal-ceramic alloys.
Uniterms: Ceramics; Shear test; Alloys

RESUMO

INTRODUÇÃO: Baseados na importância da integridade da interface metal-cerâmica, este trabalho tem como objetivo avaliar a resistência ao cisalhamento da união metal-cerâmica de duas ligas de Co-Cr (Wirobond C, Bego; Remanium 2000, Dentaurum) combinadas com a cerâmica Omega 900 (Vita Zahnfabrik). MATERIAIS E MÉTODOS: Foram confeccionados 11 corpos-de-prova cilíndricos para cada liga utilizada, sendo que a porção metálica foi obtida por fundição pela técnica da cera perdida, através de enceramentos padronizados com 4mm de altura por 4mm de diâmetro. A aplicação da cerâmica foi realizada segundo recomendações do fabricante, com auxílio de uma matriz de teflon que permitia sua padronização com as mesmas dimensões da porção metálica. Os corpos-de-prova foram submetidos ao ensaio de resistência ao cisalhamento em máquina de ensaios universal (EMIC), com auxílio de dispositivo desenvolvido para tal propósito, sob velocidade constante de 0,5mm/min. RESULTADOS E CONCLUSÕES: As médias de resistência obtidas foram 48,387 MPa para a liga Wirobond C, com desvio padrão de 17,718, e 55,956 MPa para a Remanium 2000, com desvio padrão de 17,198. Após análise de variância foi possível observar que não há diferença estatisticamente significante entre os valores de resistência ao cisalhamento das duas ligas metalocerâmicas.
Unitermos: Cerâmicas; Teste de cisalhamento; Ligas.

INTRODUCTION

Currently, the options for prosthetic rehabilitation have increased significantly with the popularization of metal-free prosthesis or the rank of osseointegrated implants, presenting satisfactory results concerning esthetics or function. However, the conventional metal-ceramic fixed partial dentures are still of great importance in the dental clinic because of their versatility, being viable where other therapeutical modalities are not, as well as for its accessible cost. Therefore, fixed partial dentures with metallic structures of noble or alternative alloys still have its place guaranteed in the everyday dental practice.

The oral rehabilitation, besides reestablishing function and esthetics, must respect the patient's financial capacity. Therefore, the use of noble alloys for fabrication of ceramometal dentures should be avoided in many cases because of their high cost[4].

The use of alternative metal alloys is an unquestionable need, and the use of CoCr and NiCr alloys in particular have permitted high quality treatment for a large number of patients with limited financial means in developing countries such as Brazil[1]. These and other non-precious alloys have been developed and have become superior to the gold-based metals in several aspects, including hardness, elasticity modulus and tensile strength[1,8,26]. Thinner infrastructures became viable, with a smaller volume of material, but with the necessary rigidity for extensive fixed partial dentures[26].

The currently most used non-precious alloys are the nickel-chromium based alloys with or without beryllium. However, their biocompatibility has been questioned concerning possible damages to the health of the patient and professionals involved in the fabrication of prosthesis caused by long exposure to Ni and Be[2,14]. The allergic effect of Ni and the toxic potential of Ni and Be for the laboratory technician still causes divergences among professionals of the area about the use of these materials[8,21]. The stability of NiCr alloys is lower in acidic solutions or in the presence of the acidic nature of the plaque, which modifies the release of Ni[24,25]. Thus, there is a tendency of NiCr alloys to be substituted by more biocompatible ones.

An option to nickel-chromium alloys is the cobalt-chromium alloy, an alternative that does not sacrifice the physical properties of the metal ceramic systems[8,14]. Studies in animals substantially show that the CoCr alloys are relatively well tolerated[8], being therefore more biocompatible than the NiCr alloys. However, the metal/ceramic complex does not have all its performances and properties completely defined. As a consequence, more studies on the subject are necessary.

The success of the ceramometal restorations depends on the strength and integrity of the adhesion between metal and porcelain, the most susceptible site for occurrence of cracks[4,5,7,17,18]. The cracks generally progress through the metal/ceramic interface or through the covering porcelain[5,23]. Therefore, the resistance of this fragile area must be evaluated.

Evaluation of the resistance of the interface between two cobalt-chromium alloys and ceramics is performed by the shear test, which allows evaluation of the metal/ceramic adhesion by inducing tension on the interface, so that the crack initiates at the most fragile point[7,16].

Based on the importance of the integrity of the metal/ceramic interface and the scarcity of works evaluating this interface in cobalt-chromium alloys, the purpose of this study was to verify the shear bond strength of the interface between two CoCr alloys and a ceramic.

MATERIAL AND METHOD

Twenty-two ceramometal specimens were made in standardized cylindrical format. For creation of the metallic portion of the specimen, a device was used to standardize the waxed parts. This device is composed of two milled metal parts. The first structure is a metallic ring that served as a matrix placed on a flat surface where the wax was melted. The purpose of the second structure is to remove the wax standardized by the first. Twenty-two wax molds were made to obtain, through the lost wax casting technique, the correspondent metallic portion of the specimens in two types of cobalt-chromium alloys (Wirobond C, Bego; Remanium 2000, Dentaurum), whose composition is presented in Table 1. After unmounting and removal of the sprue, the cylinders were finished in order to refine and finish its forms, since all specimens must have accurate dimensions to allow a perfect relation with the shear device.

The metallic structures were prepared for application of the covering ceramics (Vita Omega 900, Vita Zahnfabrik), first with aluminum oxide spurt (100µm) for 10 seconds at a distance of 2cm and at 45°. The structures were cleaned with tap water, isopropyl alcohol and then dried.

Application of the ceramics was performed according to the manufacturer's instructions, on the upper surface of the cylinders with the aid of a Teflon matrix to standardize its dimensions. The metallic structures were placed in each of the ten orifices of the Teflon device, and 4mm of ceramic material were applied. The specimens were carefully removed and fired as recommended by the manufacturer. Contraction of the ceramic was compensated with a second firing, allowing achievement of the samples' final dimensions as described in Figure 1.

After preparation of the specimens, they were divided into experimental groups as described in Table 2.

For accomplishment of the mechanical shear bond test, a steel device was made (Figure 2). This device is composed

TABLE 1- Composition of CoCr alloys given by manufacturers

Alloy	Composition in % by weight
Wirobond C	Co 61, Cr 26, Mo 6, W 5, Si 1,Fe 0.5, Ce 0.5, C max. 0.02
Remanium 2000	Co 65, Cr 28, Mo 4,5, Si 1,6

of two independent pieces. The first one (A) is cylindrical with a flat adaptation on its walls to allow introduction of the second part (B) in its interior. The second part, also cylindrical with one flat wall, served as a piston during mechanical evaluation. On the flat sides there is a perforation with 4-mm diameter to allow introduction of the specimens in both parts simultaneously. The metallic portion is lodged in part A and the ceramic portion in part B. The set was placed in a universal testing machine (EMIC) and on the upper cylindrical prolongation of part B, load was applied at a constant speed of 0.5mm/min until the samples were cracked. This way, the maximum load supported by the metal/ceramic interface was obtained.

RESULTS

The means and standard deviations obtained from the data of the shear bond strength test for each alloy investigated can be seen in Figure 3. Analysis of variance was performed for the studied groups. No statistically significant difference was observed between groups at a significance level of 5% (p=0.05).

DISCUSSION

Nowadays, the use of alloys, especially NiCr with and without Be, represents the largest amount of alloys used in ceramometal prosthesis. On the other hand, questions about toxic and allergenic elements and even on the carcinogenic potential of these alloys have been raised[8,12-14,21]. The biological characteristics of these alloys should also be taken into consideration when selecting the material[12,13], considering that their use could harm the health of patients and professionals involved in fabrication of the prosthesis. The Ni is considered one of the most common causes of allergic dermatitis[1], appearing in researches as a component with the higher allergenic[8,13] and toxic potential together with Be[10].

Therefore, the CoCr alloys were developed to become an option to the Ni-based alloys, and are considered secure substitutes for clinical use[8] with favorable physical and mechanical properties[8, 14]. Thus, the performance of the metal-ceramic interface of these alloys must be evaluated and, in

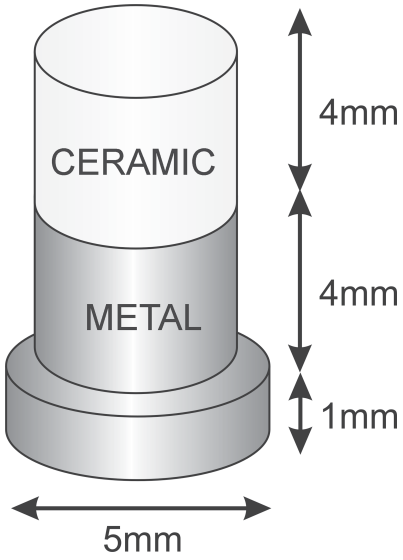

FIGURE 1- Specimen project and respective dimensions

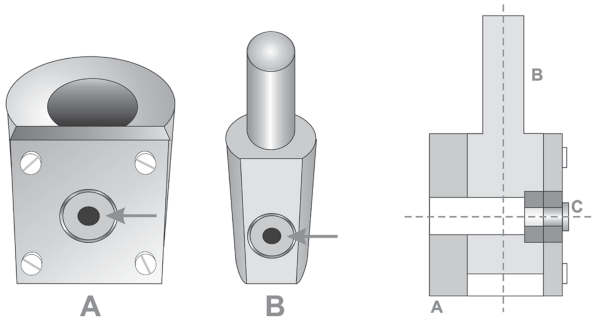

FIGURE 2- Device for the mechanical test: A) external part; B) internal part; C) specimen. The arrow indicates the orifices where the specimens were placed

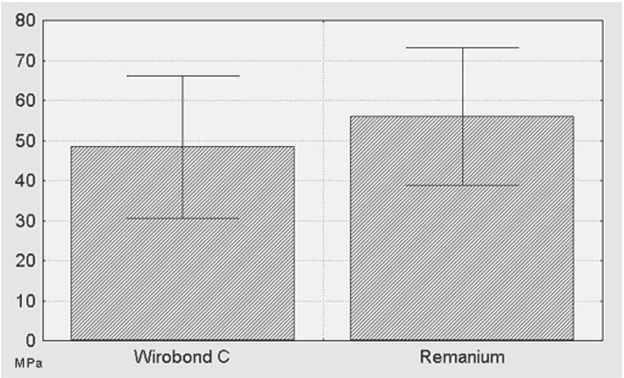

FIGURE 3- Graphic representation of the means and standard deviations of shear resistance data (MPa) according to the alloy used

TABLE 2- Experimental groups division

Group	Alloy	Ceramic	n
G1	Wirobond C, Bego	Omega 900, Vita Zahnfabrik	11
G2	Remanium 2000, Dentaurum	Omega 900, Vita Zahnfabrik	11

the present study, two commercial brands were evaluated.

Adhesion between ceramic and metallic base is a crucial point for clinical success, because a very complex stress situation occurs in the metal-ceramic interface [23], with the tendency of cracks in this region[4,5,7,17,18]. Several tests are capable of evaluating the metal-ceramic bond strength, such as flexural mode, twist, shear, tension or the combination of flexural and twist modes[10], all presenting advantages and disadvantages. The shear test is considered by some authors as the most adequate to measure bond between two materials[3,6,9,11,15,16,18-20,22,23]. This type of test is performed so that tension is induced directly on the interface between the studied materials. Hammad, 1996[10] carried out a critical analysis of the tests used for ceramometal systems. The author states that shear tests with flat interface surface can direct the tension mostly to the interface, and not to suffer metal elasticity modulus influence, as in flexural tests.

The shear bond tests with a flat structure, which had their methodology developed by Itinoche[11], have a different configuration, where the specimens are held in a uniform way, unlike the traditional methodology, in which the test point is applied punctually and tangent to the interface. Thus, the oblique forces that could appear in this type of test can be minimized, by directing the forces parallel to the metal-ceramic interface union, with a tendency toward adhesive fracture, avoiding cohesive failure of the material. This methodology was already used by other authors in other types of interfaces with good results[6,11,19,20,15].

Oyafuso[20], 2001, evaluated the shear strength of ceramics combined to casting and milled titanium, and found values between 59 and 76MPa. He concluded that the combinations presented in this work can be applied in the dental clinic. Itinoshe[11], 1999 found higher shear strength for CoCr alloys compared to a gold and NiCr alloy, combined with esthetic materials (Artglass and Targis). All alloys were considered with a good resistance to shear strength, and the values obtained ranged from 21 to 30MPa for the esthetic material Targis. Olivieri[19], 2003 compared the shear bond strength of titanium in two different conditions to two ceramics using gold alloy as control. The author found mean resistance values between 62.71 and 68.16MPa for the titanium samples and the shear bond strength of gold alloy and ceramic was 40.55MPa. The present study found higher values of resistance for CoCr alloys than Olivieri found to the gold alloy used. All these studies used the same type of shear test as the present work.

In the present study, no statistically significant differences were observed between the two tested alloys as to their clinical behavior. Because of the scarcity of works with CoCr alloys for ceramometal dentures, development of research in this area is of great importance, since its clinical introduction is inevitable. Comparison with other types of alloys and the influence of time on the clinical use must be evaluated.

CONCLUSION

Based on the present results, it is possible to conclude that the tested alloys presented similar characteristics as to the interface adhesion aspects with covering ceramics. However, tests are still required because of the small range of research on the subject.

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