Comparative analyses of the rotational freedom of UCLA-type abutments before and after casting with cobalt-chromium alloy and after application of porcelain

Análise comparativa da liberdade rotacional de pilares protéticos de hexágono externo e interno em três estágios: inicial, após a fundição e após a aplicação da porcelana

Cleide Gisele RIBEIRO
PhD – Department of Dental Implantology – University of Santa Catarina – Florianópolis – SC – Brazil.

Antônio Carlos CARDOSO
PhD – Head professor - Department of Dental Implantology - University of Santa Catarina – Florianópolis – SP – Brazil.

Walter Lindolfo WEINGAERTNER
PhD – Head professor - Department of Mechanical Engineering - University of Santa Catarina – Florianópolis – SP –Brazil.

Abstract

Screw loosening is a common occurrence in implant-retained prosthesis. One of the causes of the high frequency of screw loosening is greater rotational freedom in the implant/abutment interface. The aim of this study was to assess the influence of various laboratory steps on the rotational freedom at the implant/abutment interface and to point out a new methodology to measure the rotational freedom. Cobalt-chromium metal base UCLA-type abutments were divided into two groups: group A (10 abutments for the internal hex implants) and group B (9 abutments for the external hex implants). The rotational freedom was analyzed under three conditions: in the original state, after casting with cobalt-chromium alloy (Degudent, Guarulhos, São Paulo, Brazil) and finally, after porcelain OMEGA 900 (Vita Zahnfabrik H. Raulter GmbH & Co. KG, Germany) application. The rotational freedom values for group B did not show variance between the intervals (with a mean value of 3.333º before casting; 3.089º after casting and, 3.044º after coating with porcelain). In group A, the values increased significantly after coating with porcelain. Only the porcelain application step influenced the interface passivity, and a new device that was developed in this study to assess the rotational freedom between the implant and abutment may be effective and applicable in further studies.

Uniterms
Implant-supported dental prosthesis; dental implants; prostheses and implants.

Introduction

In recent years, the use of implants for single-tooth prosthesis has gained popularity, after many studies have shown success in long-term clinical follow-up of this treatmeant modality [1]. Although the success of biological integration of single-tooth implants appears to be similar in patients who are completely edentulous, problems associated with the integrity of the abutment screw appear to increase [2].

The most common complication that is reported in the literature is the loosening or fracture of abutment and occlusal screws [3-6]. One of the causes of the high frequency of screw loosening is the presence of greater rotational freedom in the implant/abutment interface [7-10]. From a biomechanical perspective, the major distinction among implant systems is the implant-abutment connection [11,12]. The precise fit between the hexagon of the implant and the hexagon of the abutment should allow less than five degrees of micromovementto obtain a stable screwed joint [2].

A well-known abutment for single-tooth restorations is UCLA. It was introduced by Lewis [13] and was projected to engage directly into the implant, allowing the prosthodontist to extend the porcelain subgingivally into areas with extremely limited gingival tissue height. Prosthesis that is placed subgingivally not only improves aesthetics but also helps situations in which the interocclusal space is limited [13]. In recent studies, the quantity of rotational freedom between the implant hexagonal extension and the abutment counterpart has been evaluated, and a close correlation has been established among horizontal misfit and screw loosening [2]. When alloys are cast into UCLA abutments, the last ones are exposed to temperature levels that are required for the burning out and casting procedures. These procedures may alter the abutment surface that is in contact with the implant, and may lead to alterations in the original horizontal fit at the implant-UCLA cast abutment interface [9].

The following study was undertaken to evaluate and compare the rotational freedom of external and internal hexagonal implants and their abutments counterparts, after casting with cobalt-chromium alloy and coating metal base UCLA-type abutments with porcelain, and to point out a new methodology to measure the rotational freedom.

Material And Methods

Cobalt-chromium metal base UCLA-type abutments (Conexão Sistemas de Prótese, São Paulo, SP, Brazil) were divided into: group A was comprised of 10 abutments for the internal hex implants, and group B was comprised of 9 abutments for the external hex implants (Figure 1). Group B constituted 9 of 10 samples, due to a defect in one sample, which made it difficult to take measurements.

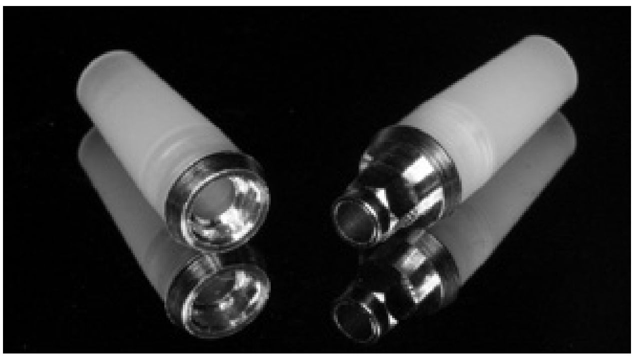


Figure 1 - Cobalt-chromium metal base UCLA-type abutments.

The rotational freedom was analyzed at three time intervals: in the original state, after casting with cobalt-chromium alloy (Degudent, Guarulhos, São Paulo, Brazil) and, finally, after coating with porcelain OMEGA 900 (Vita Zahnfabrik H. Raulter GmbH & Co. KG, Germany).

Casting procedures

For standardization of all prosthetic connections, a silicone matrix was fabricated as a casting mold. The abutments were invested in a carbon-free, phosphate-based investment (Termocast; Polidental Ind. e Com. Ltda., São Paulo, Brazil). After cobalt-chromium alloy casting (constituted 63% Co and 28% Cr; fusion intervals of 1320-1380 ºC), the abutments were sandblasted with aluminum oxide (grain size: 110 µm) and 2.8 Bar.

Porcelain application procedures

Porcelain OMEGA 900 layered onto the cast abutments and then baked according to the manufacturer's instructions. The synthesizing temperature of the porcelain was 930 ºC. Finishing was performed with a Maxcut drill (EDENTA, Haupstrasse, Switzerland). A new mold was fabricated with a special silicone (ZETALABOR, Zermach, Italy) to standardize the quantities of porcelain (Figure 2). Glazing process was not performed.

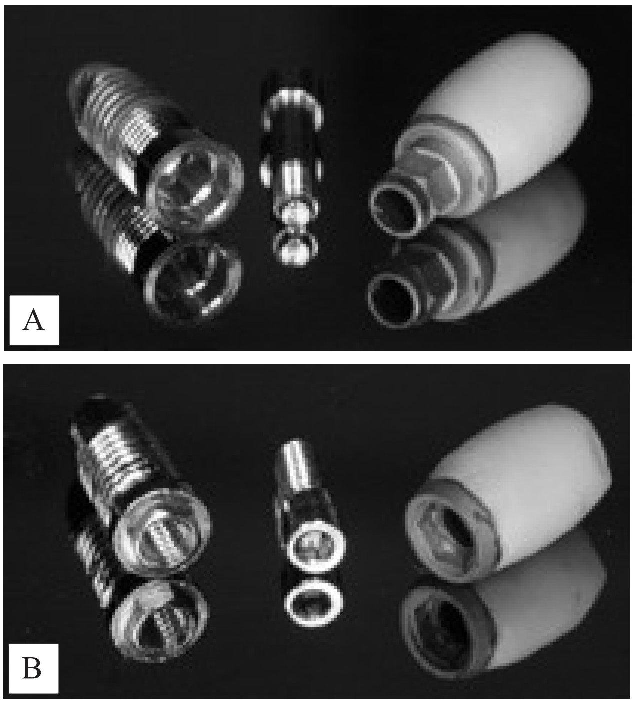
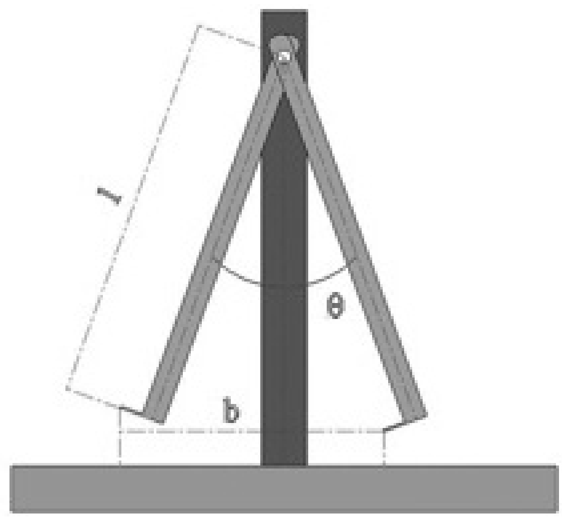


Figure 2 – a) After porcelain application (group A); b) After porcelain application (group B).

To assess rotational freedom, a device similar to a clock pendulum designed to avoid friction between the measuring handle and the table was manufactured. The implant rotational axis was placed horizontally, and the measuring handle was placed vertically. The implant was secured by threading it into a fix bar with a tighter torque than the one applied when rotational freedom was tested. The abutment was seated on the implant and screwed until manual resistance occurred, to permit rotation of the abutment (Figure 3). On the other bar, which was the pendulum device measuring the angle, the abutment was secured to the pendulum's lower edge at a known distance (Figure 4). A minimum torque was applied for the pendulum motion, which allowed the precise identification of the pendulum's oscillation extreme points. The pendulum oscillation was verified by a millimeter scale at its inferior base (Figure 5) and was converted to degrees. The conversion to degrees was achieved by the following: the trigonometric transformation of the horizontal displacement from the resting position to the position of maximum deflection (the position where it feels the resistance to rotation) was divided by the length of the pendulum (opposite cathetus divided by the hypotenuse or opposite cathetus divided by the adjacent cathetus), small angles are equal it. In the first case, we obtained the tangent of the angle and in the second case, we obtained the sine of the angle. The tangent value and the sine value can be converted into degrees using a trigonometric table or a scientific calculating machine. Measurements were taken by two trained operators who performed independent measuring. Therefore, to establish confidentiality for the measuring system, initially, each operator carried out 10 experiments. The average values were used to calculate the mean of rotational freedom angles and the difference between the higher and lower values were used to establish the rotational scattering.



1=Pendulum length Θ=Rotational freedom = tangent arch b/a, b= pendulum horizontal dislocation

Figure 4 - Pendulum scheme.

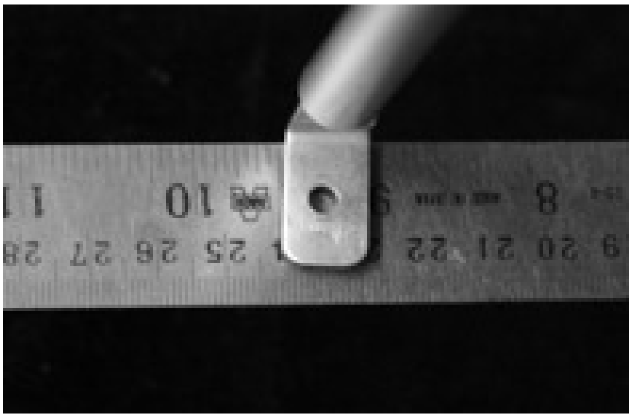


Figure 5 -Millimeter scale at its inferior base.

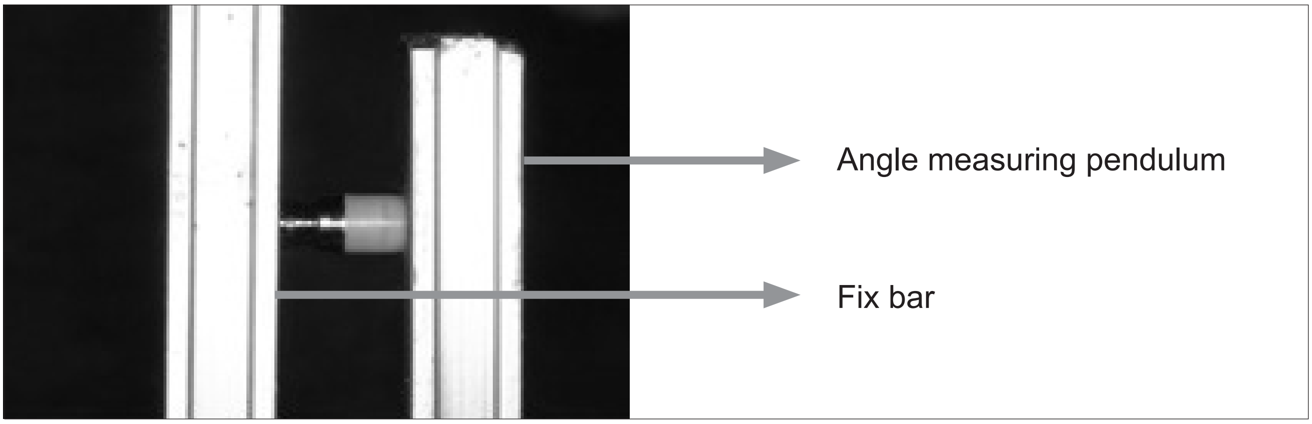


Figure 3- The custom made apparatus that was used to assess the rotational freedom at the implant-abutment interface.

Statistical Analysis

According to the research delimitations and variable types, repeated measures analysis of variance was chosen. Periods (in the original state, after casting and after porcelain) were the dependent variables (among themselves inclusive), and the type of hexagon (internal or external) was the factor (independent variable). Variance analysis was chosen because of the parametric variables. Unequal N HSD test (similar to Tukey, but for different sample unit numbers, because specimen 4 was excluded from the study) for multiple comparisons of averages was chosen. Statistical testing was carried out at the 5% significance level. The variance analysis performed supports the decision to accept or reject the null hypothesis of this experiment. The null hypothesis was the most important factor of the interaction (hexagon) and period.

Initially, the prerequisites for using analysis of variance were checked. The sample showed normal distribution and variance homogeneity (Box M test, $p = 0.127$), allowing the application of the test. The analysis was performed with Statistica 6.0, StatSoft.

Results

Table 1 shows the mean values of the rotational freedom of all samples during all laboratory phases. The interface (internal or external) was statistically significant, which indicated that rotational freedom values comprise a different behavior in at least one analyzed period and depend on the abutment hex type.

For the external hex implants, there was no significant variance between the periods regarding rotational freedom, while for the internal hexagonal implants, there was a significant increase after coating with porcelain. There was a significant difference among the rotational freedom of the internal hex implants after coating with porcelain, and among all other combinations carried out.

Discussion

The fit between implants and implant-retained prostheses may be responsible for stress transmission, biological responses of peri-implant tissues and mechanical complications with prosthetic reconstruction [13]. Currently, there are some 20 different implant/abutment interface geometric variations available. With few exceptions, the majority long-term clinical data on interface performance that is reported in the literature involvesthe external hexagonal. This is primarily the result of its extensive use, the broad number of prescribed clinical applications, the level of complications reported and the resultant efforts to find solutions [4].

A comparative analysis between internal and external hex implants was carried out in this study, which demonstrated that a higher rotational freedom was found in internal hex implants. The highest rotational freedom for internal hex implants was also observed in a study carried out by de Barros Carrilho et al. [8]. Nevertheless, Balfour and O'Brien [7] tested three single-tooth implant systems with different prosthetic connections for maximum and

Table 1 - Data relative to the measurements throughout the laboratory periods (in degrees)

Hexagon	Periods	N	Mean	Standard Deviation
Group A	In the original state	10	3.320	0.355
	After casting		3.380	0.678
	After application of porcelain		4.440	0.744
Group B	In the original state	9	3.333	0.320
	After casting		3.089	0.535
	After porcelain application		3.044	0.598
Total	In the original state	19	3.326	0.330
	After casting		3.242	0.616
	After porcelain application		3.779	0.974

rotational stability, compressive bending strength, and cyclic fatigue durability. Overall, they found that the internal hex design provides the highest degree of single-tooth stability. A correlation between the joint depth and failure force was found; systems with shallow joints sustained smaller bending forces than systems with deep joints.

The present study showed that only porcelain application promotes changes regarding rotational freedom at the implant/abutment interface of internal hexagon implants. Clinical and laboratory procedures used in the fabrication of implants that are supported by prostheses may contribute to a positional distortion between the machined abutment and the implant head [14,15]. Regarding the casting procedure, an alternative option to nickel-chromium alloys is cobalt-chromium alloys, which does not sacrifice the physical properties of the metal ceramic systems [16].

In single-tooth restorations, the adaptation of many abutments to the implant before and after laboratory procedures has been assessed in a limited number of studies. The vertical adaptation of machine-made abutments cast-on and laboratory modification was assessed in two portions: implant/abutment interface and screw/screw adaptation. Six combinations of abutments and implants were studied. The authors concluded that machine-made abutments with gold-palladium alloy and porcelain baking does not affect the vertical fit of machine-made UCLA abutments coupled with 3i implants. However, they pointed out that UCLA abutments had less contact area with screws when cast and submitted to porcelain baking cycles. The authors attributed these findings to heat-induced stress on the pre machine-made abutments during the procedures, or contraction- distortion induced due to the casting procedure [5].

The results showed that the rotational freedom was lower than 5 degrees for all analyzed samples, in accordance with the manufacture's specifications. However, when the rotation exceeded 2 degrees, the resistance to screw joint failure reduced from 6.7 to 4.9 million cycles. If the abutment rotated more than five degrees, joint stiffness and preload were compromised enough to allow the screw joint to enter second-stage failure, which lead to a faster screw loosening (2.5 to 1 million cycles) [17,18]. A rotational freedom of more than 5 degrees in external hex-type connections reduced the number of cycles that are necessary for screw loosening to 63% [13].

Based upon the findings, this study suggests that only porcelain application laboratory procedures promoted changes regarding rotational freedom at the implant/abutment interface of internal hex implants. However, more studies are needed to substantiate this finding. Additionally, the new device developed in this study for assessing the rotational freedom between the implant and the abutment may be an effective method that can be used in further studies.

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Resumo

O afrouxamento de parafusos é uma ocorrência bastante comum na prótese sobre implantes. Uma das causas desta freqüência elevada de afrouxamento de parafuso é a presença de uma maior liberdade rotacional na interface implante/pilar. O objetivo deste estudo foi avaliar a influência das diversas fases laboratoriais sobre a liberdade rotacional na interface implante/pilar e, ainda estabelecer uma nova metodologia para medir a liberdade rotacional. Pilares do tipo UCLA com cinta metálica em cromo-cobalto foram divididos em dois grupos: grupo A (10 pilares para implantes de hexágono interno) e grupo B (9 pilares para implantes de hexágono externo). Foi realizada a avaliação da liberdade rotacional em três fases: estágio inicial, após a fundição em liga cobalto-cromo (Degudent, Guarulhos, São Paulo, Brasil) e, finalmente, após a aplicação da porcelana OMEGA 900 (Vita Zahnfabrik H. Raulter GmbH & Co. KG, Alemanha).O s valores da liberdade rotacional para o grupo B não variaram significativamente entre os períodos (com média antes de fundir de 3,333º; após a fundição de 3,089º e após a aplicação da porcelana de 3,044º). No grupo A, os valores aumentaram significativamente após a aplicação da porcelana. Somente o procedimento da aplicação da porcelana influenciou a passividade da interface (grupo A) e o novo instrumento desenvolvido neste estudo para avaliação da liberdade rotacional entre o implante e o pilar pode ser um método eficiente que pode ser usado em futuros trabalhos.

Unitermos

Próteses dentais implanto-suportadas; implantes dentais; próteses e implantes.

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Correspondence:
Cleide Gisele Ribeiro
Adress: Rua Carangola, 375
Democrata
Juiz de Fora
Cep: 36035-220 – MG - Brasil
Email : cleidegr@yahoo.com.br