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INFLUENCE OF MISMATCHING BETWEEN PROSTHETIC COMPONENTS AND DENTAL IMPLANTS: AN IN VITRO STUDY

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Abstract: The aim of this study was to evaluate the adaptation of prosthetic components to dental implants subjected to masticatory fatigue simulation. The evaluation was performed using implants and prosthetic components from the same brand and also mixing implants and prosthetic components from different brands. Twenty-one external hexagon implants from the Neodent® brand and 21 titanium UCLA-type prosthetic components from three different brands were used: Neodent®, Conectao® and Titanium Fix ®. Group 1) 7 Neodent® and 7 UCLAS Neodent® Implants; Group 2) 7 Neodent® and 7 UCLAS Conecta® implants; Group 3) 7 Neodent® and 7 UCLAS Titanium Fix® implants. The groups were submitted to the fatigue test. Each implant received a single component, which was attached to the implant by means of a titanium screw, using a torque of 20 N, with a manual torquemeter. Each implant/component set received 4 random markings around the circumference The results obtained were analyzed using the ANOVA test, adopting ($p<0.05$) In the readings of the specimens, in an optical microscope with magnification x160/scale 50µm, multiple comparison tests demonstrated that the CONEXÃO group had significantly greater measurements in the gaps than the other groups ($p = 0.0001$ and $p = 0.0156$ respectively in comparisons with the NEODENT and TITANIUMFIX groups). The NEODENT and TITANIUMFIX groups did not differ significantly ($p = 0.0720$). No statistically significant difference was found between the groups regarding the measurements of the readings of the specimens in a scanning electron microscope with magnification x200/scale 500µm ($p = 0.0952$). It is concluded that there is compatibility between the components of the three different brands with the Neodent® implants.

Keywords: Dental Implants, Dental

Abutments, Dental Materials.

INTRODUCTION

In implant-supported prostheses, the phase of choosing the prosthetic components to be used on the implants is extremely important for the success and predictability of the treatment. For the prosthodontist, this task is not always easy. In the clinic, the professional often has no way of knowing the commercial brand of an implant installed by another professional, or even, the commercial brand of the implant used does not have the necessary prosthetic component for the solution of the clinical case. This situation leads the dentist to look for a possible combination between the installed implant and a compatible prosthetic component, but with a different commercial brand (Aquino et al., 2011).

There are several options for prosthetic components offered by companies that manufacture dental implants. Choosing the ideal prosthetic components for each clinical case is just one of the stages of oral rehabilitation. The nomenclature is not standardized, and each manufacturer uses different types, shapes, and sizes. All companies declare that the prostheses must be made with components of the same commercial brand as the chosen implant. The possible combination of prosthetic components and implants from different commercial brands opens up a huge range of options for the professional. However, this combination may offer risks and compromise the correct adaptation of the prosthesis/implant set. The ideal prosthetic component will have a fair and passive adaptation to the implant (Cox & Zarb, 1987) and misfits of around 10μm are acceptable (Branemark, 1983). A variation for the level of misfit was suggested by Jemt in 1991, who quantified levels of misfits of up to 150μm that could be compatible with well-fitting prostheses. The trajectory of the microgap 12 between the implant and the prosthetic component is irregular. Factors related to the deformation of the edges, in addition to under or over outline of the components, can alter the assessment of the real misfit (Dias, 2007).

In this sense, the ucla-type pliers were designed to simplify the process of making prostheses on implants, maintaining a direct connection to the implant through its screw (Parel, Sulivan, 1997). The titanium UCLA-type component is suggested by implant manufacturing companies for temporary prosthetic work, and must be attached with a torque of 20N.

In the clinic, it is difficult to evaluate prostheses inside the oral cavity, since the parameters for measuring the space or gap between prostheses and implants are based on measurements made through microscopes and on micrometer scales, which are imperceptible to the human eye (Dinato, 2001). The path of the crack is irregular in its path, and the levels of maladjustment accepted as tolerable have not yet been determined (Dinato, 2001; Kano et al., 2007, Bisognin, 2009).

Recent studies suggest that marginal misfits induce stress in prostheses, components, implants and supporting bone tissue. Excessive tensions can lead to mechanical failures of the prosthesis, such as loss of torque of the prosthetic screws after simulating masticatory cycles (Silva, 2012). Therefore, the present study aims to evaluate the degree of in vitro adaptation of the prosthetic component/ implant interface.

METHODOLOGY

SAMPLE PREPARATION

Twenty-one (N=7) UCLA-type titanium prosthetic components with external hexagon implants and their respective screws, also made of titanium, from three national commercial brands, were selected, distributing 7 components for each group as described above: Neodent®, Conectao® and Titanium Fix®. Then, a UCLA-type prosthetic component was attached to each implant by means of the prosthetic screw, with manual torque of 20 N and reaffirmed the torque in a digital 10 minutes. Using a marking pen, random markings were made at four points around the circumference of the UCLA component, these points simulated the mesial, distal, lingual and buccal dental faces, which allowed measurement at different points of the circumference of the implant interface / prosthesis (Klineberg, Murray,1985; Silva, 2005). The UCLA-type components were standardized in their height, for this purpose a carbide drill was used at high speed to cut the free end, leaving all specimens with a height of 10 mm. After making the final specimens, the components were submitted to the cycling test, simulating the oral cavity of the set (component/implant) for a period of six months.

FATIGUE SURVIVAL ANALYSIS

The specimens were positioned on a base at an angle of 30° in relation to the base of the mechanical fatigue simulator (ER 37,000 Plus, Eros; São Paulo, Brazil) for the fatigue survival test and received 500,000 cycles at a frequency of 2 Hz and 100 N of Load with a 1.6 mm diameter stainless steel applicator, as described in ISO 14801:2016 (Matos et al., 2022), with the specimens immersed in distilled water at 37 °C.

MISADAPTATION ANALYSIS

Measurements were performed in the three groups (1-Neodent, 2-Conexão and 3-Titanium Fix) after cycling, using an optical microscope and, soon after, using a scanning electronic microscope. Each specimen was placed on the OM microscopic table and, with the aid of a 160x magnification objective lens, measurements were taken of the existing space between the implant platform and the prosthetic component at the four points previously marked, which simulated the mesial dental surfaces., distal, buccal, palatal/lingual. Four measurements were performed on each specimen, totaling 63 measurements in the three groups. The unit of measurement was micrometer (μm). Soon after, the specimens were placed on the SEM using a lens with a 200x magnification and the same procedure was performed to allow a correlation of the data and the adopted analysis.

SCANNING ELECTRON MICROSCOPY ANALYSIS

Adaptation differences were evidently marked when submitted to SEM. The best magnification for this study was using a 200x magnification lens, as higher magnifications took the focus off the mismatch line and began to better assess the surface.

STATISTICAL ANALYSIS

The Kolmogorov-Smirnov test was used to assess whether the variables followed a normal distribution within each study group. In the analysis of the measurements of the specimens by optical microscope, the technique of analysis of variance (ANOVA) was applied with Brown-Forsythe correction for inequality of variances. Differences were located by Bonferroni multiple comparison tests. The technique of analysis of variance (ANOVA) with the fixed factor Group was applied in the comparison of the averages of the measurements of the specimens by scanning electronic microscope. A significance level of 0.05 ($\alpha = 5\%$) was adopted for all statistical tests applied and descriptive levels (p) below this value were considered statistically significant.

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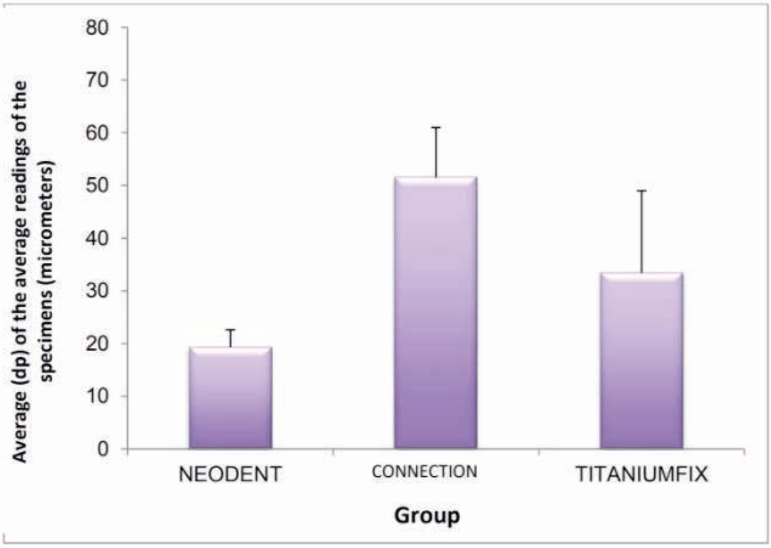
RESULTS

Group	Average Readings of Test Pieces (µm)					
	Average	dp	Minimum	median	Maximum	n
1 -NEODENT	19,3	3,3	14,3	20,3	24,5	7
2 - CONNECTION	51,5	9,5	32,3	54,3	62,0	7
3-TITANIUM FIX	33,4	15,6	22,5	24,5	62,5	7
Comparison	p = 0,0006 *					

Table 1 – Descriptive measures of the mean readings of the test specimens by the optical microscope with x160 magnification/50µm scale, according to the study group.

A statistically significant difference was found between the groups regarding the mean measurements of the readings of the optical microscope test specimens with x160 magnification/50µm scale (p = 0.0006).

The multiple comparisons tests demonstrated that the CONEXÃO Group (2) presented a significantly higher average of the measurements in the slits than the other groups (p = 0.0001 and p = 0.0156 respectively in the comparisons with the NEODENT and TITANIUMFIX groups). Groups (1) NEODENT and (3) TITANIUM FIX did not differ significantly (p = 0.0720).

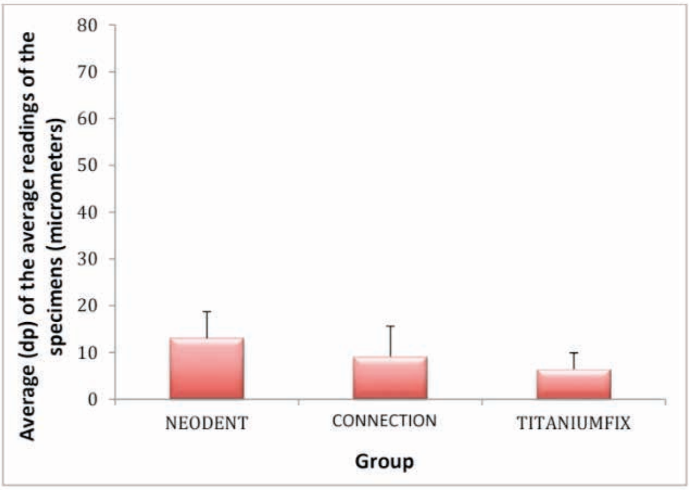


Graph 1 – Mean (+ 1 dp) of the measurements of the readings of the specimens by the optical microscope with magnification x160/scale 50µm, according to the study group.

Group	Average Readings of Test Pieces (µm)					
	Average	dp	Minimum	median	Maximum	n
1-NEODENT	13,0	5,7	5,7	12,6	21,5	7
2- CONNECTION	9,1	6,5	2,9	6,5	21,1	7
3-TITANIUM FIX	6,4	3,5	4,2	5,1	14,3	7
Comparison	p = 0,0952					

Table 2 – Descriptive measurements of the mean readings of the test specimens by the scanning electron microscope with magnification x200/scale 500µm, according to the study group.

No statistically significant difference was found between the groups regarding the means of the mean readings of the specimens under scanning electron microscope with magnification x200/scale 500µm (p = 0.0952).



Graph 2 – Mean (+ 1 dp) of the measurements of the readings of the test specimens by scanning electron microscope with magnification x200/scale 500µm, according to the study group

DISCUSSION

When carrying out a single, partial or total fixed implant prosthesis, the importance of a good passive adaptation is reflected in the quality and longevity of the work (Branemark, 1983). Having prosthetic components that make it possible to make the prosthesis correctly is a constant search for professionals and companies that work in this area. Skalak (1983) cited that a critical aspect of the success or failure of implants is the mechanism that transfers forces from the implant to the bone. Cox & Zarb's research (1987) confirmed these data, in which they found that passive adaptation is essential for the longevity of prostheses on implants and that the lack of adaptation can lead to tensions in the system, which can even lead to loss of osseointegration. Taking into account that the success of the implant-supported prosthesis also depends on the maintenance and integrity of the bone that supports the implants, the studies by Broggini et al. (2003) reported that the presence of a micro gap between the implant and the prosthetic component favors the appearance of an inflammatory infiltrate in the region, which may lead to bone loss and prosthetic complications. Adding knowledge, Kohavi (1993) made a study of the complications that occurred in the soft tissues and in the prosthetic components of implant-supported prostheses. Two reasons were observed to justify the problems: misfit or lack of passive adaptation between the prosthetic component and the prosthetic restoration, and premature occlusal contacts. In addition to these authors, Guimarães et al. (2001) performed an analysis of the marginal adaptation of the prosthetic abutment with the implant and reported that the misfit between the base of the implant and the prosthetic abutment and the lack of passive adaptation between the prosthesis and the abutments can lead to fractures of both the prosthetic components and the implant. of the abutment screw or the implant itself, can also lead to inadequate distribution of forces to the supporting bone, accumulation of bacteria and even loss of osseointegration. The nature of loss or displacement of prostheses is complex, involving factors such as: material of the prosthetic abutment, type of fitting, degree of conicity, machining accuracy of system components, fatigue, penetration of oral fluids, chewing forces, among others.

In the present study, the average gap between the prosthetic components and the base of the implants was above 10 μm, in contrast to Bränemark (1983) who quantified the gap size between the implant and the abutment that allows for osseointegration to be 10 micrometers. Klineberg & Murray (1985) reported accepting spaces of up to 30 micrometers around 10% of the circumference of the abutment and the works of Carlson & Carlsson (1994) stated that a lateral misfit of up to 50 micrometers is not harmful, however, a misfit angle of the same magnitude leads to progressive loss of osseointegration. Taking this point of view into account, most of the averages found in this study fit positively for a good final result in prosthetic rehabilitation on implants. Aziz (2001) studied five different brands: Implamed (USA), Nobelbiocare (Sweden), Restore (USA), Calcitek (USA), Intra-Lock (Brazil). The author reported that despite being commercially presented in equal dimensions, after being evaluated and tested in the study, they presented statistically different rotational amplitudes at the 5% level, ranging from 75 μm to 128 μm.

Another factor to evaluate the adaptation quality of the components is the torque received by the prosthetic screw. In theory, the components of the same trademark as the implant must have a superior fit. However, in this study, two specimens that were composed exclusively of Neodent® brand products showed much higher values for marginal misfit (Tables 2 and 3), suggesting that during the cycling test, screw loosening may have occurred. This would lead to another study to evaluate the degree of torque on the screws after cycling tests. Therefore, we must take into account the studies that also aim to study the role of the prosthetic screw in the adaptation of prostheses on implants. Weinberg (1993) when evaluating the biomechanics of force distribution in implant-supported prostheses, stated that the distribution of forces in the union of natural teeth in a fixed prosthesis is comparable to that which occurs in implant-supported prostheses. If the fit of the prosthesis/interface is faulty, the resulting occlusal force line is not adequate and may exceed the amount of tension that the screw thread was designed to receive. Titanium screws are stronger than gold screws. When it comes to implant-supported prostheses, poor adaptation in a single prosthesis can cause screw loss and failure of the prosthesis, but in multi-element prostheses, poor adaptation in a given region leads to overload of forces where the prosthesis is better adapted and may also cause overload in some implants; especially when this misfit occurs in the most distal prosthetic component of the prosthesis. Also in 1989, a study by Jemt et al. together with two mechanical engineers, Rangert and Jörneus, it was carried out and based on clinical experiences and theoretical considerations. They studied the Branemark implant system in a single prosthesis on implant situation and reported the following observations: a) if mainly axial forces are encountered, failure of implant components will not regularly occur; b) the weakest point of the system is the screw of the prosthetic component, which must be considered as a safety item; c) the precision in the adaptation between the prosthesis/prosthetic component and the sufficient tightening of the gold screw are fundamental parameters for a high capacity of load distribution next to the screw.

In 1996, Binon & McHugh evaluated the effect of rotational play between the implant and the abutment and its relationship with interface stability. It was determined that cast abutments were more resistant to prosthetic screw loss than prefabricated components. Contrary to this study, Goll (1991) recommended that factory-machined components be used, as they have predictable intimate contact between the prosthetic parts and the implants. In a study carried out by Ma et al. (1997) who evaluated the tolerance of variations in measurements of implant components, it was proven that the second generation machined components improved the machining conditions in relation to the first generation machined components. Attesting to the same opinion, Byrne et al. (1998) tested cast and prefabricated castable intermediates, reaching the conclusion that prefabricated intermediates are superior in the degree of adaptation. Dellow et al. (1997) indicated that there was good machining tolerance when interchanging various implant and abutment systems. The laboratory data resulting from the research carried out to obtain this dissertation work showed that there were no significant differences when we used Neodent® brand implants combined with prosthetic components from the companies Conectao® and Titanuim Fix®, probably due to the fact that all prosthetic components are manufactured on high-precision computerized lathes.

The authors Binon (1994) and Kano (1998) reported in their studies that the wrong combination of components from different systems results in a bad prosthetic adaptation, increasing the risks of problems for the implants. Completing this line of thought, Jaarda et al. (1996) considered that no combination between components of different systems can present values lower than those obtained within the same system. In the study by Jansen et al. (1997), all 13 sets of combinations between implant and intermediates from different commercial brands showed bacterial microleakage, despite all being factory-machined components. This study demonstrated a concern to invest in changes that guarantee a better sealing of the marginal adaptation area.

Despite all the studies already carried out to date, the micro gap at the interface between the implant and the abutment is a constant present in all studies and its adverse effects include loosening and/or loss of the prosthetic screw, rotation and/or fracture. of the intermediary. Passive adaptation of the prosthetic component to the implant base is often difficult to achieve and interpret in a clinical situation (Waskewicz et al., 1994).

A standardization for the classification of this micro-gap has not yet been established (Kano et al., 2007). A study by Diaz et al. (2009) investigated the use of the Nobel Direct (Pund) single-piece implant, which advocated preventing marginal alveolar bone loss due to its macrogeometry and providing the absence of a microgap between the fixation and the prosthetic component. The objective of the study was to verify through digital radiographic subtraction of Punds submitted to immediate loading under a new prosthetic protocol. Standardized radiographs were taken using a personalized occlusal splint. It was concluded that this implant system does not prevent marginal alveolar bone loss and that after installing the definitive crowns, it presents results similar to conventional two-piece implants.

The impact of abutment rotation and angulation on marginal adaptation is reflected in the misfit of prostheses on implants (Semper et al., 2010). Sousa et al. (2010) published a research that studied the observer's experience in the diagnostic capability of implant-supported metal structures with different degrees of maladaptation, through the analysis of digital radiographs taken at different angles. Even though they were apparently fully adjusted, all the prostheses on implants showed micro cracks imperceptible to the human eye.

In 2011, Aquino et al. published results of a study that evaluated the adaptation between the implant and the base of the prosthetic component of the titanium UCLA type. 30 Neodent® brand external hexagon implants were attached to UCLAS from 03 different brands: 1) 10 Neoden®t, 2) 10 Conecta® and 3) 10 Titanium Fix®. The torque used was 20 N, with a manual torquemeter. The specimens were evaluated under the microscope of the microdurameter device, with a magnification of 200 times. There was no statistically significant difference between the groups. The average of spaces found between the base of the prosthetic component and the implants was below 10 µm. The laboratory data of the present study complement the aforementioned study. In the specimens submitted to the fatigue test, the average gap between the prosthetic components and the implants was between 19.3 µm and 33.4 µm, when evaluated in OM. In the SEM evaluation, this average was between 6.4 µm and 13 µm. These data suggest that fatigue can alter the adaptation of prostheses. In this study, evaluations with scanning electronic microscopy and optical microscopy demonstrate that there is always a micro gap in the prosthetic interface of the implant with the component; which makes the region susceptible to bacterial colonization and complications in adaptations of implant-supported prostheses, due to masticatory loads (Jemt, 1997; Kohavi, 1993). The need for more clinical and laboratory studies is evident so that in the future prostheses with better levels of adaptation can be obtained. It is important to reduce this micro gap, with prostheses that are as well adapted as possible. This way, the dental surgeon will have more lasting results from his work, also protecting the peri-implant bone.

CONCLUSION

The existence of the micro-gap between the implants and the UCLA-type prosthetic components was evidenced in all specimens, presenting an irregular shape and trajectory. Therefore, it can be concluded that prosthetic components of the UCLA type of titanium from the brands conecta® and Titanium Fix® are interchangeable with implants from the brand Neodent®.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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STATEMENT OF THE INSTITUTIONAL REVIEW BOARD

Not applicable.

DECLARATION OF INFORMED CONSENT

Not applicable.

DATA AVAILABILITY DECLARATION

Data is available upon request.

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