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Relation between Implant/Abutment Vertical Misfit and Torque Loss of Abutment Screws

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This study investigated whether there is a direct correlation between the level of vertical misfit at the abutment/implant interface and torque losses (detorque) in abutment screws. A work model was obtained from a metal matrix with five 3.75 x 9 mm external hex implants with standard platform (4.1 mm). Four frameworks were waxed using UCLA type abutments and one-piece cast in commercially pure titanium. The misfit was analyzed with a comparator microscope after 20 Ncm torque. The highest value of misfit observed *per* abutment was used. The torque required to loose the screw was evaluated using a digital torque meter. The torque loss values, measured by the torque meter, were assumed as percentage of initial torque (100%) given to abutment screws. Pearson's correlation (α=0.05) between the misfit values (29.08 ± 8.78 µm) and the percentage of detorque (50.71 ± 11.37%) showed no statistically significant correlation (p=0.295). Within the limitations of this study, it may be concluded that great vertical misfits dot not necessarily implies in higher detorque values.

Key Words: dental prosthesis implant-supported, prosthesis fitting, torque.

INTRODUCTION

The implant/abutment interface has been referred to as a significant factor in stress transference, possible adverse biological response and complications on prosthetic rehabilitation (1). The fabrication of implant components and the effects of clinical and laboratorial phases can contribute to misfit between implant and prosthesis (2,3). Two possible complications emerge from this scenario: 1) biological - increase of the load transfer to the bone, and presence of mucosal inflammation due to the development of microflora in the micro-gap between the implant and the abutment with subsequent bone loss; and 2) prosthetic - loosening/ fracture of implant and/or prosthesis (4).

In case of misfit between implant and abutment as well as between abutment and prosthesis, compressive and traction loads could be directed to the restoration, resulting in loosening of the prosthesis and abutment screws, fracture of the restoration, bone microfractures surrounding the implants and even fracture of the implant body (5,6).

In a review of studies referring to success and failure in osseointegrated implant treatment published between 1981 and 1997, Goodacre et al. (7) observed mechanical and biological problems. Among the biologi-

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cal complications, the authors mentioned bone loss surrounding the implants, gingival inflammation and fistulae formation. Regarding the mechanical failures, the authors mentioned prosthesis and abutment screw loosening, implant fracture and fracture of the metal framework and the restorative material used. Misfit of components was cited as a possible cause of these complications. A previous study investigating possible occurrences of implant gold and abutment screw loosening in full arches after a 5-year period, found that screw loosening was related to misfits of the prosthetic frameworks (8).

The contact between abutment and implant platform is a key factor because it reduces the load over the abutment screw, warranting a high efficiency of these components (9). Even little misfit could result in changes in screw geometry and incidence of strain over the screws (10).

The success of a screwed connection is directly related to the preload reached during torque and the maintenance of this preload with the time (11). It is suggested that the screw loosening originates from the separation between the screw and abutment surfaces, as well as the high stresses levels generated over the screws (12). Several studies have evaluated the misfit effect between the external hex of the implant and the abutment screws, verifying a direct correlation between rotational freedom and abutment screw loosening at the abutment/implant interface (13,14).

This short review of literature shows that the presence of an implant/abutment misfit seems to be related with the loss of screw, but no study has yet correlated the misfit level with screw loosening. Therefore, the purpose of the present study was to investigate whether there is a direct correlation between the level of vertical misfit at the abutment/implant interface and torque losses (detorque) in abutment screws.

MATERIAL AND METHODS

This study was conducted using a brass master model simulating the curve of a human mandible with five 3.75 x 9 mm external hex implants (Titamax, Neodent, Curitiba, PR, Brazil) with regular platform (4.1 mm). For these implants, castable abutments (UCLA, Neodent) were tightened to a 20 Ncm torque using a torque controller device (Neodent) as recommended by the manufacturer.

Impression was obtained using a custom tray and polyether impression material (Impregum Soft; 3M/ESPE, Seefeld, Germany). After setting of the material, the molds were removed and titanium external hex implant analogues (4.1; Neodent) were adapted to the transfers. Type IV dental stone (Durone IV; Dentsply Ind. e Com. Ltda., Petrópolis, RJ, Brazil) was poured into the mold and master casts were obtained.

UCLA castable abutments (Neodent) were positioned on the master casts. Five-millimeter-diameter sticks were cut and positioned between the abutments and at the free ends, forming a 10-mm cantilever. The implants were identified by letters, being ‘A’ and ‘E’ the distal implants. Four frameworks were fabricated with a silicon matrix (Silon 2 APS; Dentsply Ind. e Com. Ltda.) reproducing the initial wax. A passive fit test of the waxed frameworks was performed by manually tightening a screw at one end and assessing the fit at the other end. When misfits were observed, the wax sticks were cut and joined again with melted wax to correct the inaccuracies. The frameworks were invested with phosphate-based investment (Rematitan Plus; Dentaurum, Pforzheim, Germany), specific for commercially pure titanium (CP Ti), and the rings were burned out in an oven (EDG 7000-10P, EDG Equipamentos e Controles Ltda., São Carlos, SP, Brazil), following the recommended thermal cycle.

The one-piece casting process was performed in a discovery plasma machine (EDG Equipamentos e Controles Ltda.), which produces electric arc melting in a vacuum and argon-inert atmosphere, with injection of the alloy into the mold by vacuum pressure. All process runs automatically. CP Ti (Tritan, grade I; Dentaurum) was used and the casting temperature was approximately 1668°C for CP Ti, according to the manufacturer’s instructions. After casting, the frameworks were divested and sandblasted with 100-μm-particle aluminum oxide stream (80 psi = 5.62 kgf/cm^2), avoiding damage to the seating regions of the prosthetic cylinders. Sprue formers and small nodules were carefully removed under magnification. No further finishing or polishing procedures were performed to ensure uniformity of the frameworks.

The vertical misfits were evaluated in “y” axis, with a comparator microscope (Mytutoyo, Tokyo Japan) at ×30 magnification after application of a torque of 20 Ncm on the frameworks with the aid of a digital torque meter (TQ-680; Instrutherm Measure Instruments, São Paulo, SP, Brazil) (Fig. 1) following a specific order (abutment screw 'C' was screwed first followed by abutment screws 'A', 'E', 'B' and 'D'). News screws were used to all frameworks. According the literature, perfect fit does not exist (15), but those under values of 10 µm are considered as acceptable misfits (16). For the microscopic analysis, a point on the buccal, lingual, mesial and distal surfaces were evaluated, totalizing 80 analyzed regions. The point with the highest vertical misfit of each abutment was selected to the analysis, obtaining a total of 20 values corresponding to each abutment, being 1 value for abutment and 5 abutments for framework.

For the evaluation of torque losses in the abutment screws, the digital torque meter (TQ-680) was used again. With the framework installed over the metal matrix the set was positioned in a paralelometer and the key installed in the torque meter to read the detorque value (Fig. 2). The matrix was turned to unscrew and the torque meter realized the detorque value reading for this screw. This procedure was performed in all framework screws following the same order ('C', 'A', 'E', 'B' and 'D'), totalizing 20 values. The torque loss values, measured by the torque meter, were assumed as percentage of initial torque (20 Ncm = 100%) given to abutment screws.

The statistical analysis was performed using the SPSS 12.0 package (SPSS Inc., Chicago, IL, USA). With the torque loss values for each abutment, as well as the misfit values for each abutment, Pearson's correlation analysis (α=0.05) was applied to verify the presence of correlation between these factors.

RESULTS

The vertical misfit values for all abutments are presented in Figure 3. The mean misfit value was of 29.08 ± 8.78 µm. All misfit values were above 10 µm. The percent values of torque loss are presented in Figure 4. The mean percent torque loss value was 50.71 ± 11.37%. High level of torque loss was observed, sometimes approaching 70% of the initial torque. Pearson's correlation did not show statistically significant correlation (p=0.295) between the values of misfit in micrometers and the percentage of torque loss.

DISCUSSION

The present work evaluated the influence of vertical misfit in one-piece five-element frameworks at the percentage of torque losses applied. The biological adverse effects of these misfits, such as mucosal inflammation, cannot be ignored. Misfits between the components of a screwed connection have been considered as a possible cause of mechanical complications, such as screw loosening and/or fractures (7,8). Some studies have reported that frameworks cast in one piece present distortions that compromise their accurate fit to the implant/abutment interface

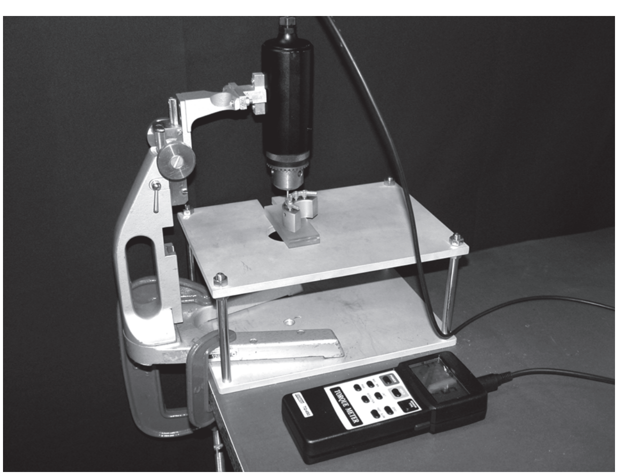

Figure 1. Torque application with the digital torque meter.

Figure 2. Detorque value registered in the digital torque meter.

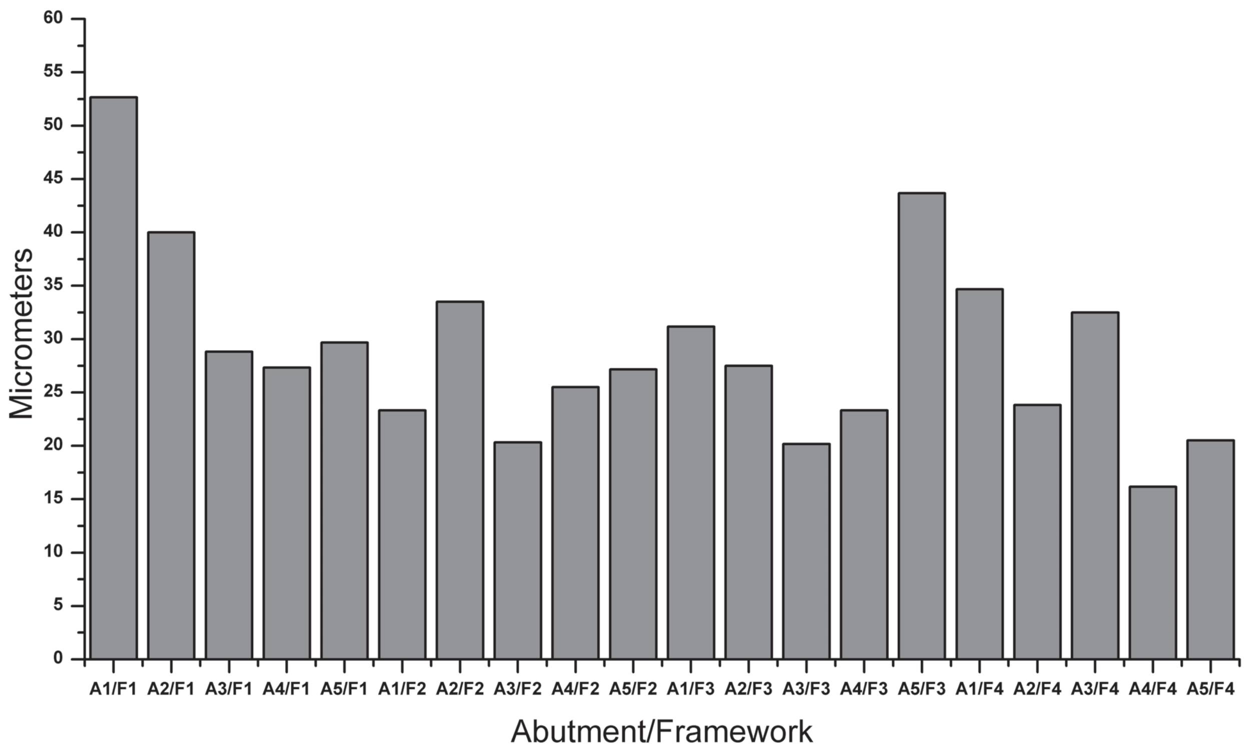

Figure 3. Vertical misfit between each abutment and the CP Ti framework.

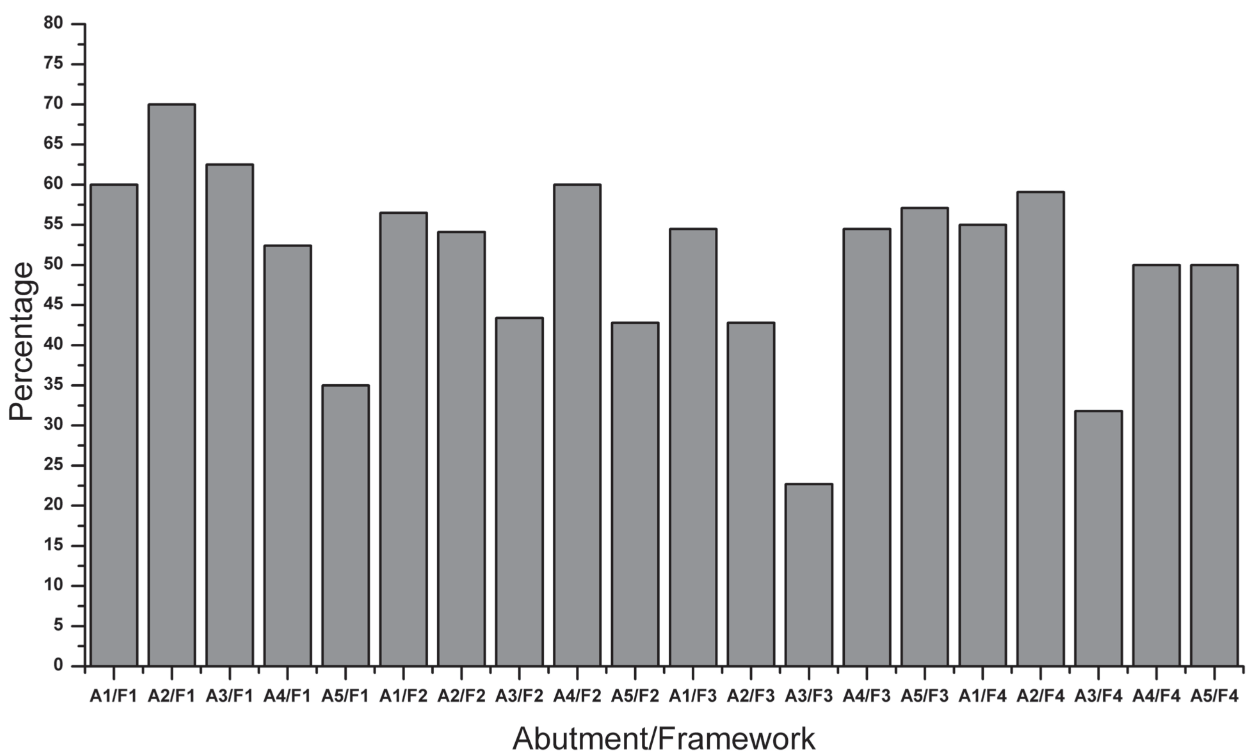

Figure 4. Percentage of torque loss values between each abutment and the CP Ti framework.

(3,17). This also occurs when using UCLA castable abutments (9). In the present study, one-piece cast associated to UCLA castable abutments is justified because this set induces the occurrence of misfits for analysis.

In the present study, the misfit levels varied considerably in the same framework. This finding can be attributed to the use of 5-element arch-shaped frameworks, one-piece casting process (17) and the inherent variations of the burn and casting processes (9) applied in the frameworks of present study.

An important factor was the use of the highest misfit found between the assessed regions for analysis by Pearson's correlation. Although misfits have been mentioned as possible causes of unscrewing of retentions screws (7,8), there was no evidence relating the misfit level with unscrewing. That is reason why the highest misfit value was used in Pearson's correlation analysis with the percentage of screw torque loss.

The success of this screwed connection is directly related to the preload reached during torque (11). The higher temperatures occurring during the cast process could change the mechanical performance and the structural properties of the surfaces that enter in contact during screwing, producing changes in the values of frictional resistance to the applied torques (18,19). In the present study, a great torque loss was observed, some times reaching 70% of torque loss. Such fact could be explained by Byrne et al. (9) study, which evaluated the fit of pre-machined, castable and pre-machined changed in laboratory abutments at the implant/abutment interface and between the seating of the inferior screw head and the abutment base. These authors observed better fit and larger number of contacts between the implant platform and abutment in the pre-machined and pre-machined changed in laboratory abutments compared to the castable abutments. In a dynamic finite element analysis, with repetitive cycles of load appliance, lack of contact between the head of the screw and the prosthesis was observed, demonstrating that unscrews and failures could be originated by this separation and by the higher levels of stresses generated over the screws (12). The higher percentage of torque loss observed in the present study could be attributed to the right seating between the screw head and the internal surfaces of the abutments, which was due to the laboratorial process used to fabricate the frameworks. Moreover, the magnitude of the stress generated on the components of a connection not only depends on the misfit levels, but also could depend on prosthetic framework dimensions (20). With that in mind, the fact that five frameworks were used could be a significant reason for the results of this study because an increase of the stress between the components could have generated the higher values of applied torque losses.

In thos way, some studies have suggested a correlation between the misfit at the implant/abutment interface and the screw loosening (7,8,11-14), there are no studies correlating the unscrews with the level of vertical misfit, and there are few studies evaluating the effect between the external hexagon of the implants and the internal hex of the abutments or rotational freedom (13,14). In a dynamic analysis, Cibrika et al. (11) evaluated the difference of the unscrew torque of abutments screws after fatigue tests, when the dimensions between the external and internal hex were changed, or when the design of the external hexagon was eliminated. The authors observed 48-55% losses of the applied torque. These results are similar to the found in the present study (50% loss on average). Binon (13) and Binon and McHugh (14) evaluated the misfit between the external hexagon of the implant and the internal hexagon of the abutment over unscrew of abutments during a simulation of oral function. Direct correlation was observed between the rotational freedom at the implant/abutment connection and screw loosening. Thus, the higher the misfit between hexagons of implant and abutment, the higher the possibility of screw loosening. In the present study, the results of misfit and percent torque losses were similar to those of the above-mentioned studies because the evaluated abutments appeared as relevant misfits, with great torque loss from the initial torque applied over the abutments.

In spite of the presence of vertical misfit in all evaluated regions and the relative torque losses of the screws, there was no statistically significant correlation between misfit and torque loss. The fact that the framework was cast in one piece could have generated horizontal misfits (3,17). It may be suggeste that the incidence of stresses over the components, acting on the screw loosening, could be associated with the vertical misfits found in the present study. Future studies should correlate horizontal misfit level with torque losses.

Within the limitations of the present study, it may be concluded that there was not significant correlation between the values of vertical misfits at the implant/abutment interface and the values of torque losses applied over the UCLA abutment screws. These findings indicate that great vertical misfits dot not necessarily implies in higher detorque values. Further reserach should be done to investigate if the level of horizontal misfit and cyclic loads could be related to losses of the initial applied torque.

RESUMO

Este trabalho teve como objetivo correlacionar o nível de desajuste vertical pilar/implante a perda do torque aplicado (destorque). Um modelo de trabalho foi obtido a partir de uma matriz metálica com cinco implantes tipo hexágono externo (Titamax, Neodent, Curitiba, Brasil) com plataforma regular (4,1 mm). Sobre esta matriz, quatro infra-estruturas foram enceradas utilizando pilares tipo UCLA e fundidas em monobloco com titânio comercialmente puro (Tritan grau I, Dentaurum, Alemanha). Os desajustes foram analisados com um microscópio óptico comparador (Mytutoyo, Japão) após torque de 20 Ncm. O maior valor de desajuste observado por pilar foi utilizado. O valor do torque de desaperto, avaliado com um torquímetro digital (TQ-680, Instrutherm, Brasil), foi calculado em porcentagem do valor do torque inicial (100%) dado aos parafusos protéticos. O teste de correlação de Pearson ($p<0,05$), entre os valores de desajuste ($29,08 \pm 8,78$ µm) e as porcentagens da perda de torque ($50,71 \pm 11,37\%$), não mostrou correlação estatisticamente significante ($p=0,295$) entre tais fatores. Dentro das limitações do estudo, pode ser concluído que não necessariamente grandes valores de desajustes verticais implicarão em grades perdas de torque.

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