JO JOURNAL OF OSSEOINTEGRATION periodontics and prosthodontics

Screw loosening of original and non-original abutments in implant dentistry: an *in vitro* study

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TO CITE THIS ARTICLE
Pournasiri I, Farid F, Zaker Jafari H, Simdar N, Maleki D. Screw loosening of original and non-original abutments in implants dentistry: an in-vitro study. J Osseointegr 2022;14():.

DOI 10.23805/JO.2022.14.21

KEYWORDS Dental implants; Dental Implant Abutment Interface; Torque.

ABSTRACT

Aim Screw loosening is one of the most common clinical complications of dental implants. This study aimed to evaluate the possibility of combining original and non original components.

Materials and methods In this *in vitro* study, 30 implants were divided into 3 groups. For the first group, original abutments of the same implant system were used, whereas for the second and third group, abutments of a South Korean implant system and a French implant system respectivelywere connected to the implants . Abutment screws were tightened to 35 Ncm. Reverse Torque Value (RTV) was measured using a digital torque meter (pre-loading RTV). The samples were subjected to cyclic loading up to 75 N for 500,000 cycles. The RTV was measured again (post-loading RTV). Statistical analysis was performed using SPSS version 24. ANOVA test was used to analyze the data. A 5% significance level was set.

Results The difference of pre-loading RTVs among the 3 study groups was not significant. Post-loading RTVs were not significantly different between the 3 groups.

Conclusion The results suggest that the non original components have acceptable compatibility with the original abutment.

INTRODUCTION

Dental implants have been widely accepted as the treatment of choice for many patients with survival rates of 89.4% after 10 years and success rates of 90% (1-2). However, some clinical complications have been observed (3). Screw loosening is the most common complication of dental implants with an incidence of 4.3-10% during the first year, especially in single implant-supported prostheses rehabilitating molar teeth (3-4).

Screw loosening may cause mechanical or biological complications (1). Mechanical complications such as screw instability, screw fracture, abutment fracture, and occlusal overload may occur as the consequences of screw loosening (1-3,5). Biological complications can be described as bacterial microleakage, infection, granulation tissue, and fistula formation, swelling, pain, peri-implant mucositis, crestal bone loss and peri-implantitis (1-3,5).

Screw loosening happens when occlusal or lateral forces on the implant are greater than the preload (6). This occurrence results from loss of preload or inadequate initial preload (1). Preload is the tension developed in the screw when it is tightened by torque application (2,6). Initial torque can vary from 10 to 35N, however, the same initial torque value will not develop the same value of initial preload due to different values of coefficient of friction which depends on the tightening speed and surface hardness of the threads (1,6,7). Loss of preload is the result of a settling effect that occurs as the rough threads flatten under load (4,8). Other factors have been considered as possible causes for screw loosening such as inappropriate position or direction of implant placement leading to unfavorable occlusal loading, the screw design or material, deformation or wear of screw and poorly fit components (3-5,8-10).

In daily practice, practitioners may select compatible abutments instead of the original components if the prosthetic components of the same brand as the patient's implant are expensive or not available (1,11). Non original components differ from the original ones for patent issues and different machining processes resulting in discrepancies in designs, shapes, and dimensions.

Discrepancies greater than 10 microns may lead to misfit and screw loosening (1,11-12).
Gigandet et al. combined abutments and implants of different manufacturers and reported that the rotational misfit of an original abutment was less than the non original abutments (13). Berberi et al. compared the leakage and micro-movement of compatible abutments to original abutments and stated that the leakage and micromovement were significantly lower when the abutment and implant from the same manufacturer were used (12,14). However, Solá-Ruíz et al. assessed the fit of non original and original abutments on implants using SEM micrographs (11). They concluded that the vertical misfit was not statistically significant and combining non original abutment and implant were clinically possible (11).
The above-mentioned studies compared the leakage and micromovement between original abutments attached to original implants and non original abutments attached to original implants. Based on contrary results, this study was designed to evaluate the compatibility and the possibility of combining original parts and third-party components by comparing their Reverse Torque Value after cyclic loading.

MATERIALS AND METHODS

In this *in vitro* study, 30 tissue level, internal connection dummy implants with a 4.8 mm diameter and 12 mm length were divided into 3 groups of 10 implants each. For Group A, the original abutment system (4.8×5.5 mm, Straumann, AG, ITI, Waldenburg, Switzerland) were connected to the implants. In the other two groups, non-original abutments were connected to the implants. A South Korean implant system (4.8×5.5mm Cowell Medi, Busan, South Korea) and a French implant system (4.8 × 5.5 mm, Euroteknika™, Sallanches, France) were used for Group B and for the Group C respectively.
A wax-up with a 30° angled occlusal surface was prepared on an abutment and an index was obtained using putty (Panasil Putty, Kettenbach GmbH & Co. KG. Germany). The putty index was used to standardize the crowns. Later, 30 uniform dimensions single crowns of base metal-alloy (Versabond 2, Albadent, Cordelia, California) were fabricated and cemented to the abutments using Temp Bond (Kerr, Salerno, Italy).
Each abutment was connected to an implant by hand torquing. A custom-made plastic block was prepared and placed on the surveying platform of a dental surveyor. Using the surveying mandrel, the abutment-implant complex was positioned in the center of the mold space of the plastic block so that the complex was perpendicular to the horizontal surface and it was primarily stabilized in the acquired position using wax. Then, self-cure acrylic resin (Rapid Repair, Meliodent, Heraeus Kulzer GmbH, Germany) was mixed and poured into the mold space up to the polishing surface to mount the abutment-implant complex.
With the help of an acrylic gauge, the abutment screw was tightened to 35 Ncm. Following 10 minutes of settling time, it was retightened to the same torque (35 Ncm) to achieve the optimal preload according to Dixon and Breeding Concept. After waiting for 5 minutes, RTV was measured individually using a digital torque meter (Lutron Electronic Enterprise Co, Taiwan) and recorded as the pre-loading RTV. Then, the samples were subjected to cyclic loading using a cyclic loading device (Chewing Simulator, S-D Mechatronic, Germany). A load up to 75 N was applied for 500,000 cycles (which is approximately 20 months of human mastication function) with a frequency of 75 cycles per minute (which is approximately the human chewing frequency). When the cyclic loading period was finished, the crown was removed by a hemostat. The RTV was measured again using the digital torque meter and recorded as the post-loading RTV.
Statistical analysis was performed using SPSS version 24. Mean, standard deviation, and frequency percentage of RTV before and after cyclic loading were reported. To compare the effect of different implant-abutment systems on RTV pre and post cycling loading, repeated measure ANOVA was used. All tests were performed at a 5% significance level.

RESULTS

For the three groups, the pre-loading and post-loading RTVs were studied under the loading force of 75N. The results of the three groups are presented in Table 1. The difference in pre-loading RTVs of the 3 study groups was not significant (P=0.907). And also, post-loading RTVs were not significantly different between the 3 groups (P=0.952). However, RTV decreased significantly after cyclic loading in all 3 groups compared to pre-loading RTV (P≤0.001).

DISCUSSION

Biological and mechanical factors affect the long-term success of dental implants. Despite the 95–97% success rate of osseointegration, mechanical complications are frequent in dental implantology. The incidence of screw fracture is reported to be as high as 44.9% (12).
The homogeneity of implants and their original components is expected to be high, however, there is a lack of conclusive evidence about the possibility of using compatible components instead of original abutments. The current study was carried out on 30 implants to assess the screw loosening in 3 different dental implant systems by comparing pre- and post- cyclic loading reverse torque values.
The success of using compatible components depends on

Implant system	Stage	Mean of Reverse Torque Value (N)	Minimum of RTV (N)	Maximum of RTV (N)
Group A (Original abutments, ITI)	Before cyclic loading	30.7±2.26	28.0	34.0
	After cyclic loading	23.0±4.63	13.0	29.0
Group B (Non- original abutments, Cowell Medi)	Before cyclic loading	29.2±3.61	25.0	35.0
	After cyclic loading	21.6±3.89	15.0	26.0
Group C (Non- original abutments, Euroteknika)	Before cyclic loading	29.1±2.60	25.0	35.0
	After cyclic loading	21.0±4.78	14.0	27.0

TABLE 1 Reverse Torque Value (RTV) before and after cyclic loading in 3 dental implant systems.

the manufacturer's standards and machining tolerance. Compatible components are expected to be in a delicate concordance with original components (12,14-15).

The findings of this study state that the difference of RTVs among the 3 study groups was not significant. As opposed, Kim et al. and Cashman et al. found ITI to be the most stable and resistant to screw loosening compared to other compatible systems and recommended to use implants and components manufactured by the same company (15-16). Kim et al. assessed screw loosening of solid abutments after 1,000,000 times of 150N loading force and Cashman et al. loaded 10 to 200 N for 5,000,000 cycles on solid ITI implants (15-16). According to Ghanbarzadeh et al. one-piece abutments show higher RTVs and resistance to screw loosening than the two-piece abutments which can explain the difference between the results of the current study and Kim et al. Implant-abutment fitness affects screw loosening (16-17). Some studies, measured vertical misfit between implant and abutment instead of torque loss to assess the compatibility of original and non original components (8,11,19-21). In agreement with the current study, Zanardi et al., who studied the gap in the implant-abutment surface of interchanged abutments, stated that the alternative abutment was compatible with the other studied systems (18). Holmes et al., Kano et al., Tsuge et al., Solá-Ruíz et al. and Duraisamy et al. reported vertical misfit of 3.17±2.73 microns, 5.6±6.4 microns, 2.3-5.6 microns, 3.46±2.96 microns, and 2.39 microns respectively (8,11,19-21). However, the vertical gaps in the above mentioned studies are clinically acceptable. Solá-Ruíz et al. and Duraisamy et al. demonstrated that the combination of implants and abutments of different brands was clinically possible (11,21).

The current study showed that RTVs in all 30 samples significantly decrease after cyclic loading in comparison to the pre-loading RTVs. This finding is consistent with the finding of Yilmaz et al. (22). On the contrary, in the study of Tsuge et al. post-loading preload was significantly higher than initial preload (8). While Khraist et al. found no significant difference between pre-loading RTV and post-loading RTV (23). Variation of abutment screw type and material, and different tightening torque may be the reason for this controversy.

In each study group, the pre-loading RTV and post-loading RTV were different among samples, however, the difference was not significant. This finding may be due to the finishing process of screws which leads to different embedment relaxation and preload of screws. Besides, the surface roughness of different components of an implant affects preload (11,21-22).

A small sample size was one of the limitations of the current study. Since loads are inconsistent and multi-directional in the oral cavity, it is not possible to predict clinical results just according to *in vitro* studies. Therefore, more *in vivo* researches are required for clinical approval of current results. Also, more studies are required to determine the threshold of cyclic loading which affects RTV and leads to screw loosening. Besides, RTV before and after cyclic loading should be assessed considering plastic deformity and cold welding.

CONCLUSIONS

No significant differences were found between the initial and post-load RTV of studied systems. The results suggest that the non original components have acceptable compatibility with original abutment and combining implant components of mentioned implant systems do not lead to screw loosening.

Authors' contributions

Conceptualization: Ilnaz Pournasiri, Farzaneh Farid, Hamidreza Zaker Jafari, Narges Simdar, Dina Maleki.
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Conflicts of interest

There is no conflicts of interest.

Funding

There was no financial support for the manuscript.

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