CONE MORSE IMPLANT-ABUTMENT INTERFACE BEFORE AND AFTER CYCLIC LOAD: EVALUATION UNDER 3-D X-RAY MICROTOMOGRAPHY

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ABSTRACT

Currently, implant failures are mainly due to overload and bacterial infection of the peri-implant tissues. The internal conical implant-abutment connection is mechanically more stable and tight compared to flat-to-flat connections or tube-in-tube connections and is able to provide a better seal. The aim of this paper was to evaluate, with X-ray 3-D microtomography, cone morse implant-abutment contact surfaces before and after cyclic loading. A total of 10 implants were used in this *in vitro* study. The implants presented a screw-retained cone morse taper that was internally connected. No statistically significant differences were found in the dimension of the microgap before and after cyclic loading (P= 0.17). In all cone morse connection samples, no abutment-fixture movement was recordable. In conclusion, the cone morse taper internal connection can resist cyclic load without creating spaces between the abutment and implant.

KEYWORDS: *crestal bone remodeling micro gap, bacterial leakage, implant-abutment connections, X-ray microtomography*

INTRODUCTION

Dental implant systems using screw-retained abutments have been clinically used for many decades, and their long-term success is well documented (1-3). A problem associated with this type of implant-abutment connection is the loosening and the screws fracturing. Screw loosening could be also an indication of an inadequate biomechanical design of the prosthetic reconstructions and/or occlusal overloading. It has also been reported that, with screw-retained abutments, the abutment loosening occurs frequently (4, 5).

Loosened abutment screws and prosthesis screws are often found at yearly clinical examinations. Loosened screws may cause costly complications, such as screws and framework fractures (6). The problem of the micro gap between the implant and abutment is biological and mechanic. The biological issue is related to the presence of bacteria that have been found in the apical portion of the abutment screw (7, 8), and this fact, *in vivo*, could produce a bacterial reservoir that could interfere with the long-term health of the peri-implant tissues (8-32). The mechanical problem of the micro gap is related to

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micromovements and possible loosening or fracture of screw-retained abutments (33-36). The internal conical implant-abutment connection is mechanically more stable and tight than flat-to-flat connections or tube-in-tube connections(17, 37) and able to provide a better seal (14-16, 25-27).

The aim of this paper was to evaluate, with X-ray 3-D microtomography, cone morse implant-abutment contact surfaces before and after cyclic load.

MATERIALS AND METHODS

A total of 10 4 mm x 13 mm implants were used in this in vitro study (Isomed, DUE CARRARE (PD), Italy). The implants presented a screwed connection with a cone morse interface. All abutments were coupled according to the recommended torque values.

Specimen processing

Each sample underwent five X-ray microtomography consecutive acquisitions by Skyscan 1072 (SkyScan, Kartuizersweg 3B, 2550 Kontich, Belgium) to measure implant-abutment contact areas and to detect the possible presence of microgaps over and along the whole interface. This innovative investigation technique has made it possible to assess the perfection of connection sealing in a non-destructive, non-invasive, and three-dimensional way (11, 12). All implants have been resin-embedded vertically to avoid motion artifacts within a cylinder-shaped mold. The same acquisition parameters adopted for all samples are as follows:

1. rotation step= 0.45°,
2. total rotation angle = 180°,
3. power source 100 KV/98 micro A,
4. filter thickness 1mm (Al)
5. magnification at x30 and cross-section pixel size of 9.77mm.

All images obtained have been processed by a dedicated reconstruction software (CTan), able to reproduce the exact 3D model of each examined implant.

Mechanical test

The samples were fixed by an acrylic self-curing resin to the aluminum sample holder with the major axis perpendicular to the shelf.

The loading force was applied to the abutment. The customized jig was designed to hold the implant, and the distance was 3 mm from the implant platform to the exposed position of the implant. The distance of 3 mm was chosen to represent the worst case in bone retraction (38, 39). The load was applied to the abutment at an angle of 30°C, and the distance was 11 mm from the center of the hemisphere to the exposed position of the implant. Then, each sample was loaded in a cyclic loading mode with a Lloyd 30K universal testing machine (Lloyd Instruments Ltd, Segensworth, UK), which controls the 20-200 N/cm cyclic loading in an Hsine shape at 4 Hz for $6x10^6$ cycles (ISO/DIS 1480) (39). The cyclic load application was investigated in each sample by evaluating the presence or absence of abutment mobility with respect to the fixture. The samples were removed from the aluminum blocks and observed by X-ray microtomography consecutive acquisitions by Skyscan 1072 (SkyScan, Kartuizersweg 3B, 2550 Kontich, Belgium). To measure the implant-abutment interface, the presence of microgaps over and along the whole interface.

Statistical evaluation

The size of the micro-gap, expressed as a mean +/- standard deviation, was evaluated using the Analysis of Variance (ANOVA). Statistical significance was set at $p< 0.05$. Data treatment and statistical analysis were done using Excel, Origin, and SPSS software.

RESULTS

Implants before cyclic load

There was no detectable separation at the implant/abutment in the area of the conical connection, and it showed an absolute congruity with a 2-3 micron (mean 2.5 ± 0.1 μm) of microgaps between abutment and implant. No line was visible separating the implant and the abutment. The area of the conical connection had an extension of 3.5 ± 0.1 μm. In a few areas, gaps were present.

Implants after cyclic load

After applying a dynamic load, there was no evidence at a macroscopic level of mechanical failure referred to the interfaces between abutments and fixtures. In all samples, moreover, no abutment-fixture movement was recordable.

There was no detectable separation at the implant/abutment in the area of the conical connection, and it showed an absolute congruity with a 2-3 micron (mean 2.5 ± 0.1 μm) of the micro gap between abutment and implant (Fig. 1a, b).

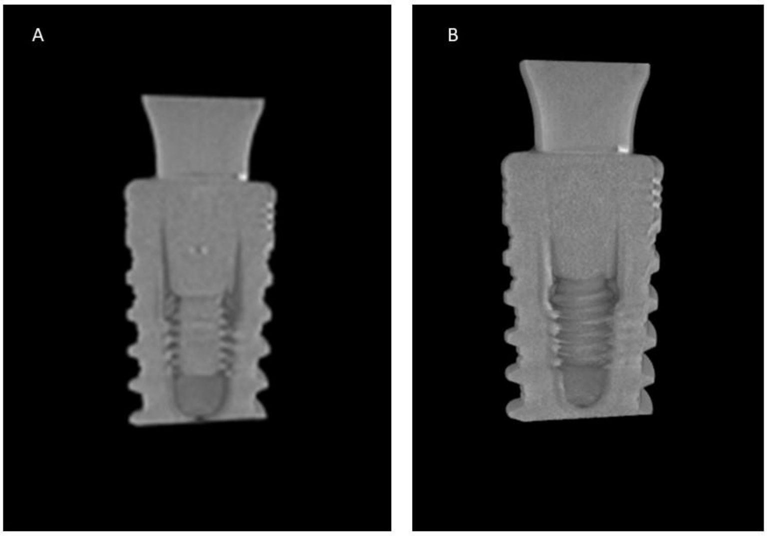

Fig. 1. *Micro-CT pictures of the marginal fit of interface implant-abutment after cyclic load. A microgap was detected before (A) and after cyclic load (B).*

Statistical evaluation

No statistically significant differences were found in the dimension of the microgap before and after cyclic loading (P= 0.17).

DISCUSSION

In this study, during the cone morse assemblies, a very small micro gap was found before and after undergoing $6x10^6$ loading cycles; this corresponds to approximately 6 years of in vivo function (38, 39). After applying the cyclic load to the cone morse abutment, the interface implant abutment showed an absolute congruity with 2.6 microns of micro gaps. There was no significant difference between the before and after a cyclic load. The quality of the surface machining of the conical abutment surfaces probably determined the resistance of the abutment interface. The structural geometric design of the implant connection has also been mentioned as a differential condition for maintaining stability at the implant/prosthesis interface. Cyclic loading of the implant-prosthesis assembly induces micromotion of the joint components, which could wear down the microscopically rough areas of the contacted surfaces, contributing to screw loosening by decreasing the preload. Many aspects guide the operator through choosing one implant system over another, and there are several connection designs between the implant and the abutment. An implant system with overlapping implant and abutment mating parts is known as a morse taper and represents an alternative to internal or external hexagon connection designs (40).

Conical interfaces (also called tapered interfaces), such as cone morse and locking cone systems, have shown a good fit between the implant and abutment (41, 42), which could, in principle, help avoid bacterial penetration. Many studies present results about bacterial penetration through the implant-abutment microgap, showing several degrees of colonization (43).

Conical morse taper connections have been shown to be more tight and stable from a biomechanical point of view than flat-to-flat connections (17). In all cone morse connection samples, no abutment-fixture movement was recordable.

In conclusion, the cone morse taper internal connection can resist cyclic load without creating spaces between the abutment and the implant.

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