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Review

MECHANICAL ANALYSIS OF THE CONE MORSE ABUTMENT IMPLANT

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ABSTRACT

After implant insertion and loading, crestal bone usually undergoes a process of remodelling and resorption. In order to reduce crestal bone loss, the "platform switching" technique has been proposed, in which the horizontal relationship between the outer edge of the implant and a smaller-diameter component is increased. The aim of the present work was to evaluate *in vitro* a fixture-abutment connection with cone morse and screw. Mechanical tests were carried out using a Lloyd 30K universal testing machine (Lloyd Instruments Ltd, Segensworth, UK). The load was applied on the coronal portion of the abutment with a crosshead speed of 5 mm/min, and the fracture load data were automatically recorded using Nexigen software (Nexigen, Batch Version 4.0, Issue 23, Lloyd Instruments Ltd, Segensworth, UK). The results indicated that the force necessary to induce a fracture when using the new fixture-abutment connection with cone morse and screw joint systems reached 1250±60 N. In conclusion, the fixture-abutment connection with the cone morse tested in this study presents a very high resistance.

KEYWORDS: *bone resorption, microgap, platform switching, vertical bone loss, abutment-fixture connection*

INTRODUCTION

Successful results regarding the stability and continuity of dental implants and prosthetic structure within the oral cavity depend on multiple biological and mechanical factors; several *in vitro* and *in vivo* studies aimed to investigate the biochemist and cellular mechanisms that gather the process of osseointegration, integrating new biomaterials and clinical methods to obtain satisfactory results with standardized protocols.

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Osseointegrated implants are a valuable technique for solving partial or total edentulism in clinical practice. However, numerous issues should be further approached, such as obtaining an optimal implant-abutment connection in terms of mechanical and microbiological properties. Indeed, the aim is to minimize crestal bone loss, obtaining better and long-lasting results with advantages from the mechanical, biological and esthetical points of view (1).

In agreement with previous research (2, 3), applying the cone-morse connection or a joint screw system determine the level of intrusiveness within the biological space by non-biocompatible materials. This event is mainly characterized by an apical migration implying biological concerns, occurring when the cone morse is connected or when the screw is placed (4). Once the biphasic implants are placed, and the abutment connection is established, the apical migration of the soft tissues opens a new scenario. The migration is influenced by the creation of micro-gaps, the implant design in the coronal part, and the distance between the implants (5). After the initial remodelling of the crestal bone of around 1-2 mm, the loss remains constant or limited to 0.1-0.2 mm per year (6).

Pathogenic bacteria for the periodontal tissues can penetrate the junctions within the complex implant-prothesis, colonizing the spaces created by the mechanical connections (2, 7, 8). As stated in previous research, the biocompatibility of the materials implied in the abutments and prosthetic structures will be deleted due to bacterial contamination within the junctions and the internal spaces (9). Even though the abutments and screws confirm biocompatibility, the bacterial colonization induces the retreats of the epithelium to the apical part, compromising the biological stability of the implant but not of the abutment. Elimination or minimization of gaps created during the connection between implants and abutment has been proposed to solve this problem (10). This option could partially solve this issue since the abutment is exposed to contaminating agents during implantation.

Another potential solution could be re-locating the implant and positioning the implant-abutment junction as coronally as possible, although this solution is not always feasible due to functional or esthetic reasons (11, 12). Lazzara and Porter (13) evidenced how the sub-resizing of the cone morse determines a lower bone remodelling, as demonstrated by histological analysis (14). The concept of "platform switching" has been used for the last 15 years (15). Clinical results from the histological analysis have demonstrated the bone's adaptation to the implant's back face, avoiding crestal bone resorption (16). Crestal bone stability carries multiple advantages from a biological and esthetical point of view. However, concerns have been raised regarding the mechanical resistance of the implant-abutment connections obtained after using a sub-dimensional cone morse.

Thus, in the present study, we analyzed the mechanical resistance of an implant-abutment connection using the cone morse technique and guided by a hexagon screw joint, combining the advantages of the conical coupling and the screw joint.

MATERIALS AND METHODS

Implant-abutment connection

The implant-abutment connection analyzed in this study consists of a cone morse and a screw joint (Fig. 1). Twenty Close BL implants 4 x 13 mm and 20 abutments with a screw-retained conical abutment connection (Isomed, DUE CARRARE (PD), Italy) were used. A static resistance test was used to test the resistance of the new connection, where the samples were fixed to the support and subjected to an increasing force until the sample fractured. Different approaches were considered to recreate the work conditions of the implant within the oral cave. For instance, resin supports containing the implant-abutment complex were realized while 1 mm of the implant base remained uncovered to reproduce the worst situation in which a prosthetic implant could work in case of bone loss in the coronal part.

After polymerizing, the acrylic resin presents a resistance above 100 MPa (the minimum value stated by the ISO normative 5833/1 is 70MPa) and an elasticity of 2750 MPa (the minimum value stated by the same organization is 1800 MPa). In addition, samples in resin were moulded to obtain an inclining implant-abutment complex of 30 degrees; thus, the applied force can be directed in a non-parallel manner to the major implant axis, creating traction and compression forces for a greater load. During the experiment, the samples were submerged in an artificial saliva solution.

Mechanical test

The sample was inserted into a clamping system to carry out the static load resistance test, where it was subjected to

Fig. 1. *Implant with positioned abutment embedded in a resin block.*

compression with a lowering speed of 5 mm/min, monitoring the displacement of the sample. The universal instrument Lloyd LR30K (Lloyd Instruments Ltd, Segensworth, UK) was used for this analysis to examine biomedical devices' functioning under pressure conditions. The equipment used allowed the application of a non-axial load by using a mechanical piston and a load cell, the last consisting of a balance able to absorb the load, determine the values and transmit them to the computer system. The load cell used for this test reached 2000 N, and the feed speed was 5 mm/min. The test was stopped as soon as any sign of fracture or deformation was noted.

RESULTS

The samples subjected to the mechanical test supported a load of 1250±60 N before fracturing (Table I, Fig. 2). For all samples, the deformation was represented by a folding of the coronal part of the abutment under a load of 900N, without inducing modifications in the implant neck.

DISCUSSION

The implant-abutment connection is considered of central importance for the correct functioning of long-lasting prosthetic implants due to the significant advances in implant surfaces that contribute to faster and more adequate bone healing.

Several studies have documented the complications related to the screw prosthodontics superstructures, mainly represented by a loosening and fracture of the clamping screw or by a fracture of the abutment. The loosening of the clamping screw occurs more frequently during the first year after implant positioning and in single implants (17). The introduction of accurate prosthetic systems for single implants and the use of new components (gold screws, torque wrench) has been accompanied by decreased complications and improved clinical results. However, in the posterior region, where the chewing dynamics and the functional loads are high, the problem is still present. Implants used to replace a single tooth should resist torsional forces, avoiding damage to the components. An inadequate interface with a low resistance would increase the number of potential fractures (18). For this reason, some researchers have developed the abutment system with screw coupling in the apical part and conical coupling in the coronal part, allowing the elimination of the micro-movements thanks to the friction produced by the conical coupling and thus hampering the unscrewing (19).

Other researchers focus on creating new interfaces between the implant and the screws. From the data obtained here, we can affirm that the remodelling of the abutment to obtain the platform switching does not compromise its mechanical resistance. However, the implant must not present any plastic deformation under loads below 800 N

Table. I. *Summary of the mechanical testing findings of the Cone Morse implant under the controlled compression loading*

Mechanical test summary	
Test Type	Compression to fracture
Samples	n: 20
Mean	1250 N
SD	60 N
Min-Max	(1128-1373 N)
Compression Load Speed	5 mm/min

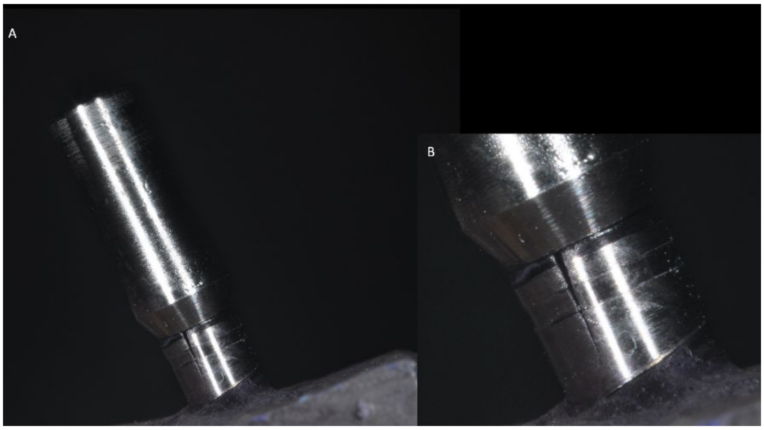

Fig. 2. *Detail of the implant at the end of the fracture test.*

(20). Furthermore, once the load is removed, the structure should be able to be back to the original conformation (elastic deformation); otherwise, the original structure could be compromised. For instance, a partial but permanent flexion of the abutment could originate a slot, which could then be colonized by microorganisms accompanied by a peri-implantation process (10).

The mechanical test is a valuable strategy to evaluate the implant-abutment connection and the probability of undergoing a fracture or damage. In the case of manufacture defects, a phenomenon of progressive propagation could be observed when applying a load, which could be due to the industrial manufacturing process more than to the potential defects within or on the surface of the material implied. If this event occurs, the effort is distributed in a non-equilibrated manner, creating small cracks able to propagate, reducing the resisting section and thus fracturing the abutment. As already stated, the samples used for this study were subjected to a load applied non-parallelly to the long axis and eccentrically, using resin-moulded blocks. Implants can be considered reliable from a biomechanical point of view when they withstand a load of 800 N. Moreover, load curves for each sample have been analyzed to determine the implant behaviour when increasing the load. In this respect, no defects were observed.

Data regarding the elasticity and resistance of the implant connection examined were obtained from the deformation diagram from material sections of appropriate form and size. While the X-axis corresponds to the deformation, the Y-axis represents the load exerted. This information allows the classification of the materials into three different groups: malleable, fragile (breakable) and plastic. Our results confirm that we can exclude fragile or malleable behaviour for our samples.

We strongly consider that the mechanical evaluation of the implant-abutment connection was a necessary step for the study of platform switching, especially considering that several studies have focused on the biological effects of this connection but not on the mechanical properties. The connection analyzed here is composed of a cone morse with an overture of 4° and a clamping screw. The close contact between the implant and the abutment reduces the micromovements of the components, considering them as a single unit and hindering the entry of biological fluids and bacteria.

In conclusion, the implant connection studied here can be considered reliable from a mechanical and biological point of view, presenting important advantages such as platform switching.

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