



# Loosening torque of Universal Abutment screws after cyclic loading: influence of tightening technique and screw coating

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**PURPOSE.** The purpose of this study was to evaluate the influence of tightening technique and the screw coating on the loosening torque of screws used for Universal Abutment fixation after cyclic loading. **MATERIALS AND METHODS.** Forty implants (Titamax Ti Cortical, HE, Neodent) (n=10) were submerged in acrylic resin and four tightening techniques for Universal Abutment fixation were evaluated: A – torque with 32 Ncm (control); B – torque with 32 Ncm holding the torque meter for 20 seconds; C – torque with 32 Ncm and retorque after 10 minutes; D – torque (32 Ncm) holding the torque meter for 20 seconds and retorque after 10 minutes as initially. Samples were divided into subgroups according to the screw used: conventional titanium screw or diamond like carbon-coated (DLC) screw. Metallic crowns were fabricated for each abutment. Samples were submitted to cyclic loading at 10<sup>6</sup> cycles and 130 N of force. Data were analyzed by two-way ANOVA and Tukey's test (5%). **RESULTS.** The tightening technique did not show significant influence on the loosening torque of screws ( $P=.$ 509). Conventional titanium screws showed significant higher loosening torque values than DLC ( $P=.$ 000). **CONCLUSION.** The use of conventional titanium screw is more important than the tightening techniques employed in this study to provide long-term stability to Universal Abutment screws. [J Adv Prosthodont 2015;7:375-9]

**KEY WORDS:** Single-tooth dental implant; Dental prosthesis retention; Implant-supported dental prosthesis; Prosthesis loosening

## INTRODUCTION

Implant-supported prostheses confectioned on external hexagon connections may be screwed (on the implant or on the abutment) or cemented on an abutment. The screwed prostheses are largely utilized for multiple and single units

because the screws can be easily accessed without damage to the prostheses. This is important because although historical clinical success of implant-supported rehabilitations, some adversities still occur, such as the loosening or fracture of the prosthetic screws.<sup>1,2</sup>

On the other way, for rehabilitations with single crowns in anterior region, the cemented prosthesis allows for the advantage of better contact with the opposite teeth, due to absence of a palatal hole (with is also an esthetic vantage depending on the implant inclination). It might also avoid the palatal overcontour of the crowns when implants are placed in more palatal region for a better bone implantation.<sup>3</sup> Still, the access hole takes a relevant part of the restoration when it is present in single crown, which might make the crown weaker than full-contour crowns.<sup>4</sup> However, if one adversity such as the common screw loosening occurs, the confection of a hole in the cemented restoration is necessary for accessing the screw. So, the cemented implant-

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supported prosthesis is strictly dependent on the screw stability for the success of the rehabilitation, while the screwed prosthesis allows the advantage of reversibility, easy maintenance and eventual repairs.

The stability of the retention screw is related to several factors such as the geometrical shape, the format of the threads, the fit of the prosthetic component, the frictional coefficient of the screw, the amount and properties of lubricant (if used), the speed of tightening, the tightening force used, the occlusal loads applied.<sup>5</sup> Techniques have been proposed to provide greater screw stability, such as its retightening. This procedure has been employed because when the torque is applied to a screw, the energy is expended in smoothing surface irregularities for maintaining the surfaces together. After thread engagement, surface asperities are flattened and additional input torque is applied toward elongation of the screw and generation of preload.<sup>6</sup> A previous study<sup>7</sup> evaluated the effect of retightening sometime after initial tightening torque on the joint stability of the abutment screws, and concluded that it represents an easy and fast method to increase the joint stability. Still, it has been observed in the literature that holding the torque meter for a period during the tightening of the screws could provide elongation of the screw and increase the preload.<sup>8</sup>

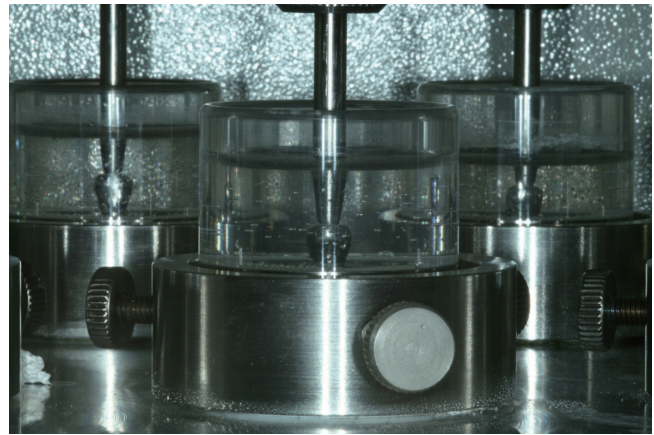
Modifications in the screw surface have been proposed to promote greater preload stability. The coating of the screw surface with diamond-like carbon (DLC) film is one of the methods employed and already commercially available. The principle of DLC coating is based on the use of a surficial material stronger, more durable and resistant to wear than titanium. Moreover, DLC has given to titanium surface a characteristic of lower friction resistance, important for increasing preload in the tightening process.<sup>9</sup>

The aim of the study was to evaluate the influence of the tightening technique and the screw coating on the loosening torque of the Universal Abutment screw for cemented implant-supported single crowns after cyclic loading. The null hypothesis tested were that (I) there is no influence of the tightening technique used and (II) the screw coating does not influence the loosening torque of the Universal Abutment screw.

## MATERIALS AND METHODS

Forty external hexagon implants (Titamax Ti Cortical 4.1, Neodent, Paraná, Brazil) with 13 mm in length and 3.75 mm in diameter were submerged in poly(methyl) methacrylate (Jet, Clássico, São Paulo, Brazil) into hollow stainless steel cylinders. A surveyor (Delineator B2, Bio-art, São Paulo, Brazil) was used to standardize the implants' insertion procedure.

On the implant platform, Universal Abutments (Slim Fit Rotational, 4.5 mm wide × 6 mm in length × 2 mm trans-mucosal neck) were screwed using two types of screws: conventional titanium screw or diamond like coated-screw (DLC) (Neotorque, Neodent, Paraná, Brazil).



**Fig. 1.** Samples under mechanical loading cycles.

Different tightening techniques were also evaluated: A – torque with 32 Ncm (control); B – torque with 32 Ncm holding the torque meter for 20 s; C – torque with 32 Ncm and retorque after 10 minutes; D – torque (32 Ncm) holding the torque meter for 20 seconds and retorque after 10 minutes as initially. Metallic crowns were confectioned and cemented on the universal abutments with resin cement (RelyX ARC, 3M ESPE, St. Paul, MN, USA).

A digital torque meter with precision of 0.1-Ncm (TQ8800; Lutron, Taipei, Taiwan) was used to tighten the screws and evaluate the loosening torque after mechanical loading cycles. The cyclic loading was performed using the MSCM equipment (ME Instrument, São Carlos, Brazil) which has a stainless steel tip of 4 mm in diameter in contact with the central part of the metallic crowns. Samples were submitted to  $10^6$  mechanical cycles under a load of 130 N, at a rate of 2 Hz (Fig. 1).<sup>10</sup> All procedures in the study were performed by the same operator. Data for each group were recorded and statistical analyze was carried out by two-way ANOVA (screw type vs tightening technique) and multiple comparison evaluated by Tukey's test with 5% significance level.

## RESULTS

The mean values and standard deviation of loosening torque for the different experimental conditions are presented in Table 1. The interaction between the factors tightening technique and type of screw was not significant ( $P = .516$ ). The tightening technique (Table 2) did not show significant influence on the loosening torque of screws ( $P = .509$ ). Conventional titanium screws promoted significantly higher loosening torque values than DLC ( $P = .000$ ) for Universal Abutment fixation (Table 3).

**Table 1.** Mean values (Ncm) and standard deviations for the loosening torque in regard to tightening technique used and screw coating

Torque method	Screw type	Loosening torque
A	Conventional	26.3 (2.4)
B	Conventional	25.2 (3.0)
C	Conventional	28.0 (5.0)
D	Conventional	26.3 (5.4)
A	DLC	22.7 (2.8)
B	DLC	23.3 (3.5)
C	DLC	23.0 (4.6)
D	DLC	20.8 (5.3)

**Table 2.** Mean values (Ncm) and standard deviation in regard of the torque method

Torque method	Loosening torque
A	24.4 (2.5) A
B	24.2 (1.3) A
C	25.5 (3.5) A
D	23.5 (3.9) A

Mean values followed by the same letter are statistical similar ( $P < .05$ ).

**Table 3.** values and standard deviation of loosening torque (Ncm) in regard to screw type

Screw type	Loosening Torque
Conventional	26.4 (1.16) A
DLC	22.4 (1.14) B

Mean followed by different letter are statistical significant ( $P < .05$ ).

## DISCUSSION

This study evaluated the influence of four tightening methods and DLC coated screws on the preload maintenance in Universal Abutments after cyclic loading application. The first null hypothesis of the study was accepted, as the tightening method did not influence the loosening torque values. The simple application of a torque until reach the 32 Ncm was as effective as the long time torque applications and/or retorquer methods. The previous emphasized retorquer and long-time torque applications were based in the fact that during the manufacturer process the screw threads cannot be machined perfectly smooth,<sup>10</sup> so that, part of the torque applied to the screws could have been

lost to smooth the irregularities in the screw threads and abutment threads.<sup>7,11</sup> Therefore the application of a longer torque period or retorquer once again after embedment relaxation or settling would act to regain preload and to increase contact area between the threads.

In contrast to the results of this study, Siamos *et al.*<sup>7</sup> evaluated the effect of retorquer on premachined abutments and advocated that retorquer abutment screws 10 min after initial torque application should be performed routinely to abutment-implant connections. The high number of mechanical cycles applied in the present study ( $10^6$ ) suggests that after long-term function the effects of pre-load and long-time torque application are not improved. Farina *et al.*<sup>11</sup> also observed that the retorquer application provided significantly higher loosening torque of prosthetic screws after mechanical cycles. Although, the study evaluated full-arch prostheses supported by five implants. Full-arch prostheses are more likely to dissipate cyclic loading along all components, reducing the effect of loads on the screws in comparison to single-crowns. Another study has shown that retorquer does not significantly interfere on the loosening torque when the titanium screws are used in dentures with passive fit. On the other hand, the retorquer significantly increased the loosening torque when these screws were used in dentures with misfit.<sup>8</sup> According to these findings, the passive fit of cemented restorations used in the present study may have contributed to the similarity among the groups. A finite element study has shown that screw retightening reduces the settling effect and has an insignificant effect on the preload.<sup>12</sup> Different of the absence of significance by the retightening or by holding the torque meter for 20 seconds, one study has shown that increasing the tightening speed would be able to reduce the response rate to the frictional resistance, thus diminishing the coefficient of friction and slightly increasing the preload.<sup>13</sup>

The second null hypothesis tested in this study that the screw coating does not influence the loosening torque of the Universal Abutment screw, was rejected. The conventional titanium screws have shown significantly higher loosening torque than DLC coated ones. DLC coated screws were introduced following the principle that a crystalline diamond coating can increase the wear resistance of titanium.<sup>14</sup> Yet, DLC has properties similar to those of real diamond, including hardness, wear resistance, and chemical stability.<sup>15</sup> Moreover, low friction resistance and excellent wear resistance makes DLC one of the best materials for use as it acts as a protectant and lubricant, according to a previous study.<sup>9</sup> Although these considerations, the lower loosening torque values are probably explained by the fact that besides the DLC coating reduces the friction during tightening to provide a higher preload, it may equally reduce the frictional resistance of the screw to removal. Similar findings were observed by Park *et al.*,<sup>16</sup> in a comparable investigation of metallic abutments screwed with coated or uncoated screws. In that study, initial loosening torque for titanium screws was significantly higher than titanium screws coated with tungsten carbide carbon.

However, there is no consensus in the literature in regards to the benefits of coated screws for abutment fixation. Other reports presented contrary finds to those of this study. They have shown that coated screws are able to promote preload maintenance similar to conventional titanium ones after  $0.5 \times 10^6$  mechanical loading cycles<sup>17</sup> or, higher values of preload than conventional titanium screws after  $10^6$  cycles.<sup>16</sup> The above mentioned studies suggest that coated screws may have lower reduction in preload after cyclic loading because the coated surface provides greater preload and more stable joints, thereby resulting in less screw vibration and micromotion during cyclic testing.<sup>17</sup>

The loosening torque of prosthetic screws was lower than the tightening torque in all groups of this study, which was also already observed in literature.<sup>7,18,19</sup> Preload is lost because of the settling effect and it is hypothesized that this reduction is about 2% to 10% of the initial torque.<sup>20</sup> In this process, thread friction is higher for the first tightening and loosening of a screw; after repeated tightening and loosening cycles, friction decreases.<sup>21</sup> The result of the settling effect is that the torque necessary to remove a screw is less than the torque used to initially place the screw.<sup>22</sup> It has therefore been suggested that the implant-abutment joint should be tightened after initial screw insertion and periodically thereafter.<sup>7,23</sup> Moreover, the mechanical cycling load applied promotes micromotion to the screw/implant interface favorably contributing to loose friction.

## CONCLUSION

Within the limitations of this *in vitro* study, considering the materials and techniques evaluated, it was possible to conclude that the use of conventional titanium screws for fixation of Universal Abutments provides higher loosening torque values than DLC screws after cyclic loading irrespective of the technique applied.

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