30 Volume 8 - Number 30 - 2017 - ISSN 2175-7437

Full Dentistry in Science - Volume 8 - Number 30 - 2017

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EDITORAPLENA

Evaluation of final torque and reverse torque of different implant designs

Evaluation of insertion and removal torque of different designs of dental implants

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Summary

The aim of the study was to compare the design of three types of implants in achieving primary stability through final torque and counter-torque evaluation. Thirty implants of the Bionovattion® brand were used in this study, being 10 cylindrical (Biodirect® Cylindrical), 10 conical (Biodirect® Cônico) and 10 conical self-drilling (Biodirect® XP). Todos os implan-tes foram instalados por um único pesquisador, em um bloco de poliuretano rígido de 13 X 18 X 4 centímetros (Nacional Ossos®, Jaú, São Paulo, Brasil). Após a instalação dos implantes, All implants were installed by a single researcher in a 13 x 18 x 4 cm rigid polyurethane block (Nacional Ossos®, Jaú, São Paulo, Brasil). After implant installation, final insertion torque and counter torque were recorded in Ncm with the use of a Lutron® TQ 8800 (Lutron, Taipei, Taiwan). (Lutron, Taipei, Taiwan). As a result there was a significant difference ($p < 0.05$) between the three groups in the torque and in the counter torque, and the self-drilling conical group presented higher values, followed by the cylindrical and conical implant group, respectively. It was concluded that self-drilling conical implants had higher primary stability and were indicated for low density bone, as well as conventional conical implants, even those showing lower values of torque and counter-torque. Cylindrical implants are indicated for situations in which bone density is higher, as in cases of bone type I and II.

Keywords: Osseointegration, torque, in vitro, dental implants.

Summary

The study aimed to compare the design of three types of implants to obtain primary stability by evaluating the final torque and counter-torque. Thirty implants Bionovattion® were used in this study, 10 cylindrical (Biodirect® Cylindrical), 10 conical (Biodirect® conical), and 10 conical self-drilling (Biodirect® XP). All implants were installed by a single researcher, in a rigid polyurethane block 13 X 18 X 4 cm (Nacional Ossos®, Jau, São Paulo, Brazil). After installing the implant, insertion torque and counter-torque were recorded in Ncm with the use of a torque wrench portable digital Lutron® TQ 8800 (Lutron, Taipei, Taiwan). There were significant difference ($p<0.05$) between the three groups in torque and counter-torque, and the conical self-drilling group showed higher values, followed by conical implant group and cylindrical, respectively. It was concluded that the conical self-drilling implants showed greater primary stability, being indicated for low bone density, as well as conventional conical implants, even those showing lower values of torque and counter-torque. Then, the cylindri- cal implants are indicated for situations which the bone density is higher, as in cases of bone type I and II.

Descriptors: Osseointegration, torque, in vitro, dental implants.

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Received for publication: 04/22/2015
Approved for publication: 11/03/2015

Introduction

Since Branemark et al.[4] (1969) reported that titanium implants integrated into bone tissue, they have been widely used.

Many studies agree that the primary stability of a dental implant is important for implant success and longevity [20].

Primary stability is defined as the absence of movement of an implant after insertion into the bone tissue, being considered a prerequisite to allow adequate healing leading to osseointegration [20].

There are three main parameters to achieve primary stability: implant *design*, surgical technique (size of the final drill X implant, cutting power of the drill) and bone quality of the recipient. The interaction of these three parameters determines the initial stability of the implant, that is, the primary stability of the implant can be obtained by choosing an appropriate implant according to the quality of the bone and by applying an appropriate surgical technique[22]. The interrelationship of these parameters determines the primary stability of the implants.

The first developed implants were cylindrical 4. Later, conical implants were created for immediate use after the extraction. The conical design causes compression of the bone tissue of low density increasing the initial stability [19].

In order to provide greater primary stability in low-quality bone, the self-piercing conical implant was developed. The Biodirect XP® implant is made of commercially pure titanium, receiving SUPEX®: surface treatment: porous surface by acid etching through double acid etching. This implant has cylindrical body with taper at the apex with three cut-in entries, double thread and high compaction power and bone expansion. In these implants, cutting blades are present in their apical third, conferring a high cutting power, which confers the possibility of less instrumentation and, consequently, greater compression of the osseous tissue, resulting in improved primary stability [19].

However, a possible disadvantage would be that the cutting blades could reduce the screw surface area, minimizing bone-implant contact [19].

There are different methods for measuring implant stability such as percussion, resonance frequency: Ostell® (Göteborg, Sweden), Periotest® (Siemens AG, Modautal, Germany), Dental Fine Tester® (Kyocera, Kyoto, Japan), as well as the evaluation of torque and reverse torque[11,14,23].

The resonance frequency is one of the most commonly used techniques, being a non-invasive tool to evaluate the stability of the implant during the healing phase, as well as in the maintenance consultations [11].

Ostell® can be considered a useful tool to decide when the implant can receive load, however, further research is needed to establish reliability and predictability of resonance frequency analysis to evaluate osseointegration of implants[14].

Stability can be considered a direct indication of osseointegration and is observed in two stages: primary stability, measured immediately after implant placement, and secondary stability, which is verified after the healing phase [16,14].

The numerical value of the initial stability can be translated as the torque value at the moment of final implant placement in the recipient bed [7,9,12], which would be a requirement for obtaining osseointegration, and it was obtained with the help of a digital torque wrench [3].

In higher density bone tissue, higher implant insertion torque values are expected due to increased contact between bone and implant, and subsequent increase in initial stability[8,10]. It is recommended a minimum torque of 20 Ncm and an ideal torque of 32 Ncm to achieve osseointegration [21].

Carlsson et al.[5] (1988) suggested for the first time that the measurement of the removal torque force was a useful biomechanical method to evaluate the bone and implant interface.

The aim of this study was to evaluate the influence of the *design* of three implant types on the achievement of primary stability through the evaluation of the final torque and counter torque by a Lutron® TQ 8800 portable digital torque wrench (Lutron, Taipei, Taiwan).

Material and Methods

For this study polyurethane blocks (Ossos®, Jaú, São Paulo, Brasil) were used to simulate bone tissue. Three different *designs* of implants were used: cylindrical, conical and self-drilling conical (Bionnovation®, Bauru, São Paulo).

The initial stability of the implants was evaluated by Lutron® TQ 8800 portable digital torque wrench (Lutron, Taipei, Taiwan).

Test Specimen

A 13 x 18 x 4 cm rigid polyurethane block (Nacional Ossos®, ®, Jaú, São Paulo, Brasil was used to simulate the bone in an *in vitro* environment. The American Association for Material Testing has shown that polyurethane blocks have mechanical properties similar to human bone [1]. Thus, this material is considered standard for the mechanical evaluation of implants [15,24]. Using the bone density classification of Misch[18] (2009), type II density bone was simulated using 0.64 grams per cubic centimeters (40 pounds per cubic foot = 40PCF) as In the case of orthopaedic and instrumental devices (ASTM F1839)[1].the specification established for rigid polyurethane materials used as a standard material for the testing of orthopaedic and instrumental devices (ASTM F1839)[1]

Implants

Thirty external hexagon implants were used for this study: 10 cylindrical implants (cylindrical Biodirect®, Bionnovation, Bauru, São Paulo), 10 conical implants (Biodirect conical®, Bionnovation, Baurio, São Paulo) and 10 self-drilling conical(Biodirect Xp®, Bionnovation, Bauru, São Paulo).

All implants are manufactured with commercially pure titanium, the surface treatment being carried out by means of the SUPEX® process (double acid effect). This treatment allows a micro-roughness suitable for the osseointegration process.

The morphology of the implants tested differs as to the parallelism of the walls, apex size and thread size. The Biodirect XP implant (Figure 1) has a cylindrical body with apex taper with three cutting inlets, double thread and high power of compaction and bone expansion. In the cervical region, it presents microgrooves to reduce bone resorption in this region. The cylindrical Biodirect implant (Figure 2) has cylindrical body and apex, indicated for type I and II bones. Its apex is produced by flattening and has three cut-in entries, almost three times larger than XP. The conical Biodirect (Figure 3) has a cylindrical body with taper at the apex. It has the same type of threads as the cylindrical Biodirect, however, presents micro threads in the cervical region, providing a more pronounced lock in this region.

Cylindrical implants were 4.1 mm in diameter and 10 mm in length and the conical and self-drilling conical implants were 4 mm in diameter and 10 mm in length. The 30 implants were installed in the same block of polyurethane.

Figure 1 – Biodirect XP.

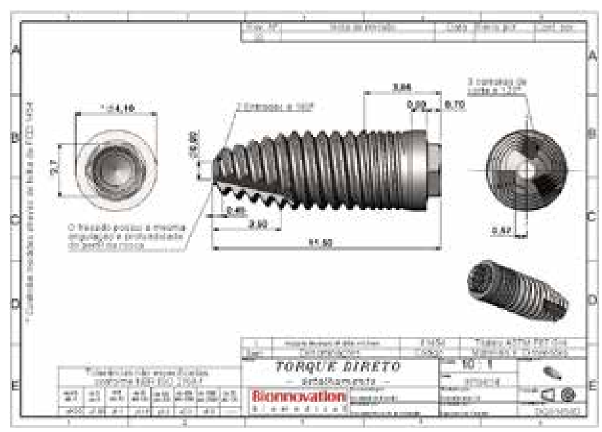


Figure 2 – Biodirect cylindrical.

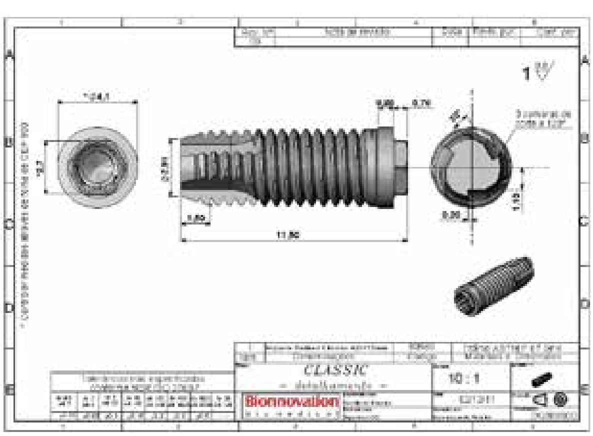


Figura 3 – Biodirect cônico.

Final torque measurement and counter torque

After the implant was installed, the final torque of insertion and counter torque were evaluated, both recorded in Ncm (Newtons per centimeter) using a Lutron® TQ 8800 portable digital torque wrench (Lutron, Taipei, Taiwan).

Study protocol

The preparation for implant installation was conducted as described below:

With the use of a Smart Driller® surgical motor (Driller, Carapicuíba, São Paulo, Brasil), it was adjusted with a torque of 40 N, a speed of 1000 RPM and a counter angle with 20: 1 Kavo® reduction (Kavo, Joinville Santa Catarina, Brasil), the milling of polyurethane block.

The drills used of the *kit* Bio-nnovation surgery® in the following sequence: jib drill, helical drill - Ø 2,2 x 15,0 mm, pilot drill - Ø 3,2 mm, helical drill - Ø 3,2 x 15,0 mm and drill *countersink* RP.

After the preparation of the surgical bed, the implants were inserted with the Kavo®, counter angle, 20: 1, torque of 40 Ncm, with a speed of 20 RPM, when the torque reached 50 N the installation was finished with a manual mechanical torque wrench.

All implants were installed at the bone level as recommended by the manufacturer.

Torque and counter torque were measured using the Lutron® TQ 8800 handheld digital torque wrench (Luogo, Taipei, Taiwan).

For this purpose, the specific implant installation key was adapted to the torque wrench and was then connected to the implant.

After that, torque was performed clockwise until the moment the implant began to move. At that time, the insertion torque value of the implant was recorded.

After the torque evaluation, the counter torque was measured. For this evaluation, torque was performed counterclockwise until the implant was dislodged from the recipient bed, and the value, expressed in Ncm (Figure 4), was recorded.

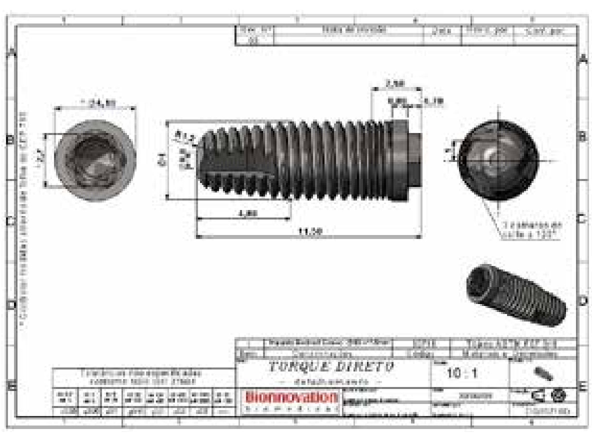


Figure 4 – Torque meter adaptation in the implant for torque measurement and counter-torque.

Results

The study was carried out from December 2014 to January 2015.

In the present study, 30 implants were used. external hexagons of the company Bionnovation® (Bauru, São Paulo, Brazil), being 10 cylindrical, 10 conical and 10 self-drilling conical in a single block of polyurethane, with uniform density.

The preparation of the polyurethane block and implant installation were performed by a single researcher.

The implants were installed without any intercurrence, being possible to carry out the analyzes of torque and counter-torque in all.

After the installation, another researcher assessed the torque and counter-torque values of the implants. It should be noted that this researcher was not aware of which implant *design* he was evaluating, since only the prosthetic platform was visible at the time, and this did not differ between the three groups.

Descriptive measures were evaluated through means and standard deviation. Data normality was tested using the Kolmogorov-Smirnov test with normal distribution. Differences in torque and counter-torque between groups were tested with One-Way (ANOVA).

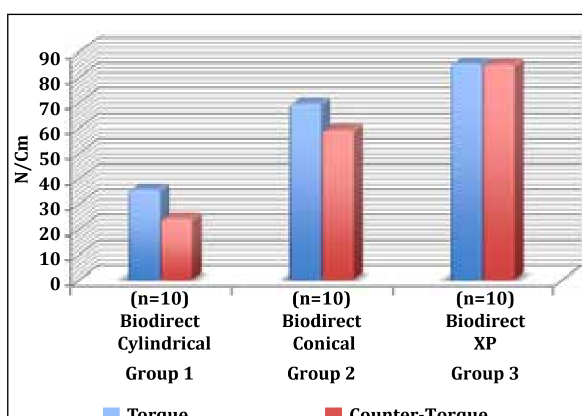
All analyzes were performed using SPSS Statistics® 18 (SPSS inc., Chicago, USA) and the difference was considered statistically significant when p<0,05.

There was a statistically significant difference (p <0.05) between the three groups in the torque and in the counter--torque, as shown in Table 1 and Figure 1.

Table 1 – Average ± standard deviation of torque and counter- -torque in groups during the trial period.

	Group 1 Cylindrical implant (n=10)	Group 2 Conical implant (n=10)	Group 3 XP conical implant (n=10)
Torque	35,6 ± 1,24^{A}	69,50 ± 3,92^{B}	85,40 ± 9,43^{C}
Counter-torque	24,10 ± 3,34^{A}	59,20 ± 4,07^{B}	85,00 ± 10,57^{C}

Intergroup data were compared by One-Way ANOVA, Post-hoc Tukey;
Different upper case letters show intergroup differences (p <0.05).



Graph 1 - Visual evaluation of the average torque and counter- -torque in groups.

Discussion

Primary stability is an important factor for success in osseointegration [19,20,22]. Optimal implant stability is especially essential in cases of immediate loading[25].

In addition to bone quality, the initial stability depends on the surgical technique and *microdesign*, which consists of the surface treatment performed in the implant, and the macrostructural form of the implant [22].

In this study only the macrostructural form was evaluated, since all the implants evaluated presented the same surface treatment, and the details of this treatment are kept in secrecy by the manufacturer.

According to this study Biodirect® conical implants provide greater initial stability when compared to cylindrical ones, in both torque and counter torque evaluation.

The greater stability of these implants was associated with compression in the lateral walls developed by this implant. According to the manufacturer, the presence of microthreads in the cervical region confers a more pronounced locking in this region, contributing to obtain an upper final torque.

When using Biodirect XP self-drilling conical implants the initial stability increased significantly [19].

This type of implant is conical at the apex with three cut-in, double-threaded and high compression and bone expansion inputs, and is indicated for optimization of primary stability, especially in situations in which the bone tissue has low density .

Another positive feature of this implant is to present microgrooves in the cervical region to reduce excessive compression and, consequently, bone resorption in this region.

Regarding self-drilling implants, higher values of both torque and counter-torque were observed. Therefore, even if this implant provides less contact with the bone tissue in the apical third, it has a greater capacity for compaction of the bone tissue, leading to a greater initial stability when compared to the conventional conical implant.

These results are in agreement with similar studies [19,20,25,26] which compared cylindrical and conical implants at initial stability.

In the present study, standardization of milling the surgical bed, in this way, it was intended to evaluate only the different *designs* of these implants, without modification of milling protocol

According to the American Society for Testing Materials, polyurethane specimens have mechanical properties that properly simulate human bone, being used as material for performing mechanical tests for implants [10].

This study used the specimen simulating bone density according to the classification of Misch [18] (2009).

The choice of this density is due to the smaller deformation when submitted to forces of compression and flexion, being this body of evidence the most suitable for mechanical tests with implant [15].

Despite the best mechanical characteristics of the specimen used in this study, it should be emphasized that it represents a high-density bone, therefore, high values of torque and counter-torque were obtained, mainly in the groups of the conic implants and conical self-drilling.

In cases of high bone density, the use of cylindrical implants provides adequate initial stability, being indicated in these situations, as the results showed [21].

Therefore, self-piercing conical and conical implants are indicated in situations of lower bone density, as in cases of bone type III and IV [18]. These implants provide higher values of final torque and counter-torque, as was observed in this study. They are therefore indicated to improve initial stability.

There are a number of ways to measure implant stability, such as percussion, osstell resonance frequency ® (Göteborg, Suécia), Periotest (Siemens AG, Modautal, Germany), Dental Fine Tester® (Kyocera, Kyoto, Japan) assessment of torque and reverse torque [11,14,23].

The choice of the initial stability through the torque and reverse torque through the digital torque meter was due to the precision and reproducibility of this technique, besides, it is known that there is a direct relation between the insertion torque and counter torque and the initial stability of the implants [2,6,13].

No studies were found in the literature that evaluated both torque and counter-torque, comparing the different *designs* of implants.

It should be noted that the difference between the groups was noted in the torque and counter-torque, and it can be inferred that both are suitable methods for assessing the initial stability.

Conclusion

It was concluded that self-drilling conical implants had higher primary stability and were indicated for low density bone, as well as conventional tapered implants, even those showing lower values of torque and counter-torque.

Cylindrical implants are indicated for situations in which bone density is higher, as in cases of bone type I and II.

Live evaluations are necessary to study the bone-implant interface of these three implants, at different times, from their installation to follow-up after the installation of the prosthesis.

The specimen used in the study, with a density of 40 PCF, is suitable for performing dental implant work.

The torque and counter-torque evaluation methods are easily reproduced and are effective in checking the initial stability of the implants.

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How to cite this article:
Cielo VF, Mizutani FS, Freitas GC. Final torque and reverse torque evaluation of different implant designs. Full Dent. Sci. 2017; 8 (30): 28-33. DOI: 10.24077 / 2017; 830-01383343.