Comparison of Reverse Torque in Different Types of Implant Screw Systems

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Abstract

The aim of this study is to compare the torque loss values of two different implant internal thread systems after tightening-loosening cycles. A total of 30 dental implant, including two different internal thread design and three different brands were used in our study (Straumann, n:10 , Bego, n:10 , BioHorizons, n:10), (Straumann and Bego : conventional internal thread system, and BioHorizons : Spiralock® internal thread system). A digital torque measurement device was used in assessing the insertion and reverse torque values. The each group were tightened at the digital torque gauge showed 30 N/cm2, and loosened 20 times in total. The minimum torque loss value was observed in Straumann (1.49 N/cm2), and the maximum torque loss value was observed in Bego (3.58 N/cm2) during the first 10 cycles. No statistically significant difference was found between the groups. The effect of implant thread design on reverse torque was not statistically significant, but it should be kept in mind that decrease in reverse torque value depending on number of uses was observed in clinical use.

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Introduction

Screw loosening is one of the most frequent technical complications in single-tooth implant restoration. The reported rates of screw loosening is up to 12.7% for single crowns.[1] This problem can cause various clinical complications, including increasing the microgap between implant components, which can lead to peri-implant inflammation and even bone loss.[2] Microgaps can act as reservoirs for bacteria.[3,4] Moreover, screw loosening may cause implant or abutment screw fracture, inadequate occlusal load distribution, and possible implant failure.[5]

An abutment is joined to the implant body by a screw.[6] When torque is applied to a new screw, three contact forces are generated: between the abutment and the implant, between the head of the screw and the abutment, and between the screw threads and the abutment's internal threads. The vertical component of these forces creates a "preload" tension in the screw, causing it to elongate.[7,8] Elastic recovery of the tightened screw generates a clamping force that holds the implant body and abutment together.[9] Preload is related to applied torque, connection type and design, material components, settling effects, and screw head and thread design.[10,11]

To address screw loosening complications, manufacturers of various systems have developed screws designed to decrease the loosening rates.[12] One example is the Spiralock® fastening technology (Bio-Horizons Dental Implant System, Birmingham, AL, USA), which is also used on dental implant internal threads. It is stated in the information paper[13] as "A conventional abutment screw (V-thread) is axially loaded, but the Spiralock® thread form that distributes the load radially" (Figure 1). This screw thread system has been reported to have some advantages, including high resistance to dynamic loading, improved joint integrity, more evenly distributed load, and consistent reusability.[13] There is no study investigating the effect of this system on the amount of reverse torque in dental implants.

The purpose of this study was to compare the torque loss values of conventional and Spiralock® implant thread systems after abutment screws are tightened to 30 N/cm2. The null hypothesis of this study was that there is no

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statistically significant difference in the reverse torque values of the Spiralock® thread system group.

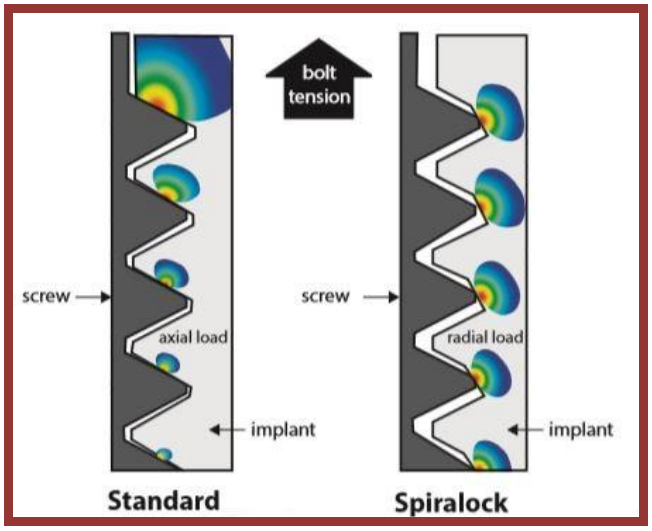

Figure 1. Load distributions between the conventional type and the Spiralock® type internal thread system.[13]

Materials and methods

Three groups were created. Each group had 10 new dental implant bodies and standard abutments and abutment screws. In group Straumann (Straumann Dental Implant System, Waldenberg, Switzerland) 4.2 x 10 mm implants were used; in group Bego (BEGO Implant Systems, Bremen,Germany) 4.5 x 10 mm implants were used; and in group BioHorizons (BioHorizons Dental Implant System, Birmingham, AL, USA) 4.6 x 10 mm implants were used. Groups Straumann and Bego received the conventional implant internal thread system, while Group Bio-horizons received the Spiralock® internal thread system.

Implant bodies were embedded into acrylic resin (Probase Cold; Ivoclar Vivadent) in 10 x 10 x 25 mm plastic rectangular boxes.[14] Abutment screws were washed with saline solution before each torque application, as recommended in Dixon et al.[15]

Each group's abutment screws were tightened with their torque gauge ratchets. The torque application procedures were performed with a digital torque gauge (TT01 Series Digital Cap Torque Testers; Mark-10, Copiague, NY) for measurement standardization. The digital torque gauge was calibrated before beginning each tightening process. During the tightening process, the operator was stabilize to the ratchet's head in left hand's finger, the other hand was applying torque to the ratchet. Tightening continued until the digital torque gauge showed 30 N/cm2. Ten minutes after the first torque application, 30 N/cm2 of force was applied again and the applied value was recorded. After the effective preload was applied, the ratchets belonging to the implant brands were moved to the reverse position and the abutment screws were removed. The maximum tightening torque (initial torque) and maximum reverse torque values were recorded in the digital torque measurement analysis program (MESURgauge Plus, Mark-10 Corp. Copiague, NY). This procedure was repeated 20 times for all groups.

The following formula was applied to calculate the torque loss for the collected data.

Torque loss (TL) = Initial torque value (ITV) – Reverse torque value (RTV)

Torque loss data for first to tenth (1-10) and first to twentieth (1-20) tightening-loosening cycles were evaluated by statistical analysis. Statistical analysis was performed using the IBM SPSS Statistics program (IBM SPSS Statistics for Windows, Version 22.0. IBM Corp, Armonk, NY, USA) Both data groups showed normal distribution. Therefore, values were analyzed by one-way analysis of variance (ANOVA). Multiple comparison tests were performed with the Tukey HSD test. A level of significance was set at ($P < 0.05$) in all tests.

Results

The average values of torque loss in first to tenth and first to twentieth tightening-loosening cycles for all groups are given in Table 1 and Table 2, respectively.

Group	Max	Min	Mean ± SD
Straumann	3.56	1.49	2.526 ± 0.691
Bego	3.58	2.66	3.000 ± 0.313
BioHorizons	3.12	2.00	2.499 ± 1.104

Table 1. For First to Tenth Cycles, Mean Values and SDs of TLVs of All Groups (N/cm2).

Group	Max	Min	Mean ± SD
Straumann	4.43	1.49	3.114 ± 0.821
Bego	5.27	2.66	3.654 ± 0.764
BioHorizons	5.30	2.00	3.401 ± 1.111

Table 2. For First to Twentieth Cycles, Mean Values and SDs of TLVs of All Groups (N/cm2).

The minimum torque loss value was observed in Group Straumann during the first 10 cycles (1.49 N/cm2). Maximum torque loss was observed in Group Bego (3.58 N/cm2) during the first 10 cycles. In all groups, the reverse torque value was lower than the initial torque value.

	Sum of Squares	Degrees of Freedom	Mean Square	F	Significant (P)
Between Groups	1,587	2	,794	3,468	,046
Within Groups	6,178	27	,229		
Total	7,765	29			

Table 3. For First to Tenth Cycles, One-Way ANOVA Results of Differences Among the Groups (P < 0.05).

	Sum of Squares	Degrees of Freedom	Mean Square	F	Significant (P)
Between Groups	2,909	2	1,454	1,750	,183
Within Groups	47,372	57	,831		
Total	50,281	59			

Table 4. For First to Twentieth Cycles, One-Way ANOVA Results of Differences Among the Groups (P < 0.05).

The results of the ANOVA, where the groups were compared, are given in Table 3 and Table 4 for 1 to 10 and 1 to 20 tightening-loosening cycles, respectively. No statistically significant difference was found between the groups. Multiple comparison tests showed, that there was no statistically significant difference between the mean values of the groups.
The scatter plot graphics of the torque loss values of the groups are shown in Figure 2, and their relationships are shown in Figure 3.

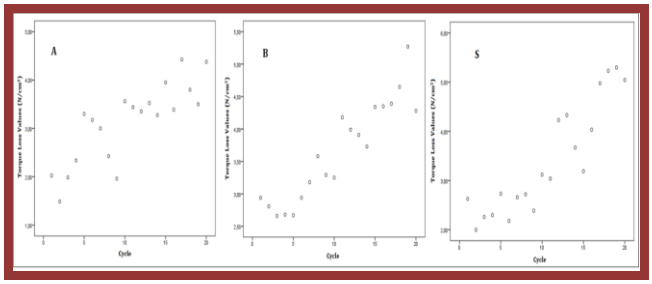

Figure 2. Mean Torque Loss Values (TLVs) on scatter plot graphics (A:Straumann , B:Bego, S: BioHorizons).

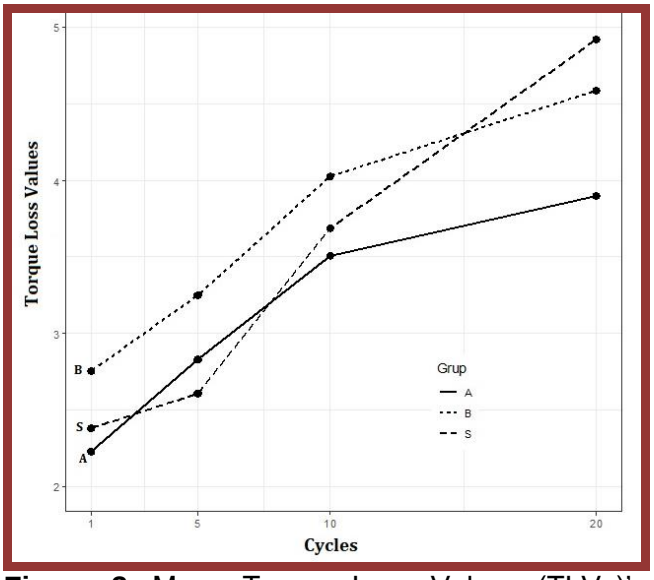

Figure 3. Mean Torque Loss Values (TLVs)'s relationship of groups (A:Straumann , B:Bego, S: BioHorizons).

Discussion

In our study, no statistically significant differences were found between the reverse torque values of Spiralock® and conventional thread systems. These results are not reject our null hypothesis. The first tightening-loosening cycles showed low torque loss values. Although there was no statistically significant difference, torque loss values for Group Straumann were slightly lower than for the other groups.

Gumus et al.'s[16] study about the saliva and blood contamination of dental implant internal threads showed that the lowest torque loss value was found in the non-contaminated group. For this reason, the authors recommended saline decontamination before the final torque is applied on abutment screws. On the contrary, Tzenakis et al.[17] indicated that higher preload was achieved after repeated use of a saliva contaminated gold prosthetic retaining screw. In our study, abutment screws were rinsed with saline solution before each torque application to simulate clinical practice, as recommended in Dixon et al.[15]

The abutment is connected to the implant with prosthetic abutment screws by torque gauge ratchets. There are different types of these ratchets, such as digital, spring, and friction types.[18] Some studies about the reliability of torque gauge ratchets reported that there may be deviations from the planned torque value to the

abutment screw.[19-20] In this study, we checked the ratchets on a digital torque measuring device and applied 30 N/cm2 torque value.

Guzaitis et al.[19] reported that for multi-unit and complete arch prostheses, screw insertion cycles would easily exceed 10 cycles and could exceed 19 cycles over the lifetime of the prosthesis. In our study, the data in the 1st to 10th and 1st to 20th tightening-loosening cycles were analyzed separately. No statistically significant difference was found between the groups in torque loss values by the number of cycles.

In Weiss et al.'s[21] study, torque loss values progressively increased in the first 200 tightening cycles. These findings are consistent with our results. When the data collected after 20 tightening-loosening cycles were evaluated in our study, it was seen that the torque loss values for increased from the first cycle to the last cycle. The lowest torque loss values were found in the first cycles. We suggest that a new screw or limited screw tightening cycles should be used to prevent screw loosening.

When a screw is tightened by applying torque, it elongates and produces tension.[22] This tension, called preload, is related to a settling effect. The settling effect occurs because of wear and flattening of microscopically rough high spots rather than because of the elongated screw, and it reduces the preload.[11] It is therefore recommended that a second tightening should be applied to limit the settling effect. In this study, the settling time used was 10 minutes, as suggested in the literature.[23,15]

It has been reported that when screws are used multiple times, their surfaces become smoother and loosen more easily.[24] Considering the macro-geometry of the Spiralock® internal thread system, the friction surface between two threads will be much less than in a conventional thread system (Figure 1) Therefore, the Spiralock® thread system cannot take advantage of friction. In our study, there were no statistically significant differences in torque loss values among the groups. The Spiralock® thread systems may have retained their preload because the force transmission in this system is different from that in conventional screw systems.

One of the limitations of our study is that natural mouth forces could not be simulated on the implant-abutment connection. The Spiralock® thread system distributes the forces on the abutment at different angles compared to conventional thread systems. In our study, we only evaluated the reverse torque values among the groups. This is the first study in the literature about the Spiralock® dental implant system's internal threads. We suggest that further studies should show the force transfer directions and friction areas.

Conclusions

The effect of implant thread design on reverse torque was not statistically significant, but it should be kept in mind that decrease in reverse torque value depending on number of uses was observed in clinical use.

Acknowledgements

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Declaration of Interest

The authors declare no conflict of interest.

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