**In vitro Effect of Chlorhexidine Gel on Torque and Detorque Values of Implant Abutment Screw**

**Abstract**

**Purpose:** Use of chlorhexidine (CHX) gel to eliminate the malodor of implant cavity may decrease the friction coefficient and effective preload and result in abutment screw loosening. This study aimed to assess the effect of CHX gel on the preload, torque, and detorque values.

**Materials and Methods:** This in vitro experimental study was conducted on three groups of five implants. Group A (G1) was the control group and no material was applied to the implant cavity. In Group B (G2), implant cavity was filled with saliva before abutment screw tightening. In Group C (G3), implant cavity was first filled with saliva and then with CHX gel. The abutments were torqued to 24 N/cm² according to the manufacturer’s instructions and were then loosed. These processes were repeated five times. The ratio of the mean percentage of detorque to torque values was measured in all groups. The collected data were analyzed using ANOVA and post hoc Tukey’s test.

**Results:** No significant difference was noted between G1 and G2. Group G2 had significantly higher detorque value \( (p < 0.05) \). ANOVA detected a significant difference in the mean torque \( (p < 0.001) \) and detorque \( (p < 0.05) \) values among the three groups. G3 showed maximum difference between torque and detorque values; the minimum difference was noted in G2. **Conclusion:** Application of CHX gel (to decrease the malodor of the implant cavity) decreases the detorque and preload values and increases the risk of screw loosening.

**Keywords:** Chlorhexidine, dental implants, torque

**Introduction**

Dental implants offer a predictable treatment modality for the replacement of missing teeth.\(^1\) Evidence shows a significant improvement in the quality of life of patients who have received dental implants.\(^2\) Dental implants currently have a success rate of 90%–100% and show promising results due to the advances in their physical design and manufacturing process and improved clinical experience.\(^3\) The malodor smelled when opening the abutment screw indicates the presence of microorganisms in the implant cavity and is displeasing to both the patient and the clinician.\(^4\) Several studies have focused on methods to eliminate this malodor. Kern and Harder were the first to use chlorhexidine (CHX) gel (Corsodyl gel) for this purpose.\(^5\) Young reported the leakage of microorganisms even when the cover screw is placed, which results in inflammation of the peri-implant soft tissue and eventual development of peri-implantitis and peri-implant mucositis. Some researchers use antibiotics to overcome this problem. Application of antibiotics to the implant cavity can remove Gram-negative microorganisms and consequently eliminate the malodor.\(^6\) Micro-gap and the subsequent microleakage through it are the common problems of implant systems. Microleakage through the implant–abutment interface may result in the development of inflammatory reactions in the peri-implant soft tissue and cause peri-implantitis of the osseointegrated implant, leading to subsequent marginal bone loss. Bacterial infection may also impair the process of osseointegration in the postsurgical healing phase.\(^7\) In the implant systems, bacteria may enter into the implant cavity during the process of screwing or unscrewing the abutment and implant or via leakage through the implant–abutment interface. The presence of voids in the cover screw enhances the inlet of bacteria into the implant cavity; this can occur due to contamination in the first or second stage of implant surgery. Bacterial transmission from the oral cavity may also occur after prosthetic loading of implant. Peri-implant mucositis can also result in...
Further microbial accumulation.[7] Micarelli et al. showed that application of an antimicrobial agent such as CHX into the implant cavity before the placement of cover screw or healing abutment can decrease bacterial accumulation and subsequent leakage of bacteria and toxins into the implant cavity.[8] However, the effects of these antimicrobial agents used for malodor on torque and detorque values of the abutment screw have not yet been evaluated. On the other hand, studies have shown that drying the implant cavity may decrease the preload value when closing the abutment screw and subsequently increase the risk of abutment screw loosening, mobility of the prosthesis, or screw fracture and increase the risk of peri-implant soft-tissue inflammation.[9]

The effect of presence of saliva in the implant cavity on the torque was also evaluated in a previous study, and it was reported that saliva had no significant effect on the final torque and detorque values.[10] Too low torque value results in screw loosening while excessive torque increases the risk of screw fracture. Thus, accurate torque application is critically important. The amount of preload is affected by factors such as the intensity and method of load application, design and composition of implant abutment, environmental factors affecting the interactions (lubrication of the screw threads), position and stability of the screw, and presence of surface irregularities that prevent maximum fit of the screw and abutment.[11] This study sought to assess the effect of CHX gel on the preload, torque, and detorque values of implant abutment screw.

Materials and Methods

In this in vitro experimental study, 15 cylindrical implants (XiVE®, Friadent) with 3.8 mm diameter and 11 mm length were selected and divided into three groups of five. In addition, 15 straight premachined abutments with different screws were chosen. First, 10 implants were placed in a container containing natural saliva. Five implants were chosen as controls and were not contaminated (as recommended by the manufacturer). In Group A (G1), implant cavity was not contaminated with any material. The cover screw was removed and the healing abutment was torqued to 15 N/cm² and remained as such until the experiment [Figure 1].

In Group B (G2), the implant cavity was filled with natural saliva [Figure 2]. The cover screw was removed, implant cavity was contaminated with the saliva, and then the healing abutment was torqued to 15 N/cm². The complex was then placed in a container filled with saliva for 1 week.

In Group C (G3), the implant cavity was contaminated with the saliva and then with CHX. Five of these implants were removed from the saliva container after 1 week; their cover screw was removed and the implant cavity was filled with 0.2% CHX gel (Elugel), and then the healing abutment was torqued to 15 N/cm². The complex was then immersed again in a container filled with saliva for 1 week. In Group B (G2), the healing abutment was removed again, contaminated with saliva, and torqued to 15 N/cm². After 1 week, implants were removed from the saliva container. The healing abutments were removed and replaced with screw abutments torqued to 24 N/cm². Due to the effect of screw tightening speed on the torque applied, screws were tightened using BTG-6 Tohnichi torque gauge (Tohnichi American Corporation, Northbrook, IL, USA). The applied load was controlled by Tohnichi torque gauge, and the actual torque for screw tightening was displayed on the monitor of the device. In this study, each screw in the experimental groups was loosened and tightened five times. Screw loosening (detorque) was performed 5 min after tightening, and the interval between the tightening and loosening of the screws was 15 min. Before tightening, the abutment screw was contaminated with CHX ointment in Group C (G3) and saliva in Group B (G2) and tightened to a torque of 24 N/cm². Group A (G1) was considered as the control group and no saliva contamination occurred in this group. The screw tightening and loosening procedures in this group were similar to those in other groups for the five screws connecting the abutment to the implant. At each time of loosening and fastening the abutment screw with 24 N/cm² torque, the torque and detorque values displayed on the monitor were recorded. In each group, torque and detorque values were measured for 25 times and recorded. The obtained data were recorded in a table. The mean torque and detorque values in each group were calculated. Intergroup and intragroup comparisons were made, and the percentage of detorque/torque ratio was also calculated for each group. Statistical analysis of the data was carried out using ANOVA and Tukey’s honest significant difference (HSD) test. Data were analyzed using SPSS version 20 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). Data were reported using descriptive statistics (number and percentage). The difference between torque and detorque values in different groups was also analyzed. Level of significance was set at \( P < 0.05 \).
Results
In this study, 15 implants in three groups were evaluated. Using general linear model and repeated measures ANOVA, no significant difference was noted between the mean torque \( (p = 0.23, p = 0.298 \text{ and } p = 0.665) \) and detorque \( (p = 0.661, p = 0.51 \text{ and } p = 0.568) \) values at different time points in any of the experimental environments \( (A, B, \text{ and } C) \) or within each group [Tables 1 and 2].

According to one-way ANOVA, no significant difference was noted in the mean torque in the A, B, and C groups in the first, second, and fourth attempts \( (p > 0.05) \). However, at the third and fifth attempts with 95% confidence interval and error of <5%, a significant difference was found in the mean torque of Groups A, B, and C \( (P = 0.03 \text{ and } p = 0.015) \). A significant difference was also noted in detorque values among Groups A, B, and C in the first to fifth attempts \( (p < 0.01) \).

Using general linear model and repeated measures ANOVA, no significant difference was noted in the mean difference of torque and detorque values \( (p = 0.215, p = 0.85, \text{ and } p = 0.661) \) or the mean percentage of detorque to torque ratio \( (p = 0.919, p = 0.783, \text{ and } p = 0.548) \) among the three Groups of A, B, and C or within each group at different time points [Figure 3 and Table 3]. However, one-way ANOVA revealed that with 99% confidence interval and error rate of <1%, a significant difference existed in the mean difference of torque and detorque values and the mean percentage of detorque to torque ratio in Groups A, B, and C in the first to fifth attempts \( (P < 0.01) \) [Table 4].

ANOVA [Table 5] showed a significant difference among groups. Tukey’s HSD test showed that the percentage of torque reduction was significantly different between Groups A and B, Groups B and C, and Groups A and C. The torque/detorque percentage ratio was 81%; this indicates that the torque value decreased by 19%. In Group B, the detorque value decreased by 14%; the reduction in detorque value was 30% in Group C. Thus, maximum torque reduction occurred in Group C while

| Group | Time | Number | Mean | Standard deviation | \( F \) | Intragroup comparison | \( F \) | Inter-group comparison |
|-------|------|--------|------|-------------------|------|----------------------|------|-----------------------|
| A     | First| 24/6   | 0/41 | 1/86              | \( P = 0/23 \) |                      |      |                       |
|       | Second| 24/3   | 0/44 |                   |      |                      |      |                       |
|       | Third | 24/6   | 0/22 |                   |      |                      |      |                       |
|       | Fourth| 24/7   | 0/27 |                   |      |                      |      |                       |
|       | Fifth | 24/7   | 0/27 |                   |      |                      |      |                       |
| B     | First| 25     | 0/35 |                   |      |                      |      |                       |
|       | Second| 5      | 24/8 | 1/42              | \( P = 0/298 \) | 0/938                | 0/418|                       |
|       | Third | 25/3   | 0/44 |                   |      |                      |      |                       |
|       | Fourth| 25/3   | 0/57 |                   |      |                      |      |                       |
|       | Fifth | 25     | 0     |                   |      |                      |      |                       |
| C     | First| 24/6   | 0/41 |                   |      |                      |      |                       |
|       | Second| 24/7   | 0/27 | 0/218             | \( P = 0/665 \) |                      |      |                       |
|       | Third | 24/7   | 0/44 |                   |      |                      |      |                       |
|       | Fourth| 25/1   | 0/41 |                   |      |                      |      |                       |
|       | Fifth | 24/2   | 0/57 |                   |      |                      |      |                       |
minimum torque reduction was noted in Group B. The minimum difference between detorque and torque was seen in Group B; maximum difference of the mean percentage was noted in Group C.

**Discussion**

Based on the results, in each group, no significant difference was noted in the five attempts made for loosening and tightening the screw; the intragroup conditions were the same for all three groups and no significant difference was noted in this respect among them. Higher torque in Group B was similar to the findings of Micarelli et al.; in their study, saliva as a lubricant increased the torque value, which is in contrast to the results of Guda et al., who stated that saliva cannot be considered as a lubricant and did not increase the torque. In Group C, CHX gel increased the torque compared to Group A, which may be due to the lubricating effect of CHX and increasing the

| Table 2: Comparison of the mean detorque value in the five repetitions of testing in A, B and C groups |
|---|---|---|---|---|---|---|
| Group | Time | Number | Mean | Standard deviation | F | Intragroup comparison | F | Inter-group comparison |
| A | First | 19/4 | 1/08 | | | | |
| Second | 20 | | 1/5 | | | | |
| Third | 20/2 | | 0/27 | 0/224 | | 0/661 |
| Fourth | 20/4 | | 0/54 | | | | |
| Fifth | 19/5 | | 1/27 | | | | |
| B | First | 21/4 | | 0/87 | | | |
| Second | 21/6 | | 1/19 | | | | |
| Third | 21/6 | | 1/29 | 0/521 | | 0/51 |
| Fourth | 21/7 | | 0/97 | | | | |
| Fifth | 21/7 | | 1/09 | | | | |
| C | First | 16/9 | | 2/21 | | | |
| Second | 17 | | 2/29 | | | | |
| Third | 17/9 | | 0/54 | 0/44 | | 0/568 |
| Fourth | 17/4 | | 0/82 | | | | |
| Fifth | 17/2 | | 0/9 | | | | |

| Table 3: The mean difference of torque and detorque values in the five consecutive attempts in groups A, B and C |
|---|---|---|---|---|---|---|
| Group | Time | Number | Mean | Standard deviation | F | Intragroup comparison | F | Inter-group comparison |
| A | First | 5/2 | | 0/75 | | | |
| Second | 4/3 | | 0/44 | | | | |
| Third | 4/4 | | 0/41 | 1/86 | | 0/215 |
| Fourth | 4/3 | | 0/75 | | | | |
| Fifth | 5/2 | | 1/3 | | | | |
| B | First | 3/6 | | 0/65 | | | |
| Second | 3/2 | | 0/97 | 0/151 | | 0/861 |
| Third | 5 | 3/7 | | 1/2 | 0/04 | | 0/85 |
| Fourth | 3/6 | | 1/08 | | | | |
| Fifth | 3/3 | | 1/09 | | | | |
| C | First | 7/7 | | 1/95 | | | |
| Second | 7/7 | | 2/25 | | | | |
| Third | 6/8 | | 0/57 | 0/224 | | 0/661 |
| Fourth | 7/7 | | 1/03 | | | | |
| Fifth | 7 | | 0/7 | | | | |

| Table 4: The mean difference and percentage of detorque/torque in the three groups |
|---|---|---|---|---|---|---|
| N | Minimum | Maximum | Mean | SD | Percentage |
| Group1 Torque | 25 | 24 | 25 | | 24.58 | 0.34 | 81 |
| Group1 Detorque | 25 | 17.5 | 21 | | 19.9 | 0.85 | |
| Group2 Torque | 25 | 24.5 | 26 | | 25.08 | 0.4 | 86 |
| Group2 Detorque | 25 | 20 | 23.5 | | 21.6 | 1 | |
| Group3 Torque | 25 | 23.5 | 25.5 | | 24.66 | 0.49 | 70 |
| Group3 Detorque | 25 | 13 | 19.5 | | 17.28 | 1.46 | |
torque. This finding was similar to the results of Guda et al. They believed that lubricants increase the torque while Micarelli et al. reported that lubricants decreased the preload.

Guda et al. stated that ideal screw tightening and preload are obtained when 60%-70% of the yield strength is achieved. By decreasing the coefficient of friction, maximum percentage of yield strength can be obtained; however, the presence of friction decreases the torque value and preload and leads to the screw backing out. In our study, reduction in preload was seen in Group C due to the excessive effect of CHX gel on decreasing the friction coefficient, and the detorque value in Group C was lower than that in other groups. However, detorque in all groups showed a 70%-86% reduction compared to torque, but, maximum reduction of detorque was noted in Group C (70%); this finding is similar to that of Kano et al. In the current study, the reduction in detorque in Group A (control group) was 81%, which is not similar to that of Haack et al. who reported that the torque reduction or detorque/torque percentage was 70%-80% in the absence of lubricant in vitro. In the study by Kano et al., this value was 92.3%, this result is different from the current findings, and this difference may be due to the difference in the structure of implant components. The amount of reduction in detorque in Group C was similar to the results of Micarelli et al. They reported that contamination decreased the detorque value. Contamination is inevitable in laboratory procedures. However, they believed that saliva increases the preload, which is in line with our findings. A previous study suggested plasma argon cleaner for complete decontamination of abutment/screw complex. Obviously, the presence of debris on the components of the screw-abutment complex in clinical follow-up sessions can decrease the coefficient of friction of components and subsequently affect the preload. Presence and quality of lubricant (saliva, peri-implant fluid, or blood) between implant components (which is clinically unpredictable) can decrease the coefficient of friction although the quality of lubricant materials is variable.

In the current study, CHX gel was not effective as a lubricant because the reverse torque following the use of CHX gel decreased, which is similar to the results of Micarelli et al. Burgue et al. stated that screw loosening primarily occurs when the external load applied to the screw joint negatively results in stress concentration. Therefore, higher preload causes higher resistance to screw loosening. However, in order for the preload to be effective, it must be lower than the elastic threshold of materials (lower than the tensile coefficient that causes injury) and more than the load applied during the clinical service. Success of abutment screw joint is related to preload. Pesun et al. and Siamos et al. reported that tightening and loosening the screw involve compressive loads that decrease preload. In addition, the load required for screw loosening is higher than the load applied for tightening. Thus, any external pressure applied for loosening may be responsible for decreased preload. Silva-Neto et al. stated that preload is particularly important in abutment screw stability, preventing screw loosening or implant dysfunction. Thus, if preload decreases during the clinical function of prosthesis, it may lead to screw loosening and compromise the stability of the joint and consequently result in clinical failure of implant. They added that use of lubricants could decrease the friction and subsequently increase the preload. However, in the current study, use of lubricant gel yielded a contrary result. Although lowering the coefficient of friction may be effective to increase preload, it may show opposite results if it drops below the critical threshold.

Conclusion

The highest percentage of detorque value was noted in the saliva group; this indicates that saliva can serve as a suitable lubricant and cause higher preload in the screw. The lowest preload was obtained when a lubricant paste was used. Gel can decrease the coefficient of friction and subsequently decrease preload. Thus, to eliminate malodor due to bacterial accumulation in the implant cavity, antibiotic pastes (not in the form of gel) should be used.

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Conflicts of interest

There are no conflicts of interest.

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