

Original Article

The effect of multiple processing and re-use on orthodontic mini-screw torque values

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ABSTRACT

Background: Reusing orthodontic mini-screws would reduce treatment cost and lead to more use of mini-screws and improvement of orthodontic treatments. This study has assessed the effects of reprocessing and reusing the titanium mini-screws on their maximum insertion, removal and fracture torque (FT).

Materials and Methods: In this experimental study, 20 titanium mini-screws (1.6-mm × 8-mm) were randomly divided into two equal groups. In the test group, the screws were first sterilized by autoclave and then their FT was assessed. In the control group, FT was assessed after 5 times of insertion, cleaning, processing (37% phosphoric acid for 10 min, 5.25% sodium hypochlorite for 30 min) and sterilizing with autoclave. The maximum insertion and removal torque values were compared using the repeated measure ANOVA and the FT data were analyzed by the *t*-test. The data were analyzed using the SPSS software (version 13.0) and the significance was set on 0.05.

Results: The paired *t*-test for maximum insertion torque (MIT) showed that MIT₁ was significantly lower than other MIT values ($P = 0.02$) and also MIT₂ was significantly higher than MIT₅ ($P = 0.01$), but other MIT values had no significant differences. The paired *t*-test for maximum removal torque (MRT) showed that only MRT₂ was significantly higher than other MRT values (except MRT₁) ($P = 0.046$). Regarding FT, the *t*-test showed that there was no significant difference between FT₀ and FT₅ ($P = 0.485$).

Conclusion: Within limitations of this study, five time insertion, cleaning, processing and steam sterilization had no significant negative effect on insertion, removal and FT of the mini-screws.

Key Words: Fracture torque, insertion torque, mini-screw, removal torque, re-use

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INTRODUCTION

Providing sufficient anchorage during tooth movement is mandatory for a successful orthodontic treatment.^[1-5] Orthodontic mini-screws as temporary skeletal anchorage have improved the quality of orthodontic treatments.^[6,7] In some instances, it is required to replace the screw into a new position, which is because:

1. Contact to the root during primary insertion.
2. Obstructing the path of desired tooth movement.
3. Mini-screw mobility due to soft tissue inflammation and adjacent bone resorption.
4. Using in the other part of the mouth for another anchorage purpose.^[3,8,9]

Using new screws for these purposes increases the treatment cost. Reusing the screws will eliminate these extra costs and lead to more clinical application of mini-screws and improvement of orthodontic treatments.^[10-14]

Reusing medical instruments has a long history. Reusing can only be performed when using or preparing the instrument for re-use doesn't cause any harm to the instrument or alter its clinical features. Reusing should be economically feasible and easily performable in the clinic.^[15]

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Comparing the mechanical features of titanium mini-screws and jaw bones shows that inserting the screws into the bone will not harm their structure. It seems that the structure, form and polished surface and titanium-based material of the screws may allow them to be cleaned by mechanical and chemical methods and steam-sterilized multiple times without altering their functions.^[12]

This study has assessed the effects of multiple reprocessing and reusing the titanium mini-screws on their maximum insertion, removal, and fracture torques (FTs).

MATERIALS AND METHODS

In this experimental study, 20 titanium mini-screws (Jeil Medical Corporation, Seoul, South Korea) with a 1.6-mm diameter and 8-mm length were randomly divided into two equal groups. The screws were examined macroscopically to ensure they had no structural defects.

In the test group, the screws were sterilized by an autoclave (Prestige Medical 2100 Classic, UK) in 121°C and 15 psi pressure for 20 min. A custom made screw drive (CSD) and a digital torque tester (Imada DiD-4, Imada Inc., USA) were used to evaluate the maximum insertion and removal and FT.

The mini-screws were inserted into a 3-mm thick polycarbonate plate (Raychung, Taiwan) mounted inside an aluminum frame. The rotation velocity (45 rpm), penetration depth (7-mm), movement axis, insertion and removal speeds (0.9-mm/360° rotation = 0.675-mm/s) and the vertical forces during insertion and removal were calibrated by mounting the combination of screws, CSD and torque tester on the rotating part of a milling machine (Jamco, CM6241, China) and the polycarbonate plates on its nonrotating part [Figure 1].

Holes with 1-mm depth and 0.8-mm diameter were predrilled in 10-mm distances on the plates to eliminate any deviation from axial inclination of the screws during insertion. Maximum insertion torque (MIT) and maximum removal torque (MRT) were recorded in N.cm units. After the torque measurements, the screws were prepared by cleaning and processing method described in a previous study of authors.^[9] First, they were completely immersed in 37% phosphoric acid gel (Ultradent Product, Inc., USA) and then soaked in 0.3 cc phosphoric acid for 10 min. Afterwards, they were rinsed with 10 cc



Figure 1: Torque testing setup (milling machine, torque tester, custom-made screw driver, mini-screw and polycarbonate plate).

distilled water using a syringe and then dried for 5 s. The screws were then placed in 10cc sodium hypochlorite 5.25% (Raga, Pakrood Co., Iran) for 30 min and afterwards washed and dried as described. After this process, the screws were sterilized inside the autoclave as above mentioned. Then, maximum insertion and removal torque tests were done again. This cycle was done 5 times.

After that, FT test was done for both multiple-re-used group and control group. The control group samples also were sterilized before measurements just like the test group. To test FTs, mini-screw and CSD were mounted on torque tester and hand-driven into a 10-mm thick polycarbonate block (Raychung, Taiwan). Predrilling with 1-mm depth and 0.8-mm diameter was done to decrease deviation from axial inclination of the screws during insertion. Maximum torque values before fracture were recorded in N.cm units.

The SPSS software (version 13.0, SPSS Inc., Chicago, IL, USA) was used to analyze the data. The maximum insertion and removal torque values were compared using the repeated measure ANOVA and the FT data were analyzed by the *t*-test. The significance was set on 0.05.

RESULTS

Maximum insertion torque and MRT values are summarized in Tables 1, 2 and Figure 2. The repeated measure ANOVA test was done for MIT and MRT values, separately. It showed that there is a significant difference. Therefore, the paired *t*-test was used to compare the variables. The paired *t*-test for MIT showed that MIT₁ was significantly lower than other MIT values ($P = 0.02$) and also MIT₂ was

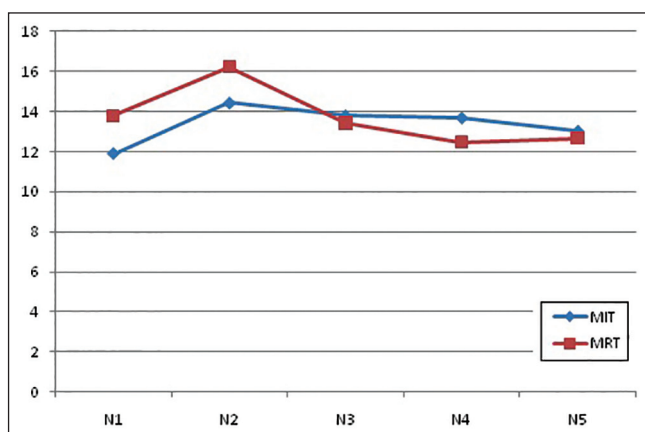


Figure 2: The changes of maximum insertion and removal torque values in multiple re-uses.

significantly higher than MIT₅ ($P = 0.01$), but other MIT values had no significant difference.

The paired t -test for MRT showed that only MRT₂ was significantly higher than other MRT values (except MRT₁) ($P = 0.046$).

Regarding FT, the t -test showed that there was no significant difference between FT₀ and FT₅ ($P = 0.485$). The amounts of FT values are reported in Table 3.

DISCUSSION

Re-using medical and dental instruments is common around the world.^[15,16] Even developed countries reprocess costly and specialized instruments to reduce treatment costs.^[16] For re-using a dental or medical instrument, there are three considerations:

1. Evaluating the physical and mechanical changes of appliances after re-use.
2. Evaluating the chemical safety of the re-use process, for instance the absorption of chemical disinfectants on the instrument surface, which can lead to toxic reactions.
3. Evaluating the biological safety of the re-use process, like remnant debris on the instrument.^[16]

If the re-use process isn't performed correctly, problems such as cross-infection, incomplete disinfection, remaining chemical disinfectants, corrosion, and fatigue-induced failure may occur.^[15] Therefore, before re-using one should consider every aspect and consider the advantages and disadvantages.^[15,16]

Reprocessors' experience has shown that dental and medical instruments re-use is limited and one could re-use most appliances for a maximum of 5 times.^[16]

Table 1: The mean value of MITs in different groups

Groups	Mean (SE)	95% CI	
		Lower bound	Upper bound
MIT ₁	11.88 (0.611)	10.499	13.261
MIT ₂	14.44 (0.411)	13.498	15.382
MIT ₃	13.79 (0.631)	12.974	14.606
MIT ₄	13.68 (0.341)	12.907	14.453
MIT ₅	13.01 (0.5)	11.88	14.14

The torque values are presented in N.cm. MIT_n: Maximum insertion torque; n : The time of insertion; SE: Standard error; CI: Confidence interval; MIT: Maximum insertion torque.

Table 2: The mean value of MRTs in different groups

Groups	Mean (SE)	95% CI	
		Lower bound	Upper bound
MRT ₁	13.78 (0.785)	12.004	15.556
MRT ₂	16.22 (1.129)	13.667	18.773
MRT ₃	13.42 (0.808)	11.592	15.248
MRT ₄	12.48 (0.673)	10.958	14.002
MRT ₅	12.67 (0.690)	11.109	14.231

The torque values are presented in N.cm. MRT_n: Maximum removal torque; n : The time of removal; SE: Standard error; CI: Confidence interval.

Table 3: The mean value of FTs in different groups

Groups	n	Mean (SE)	SEM
FT ₀	10	32.45 (2.48)	0.784
FT ₅	10	31.81 (0.68)	0.217

The torque values are presented in N.cm. FT: Fracture torque; FT₀: Fracture torque of as-received mini-screws; FT₅: Fracture torque of mini-screws after 5 times re-use. SE: Standard error; SEM: Standard error of mean.

Temporary anchorage devices are an excellent method for anchorage preparation.^[17,18] Mini-screws may need to be moved to a new position during treatment due to their mobility,^[3,8] during some tooth movements like molar distal driving and to prepare maximum anchorage on other sites of the dentition.^[8,9] Therefore, reusing mini-screws would reduce treatment costs and expand their clinical use, leading to improved treatment quality.^[10-14]

When re-using miniscrews, it should be assured that the process doesn't significantly affect their mechanical properties.^[1,2,4] In this study, we evaluated the effects of multiple re-use process on MIT, MRT and FT.

Maximum insertion torque is the result of the friction between screw threads and bone which determines the primary stability of the screw.^[3,5,19] The success rate of a mini-screw is majorly affected by its MIT.^[5] To reduce the risk of mini-screw fracture, 5-10 N.cm MIT values has been suggested for 1.6-mm diameter mini-screws.^[20] Some researchers have suggested

15 N.cm for successful insertion.^[21] In this study, we used polycarbonate plates to measure insertion and removal torque to eliminate the negative effects of bone anatomic variability (different cortex thicknesses and densities).

The similarity between the resulted MIT values in this study with the MIT values achieved in other studies,^[20,21] which the screws were inserted in clinical situations, prove that polycarbonate plate is a suitable substrate for simulating the bone for screw insertion.

In this study, the mean value for the first MIT₁ was significantly lower than the later insertions ($P = 0.02$). This increase may be due to screw thread blunting. The mean MIT values during 5 times re-use were very close; therefore, re-use had no significant adverse clinical effect.

According to Table 1, it can be predicted with 95% confidence that after 5 times re-use, MIT will only increase 4.9 N.cm. This amount is clinically neglectable and doesn't complicate screw placement and doesn't significantly increase their failure risk.

To increase torque measurement accuracy, the screws were inserted using a milling machine. The milling machine provided a monotonous rotational speed and similar to the clinicians hand speed. Therefore, the effects of speed change on torque could be controlled. The milling machine rotated the screw driver with a monotonous 0.9-mm/round (0.675-mm/s) speed perpendicular to the polycarbonate plate. This speed was selected according to mini-screw pitch. If the speed is not coordinated with the screw pitch, it will produce vertical inward or outward forces between the sloped surface of the mini-screws thread and the polycarbonate plate, which increases friction and affects torque values. Using the machine in comparison to hand-driving, allowed to eliminate lateral forces on the screw and reduced eccentric rotations thus, increasing the test accuracy.

Regarding MRT, the only statistically (but not clinically) significant difference was between MRT2 and other MRT values, which may have been occurred due to screw thread blunting in this sample size and just in this step of the experiment.

Multiple re-using had no significant adverse effects on MRT values. According to Table 2, it can be predicted with %95 confidence that after 5 times re-using, the lowest MRT (12.48 N.cm) is clinically close to as-received screw MIT values, which proves that

multiple re-using doesn't have a noticeable adverse effect on screw's clinical stability.

In this study, the FT values of the test group after 5 times re-using had no significant difference with the control group values. The results of this study, justifies the previous study of the authors,^[9] which showed that processing, sterilizing and bone insertion doesn't affect the mechanical properties of the screw.

Mattos *et al.*^[8] showed that FT of 1.4-mm × 8-mm used screws was significantly higher than the suggested MIT for successful insertion (5-10 N.cm)^[20] and also higher than the appropriate MRT (10.7-21.07 N.cm).^[11] In their study, because of the decreased FT observed in used screws compared with the as-received group, they suggested not to re-use the screws.^[8]

In vitro studies have shown that torque values higher than 23 N.cm is required for mini-screw fracture.^[20] The FT values in this study in both groups are higher than 28 N.cm and cover this suggested safe margin.

Tipping of mini-screws at first contact with the plate or during insertion can reduce their fracture resistance.^[7] In this study, to decrease the tipping, holes with 1-mm depth and 0.8-mm diameter were predrilled into polycarbonate block. These holes guided the screw into the block and eliminated eccentric movements; therefore, improved the accuracy of the test.

After fracture of screw, that part inserted in the block cannot move but the other part attached to screw-driver can move. If the movement continues after screw fracture, friction between two segments of fractured screw can affect torque values. To consider this point, we preferred hand-driving rather than machine-driving in fracture test of screws.

In this study, during the FT test, all screws fractured in the thread area, which agrees with the results of Whang *et al.* study^[7] in which the screws fractured in the intra osseous area and not the head or neck. This can be explained by the light tapering of the body of the screw and the more thickness of the head. Kravitz and Kusnoto^[22] carried out an *in vivo* study and showed that the screws fractured in the neck during removal.

According to the results of this study, re-using the mini-screws <5 times is safely suggested. Proper use of mini-screws in previous applications, like no lateral forces during insertion and removal, re-using the mini-screws in lower density bone sites, not re-using the mini-screw

when there had been a strong resistance during previous insertion and not re-using mini-screws, which have been deformed or structurally harmed will reduce the chances of unwanted complications during mini-screw re-use. It should be mentioned that in this *in vitro* study, we could not assess the effects of intraoral conditions, like loads which are applied to the screw during orthodontic treatment, on mini-screws mechanical features.

CONCLUSION

Within limitations of this study, five time insertion, cleaning, processing (37% phosphoric acid for 10 min, 5.25% sodium hypochlorite for 30 min) and steam sterilization had no significant negative effect on insertion, removal and fracture torque (FT) of the mini-screws.

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