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

Saeed Noorollahian¹, Shiva Alavi¹, Elahe Rafiei²

¹Dental Materials Research Center and Department of Orthodontics, ²Dental Students Research Center, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran

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 FT1 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

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]
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) 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 MIT\(_1\) was significantly lower than other MIT values (\( P = 0.02 \)) and also MIT\(_2\) was

\[\text{Figure 1: Torque testing setup (milling machine, torque tester, custom-made screw driver, mini-screw and polycarbonate plate).}\]
significantly higher than MIT$_5$ ($P = 0.01$), but other MIT values had no significant difference.

The paired $t$-test for MRT showed that only MRT$_2$ was significantly higher than other MRT values (except MRT$_1$) ($P = 0.046$).

Regarding FT, the $t$-test showed that there was no significant difference between FT$_0$ and FT$_5$ ($P = 0.485$). 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.$^{[16]}$

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 mini-screws, 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.$^{[1,5,19]}$ 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

![Figure 2: The changes of maximum insertion and removal torque values in multiple re-uses.](image)
15 N.cm for successful insertion.\textsuperscript{[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,\textsuperscript{[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 MIT, 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,\textsuperscript{[9]} which showed that processing, sterilizing and bone insertion doesn’t affect the mechanical properties of the screw.

Mattos \textit{et al.}\textsuperscript{[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)\textsuperscript{[20]} and also higher than the appropriate MRT (10.7-21.07 N.cm).\textsuperscript{[1]} 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.\textsuperscript{[8]}

\textit{In vitro} studies have shown that torque values higher than 23 N.cm is required for mini-screw fracture.\textsuperscript{[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.\textsuperscript{[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 \textit{et al.}\textsuperscript{[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\textsuperscript{[22]} carried out an \textit{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.

**ACKNOWLEDGMENTS**

The authors gratefully acknowledge that this report is based on a thesis submitted to the School of Dentistry, Isfahan University of Medical Sciences, in partial fulfillment of the requirement for a MSc degree. This study was financially supported and approved (grant no. 393397) by the Isfahan University of Medical Sciences, Isfahan, Iran.

**REFERENCES**

1. Chen YJ, Chen YH, Lin LD, Yao CC. Removal torque of miniscrews used for orthodontic anchorage — A preliminary report. Int J Oral Maxillofac Implants 2006;21:283-9.
2. Cheng SJ, Tseng IY, Lee JJ, Kok SH. A prospective study of the risk factors associated with failure of mini-implants used for orthodontic anchorage. Int J Oral Maxillofac Implants 2004;19:100-6.
3. Lim SA, Cha JY, Hwang CJ. Insertion torque of orthodontic miniscrews according to changes in shape, diameter and length. Angle Orthod 2008;78:234-40.
4. Papadopoulos MA, Tarawneh F. The use of miniscrew implants for temporary skeletal anchorage in orthodontics: A comprehensive review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:e6-15.
5. Salmória KK, Tanaka OM, Guariza-Filho O, Camargo ES, de Souza LT, Maruho H. Insertional torque and axial pull-out strength of mini-implants in mandibles of dogs. Am J Orthod Dentofacial Orthop 2008;133:790.e15-22.
6. Cope JB. Temporary anchorage devices in orthodontics: A paradigm shift. Semin Orthod 2005;11:3-9.
7. Whang CZ, Bister D, Sherriff M. An *in vitro* investigation of peak insertion torque values of six commercially available mini-implants. Eur J Orthod 2011;33:660-6.
8. Mattos CT, Ruellas AC, Elias CN. Is it possible to re-use mini-implants for orthodontic anchorage? Results of an *in vitro* study. Mater Res 2010;13:521-5.
9. Noorollahian S, Alavi Sh, Monirifard M. A processing method for orthodontic mini-implants reuse. Dent Res J (Isfahan) 2012;9:447-51.
10. Eliades T, Zinelis S, Papadopoulos MA, Eliades G. Characterization of retrieved orthodontic miniscrew implants. Am J Orthod Dentofacial Orthop 2009;135:10.e1-7.
11. Karch M, Alt E, Schmitt C, Schömig A. Reimplantation of an infected, abdominally implanted defibrillator in the subpectorial region. J Cardiovasc Surg (Torino) 1996;37:67-70.
12. Pringle RA, Leman RB, Kratz JM, Gillette PC. An argument for pacemaker reuse: Pacemaker mortality in 169 patients over ten years. Pacing Clin Electrophysiol 1986;9:1295-8.
13. Schwartz Z, Lohmann CH, Blau G, Blanchard CR, Koskolne AW, Liu Y, et al. Re-use of implant coverscrews changes their surface properties but not clinical outcome. Clin Oral Implants Res 2000;11:183-94.
14. Sonis AL. Air abrasion of failed bonded metal brackets: A study of shear bond strength and surface characteristics as determined by scanning electron microscopy. Am J Orthod Dentofacial Orthop 1996;110:96-8.
15. MHRAD. Single Use Medical Devices: Implications and Consequences of Reuse. London: DOH; 2006.
16. Popp W, Rasslan O, Unahalekhaka A, Brenner P, Fischmann E, Fathy M, et al. What is the use? An international look at reuse of single-use medical devices. Int J Hyg Environ Health 2010;213:302-7.
17. Crismani AG, Bertl MH, Cela AG, Bantleon BP, Burstone CJ. Miniscrews in orthodontic treatment: Review and analysis of published clinical trials. Am J Orthod Dentofacial Orthop 2010;137:108-13.
18. Moon CH, Lee DG, Lee HS, Im JS, Baek SH. Factors associated with the success rate of orthodontic miniscrews placed in the upper and lower posterior buccal region. Angle Orthod 2008;78:101-6.
19. Wilmes B, Drescher D. Impact of insertion depth and predrilling diameter on primary stability of orthodontic mini-implants. Angle Orthod 2009;79:609-14.
20. Motoyoshi M, Hirabayashi M, Uemura M, Shimizu N. Recommended placement torque when tightening an orthodontic mini-implant. Clin Oral Implants Res 2006;17:109-14.
21. Chaddad K, Ferreira AF, Geurs N, Reddy MS. Influence of surface characteristics on survival rates of mini-implants. Angle Orthod 2008;78:107-13.
22. Kravitz ND, Kusnopo B. Risks and complications of orthodontic miniscrews. Am J Orthod Dentofacial Orthop 2007;131:S43-51.

How to cite this article: Noorollahian S, Alavi S, Rafiei E. The effect of multiple processing and re-use on orthodontic mini-screw torque values. Dent Res J 2015;12:243-7.

Source of Support: This study was financially supported and approved by the Isfahan University of Medical Sciences, Isfahan, Iran.

Conflict of Interest: The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.