Journal of Research in Medical and Dental Sciences
Volume 5, Issue 3, Page No: 63-68

Available Online at: www.jrmds.in
eISSN No. 2347-2367: pISSN No. 2347-2545

Effect of insertion angles and reusing procedure on mini-screws' mechanical properties

Valiollah Aarash[1], Fatemeh Abdollahi[2]*, Reza Ghorbanipour[1], Mohammad Mehdi Naghibi Sistani[3] and Ali bijani[4]

[1]Dental Materials Research Center, Institute of health, Babol University of Medical Sciences, Babol, I.R. Iran
[2]Dental Research Center, Golestan University of Medical Sciences, Gorgan, Iran
[3]Oral Health Research Center, Institute of Health, Babol University of Medical Sciences, Babol, I.R. Iran
[4]Social determinants of Health Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran

DOI: 10.24896/jrmds.20175311

ABSTRACT

Retrieving mini-screw reduces treatment cost. However, one notable factor in this issue could be insertion angle. This study evaluates influence of insertion angles (50 and 90) and reusing procedure on mechanical properties of mini-screws. In this in-vitro experimental study mini-screws were inserted with 90 and 50 angles in initial and second application. Mechanical properties were measured by Maximum insertion, removal and fracture torque of all test and control groups. Data were analyzed with T test, Paired T- test and ANOVA. In addition surface morphology of mini-screw after initial insertion with 90 and 50 angles and as-received mini-screw were examined under scanning electron microscope (SEM). Mini-screws with 50 degree insertion angle showed higher insertion and removal torque values in initial application than 90 does ($p<0.001$). These measures were changed insignificantly between initial and second application for samples which were inserted with 90 degree for both application sections. The difference of maximum fracture torque in retrieved and controlled groups was insignificant as well. Scanning electron microscope showed no gross surface changes in retrieved mini-screws, but surface roughness was observed which were highest in samples with 50 degree insertion angles. Reusing mini-screws with 90 degree insertion angle has no adverse effect on their mechanical properties. In addition the reduction of mechanical properties of retrieved mini-screws which were inserted with fifty degree placement angle for both application sections however is acceptable for clinical setting.

Keywords: Insertion angle, Mini-screw, Insertion torque, Removal torque, Fracture torque, Reuse, Surface morphology.

HOW TO CITE THIS ARTICLE: Valiollah Aarash, Fatemeh Abdollahi, Reza Ghorbanipour, Mohammad Mehdi Naghibi Sistani and Ali bijani, Effect of insertion angles and reusing procedure on mini-screws' mechanical properties, J Res Med Dent Sci, 2017, 5 (3): 63-68, DOI: 10.24896/jrmds.20175311

Corresponding author: Fatemeh Abdollahi
e-mail✉ fatemeh.abdollahi95@chmail.ir
Received: 22/02/2017
Accepted: 10/06/2017

INTRODUCTION

One of the most critical issues in orthodontic treatment is anchorage preparation [1]. Using mini-screws to provide skeletal anchorage has several advantages such as versatility, minimal surgical invasiveness, low cost, and possibility of immediate loading [2,3]. Obtaining primary stability as an important factor for mini-screws' maintenance depends on shape, length, diameter of mini-screw, bone thickness and direction of insertion [4]. Min *et al*. [5] and Deguchi *et al*. [6] found out that oblique insertion of mini-screws increases cortical bone contact which may conclude to higher initial stability. In addition, based on Xu *et al*. [7] study, mini-screws which were placed with fifty and seventy degree of insertion angles showed the highest initial stability. In regards to expensiveness of orthodontic treatment appliances, reusing mini-screws has been considered in several studies [8-12]. Although sterilization procedure is essential for retrieving mini-screws, it has no significant effect on mini-screws' mechanical properties even after several cycles [13-15]. In addition, controversies exist in literature about mechanical strength of retrieved mini-screws [8-11]. Noorollahian *et al*. [9] reported no significant difference between insertions, removal and fracture torque of as-received and retrieved mini-screws [10]. Similarly, Estelita *et al*. [8] affirmed that

retrieving mini-screws have no adverse effect on their fractural strength. However, Mattosl *et al*. [13] showed retrieved mini-screw implants have less sharp tip, smooth threads, and less fracture torque resistance. On the other hand, previous studies tested mechanical strength of retrieved mini-screws in perpendicular placement; [8-10] however, the effect of oblique insertion angles of reused mini-screws was not studied. Therefore, this study aimed to evaluate the mechanical properties of mini-screws in initial and second application with fifty and ninety degree of insertion angles.

MATERIALS AND METHODS

Sample

It was an in-vitro experimental study. We served 59 mini-screws (Jeil Medical corporation, Seoul, Korea) with 1.4mm diameter and 8 mm length. 50 mini-screws were used for torque testing and 9 for evaluating surface morphology under scanning electron microscope (SEM). We divided 50 mini-screws into two tests and one control groups. Each test groups contain 20 mini-screws which were inserted with 90 (group 90) and 50 (group 50) degree insertion angles into polycarbonate plate with 3 mm thickness respectively. Milling machine (Jamco, CM6241, 2010, China) with 45 rounds per minute driving speed served for inserting all samples. Mini-screws were placed with a custom made mini screwdriver on imada Did-4 torque tester (Imada Inc, Northbrook IL, USA) then maximum insertion and removal torque in initial application (MIT_1 and MRT_1) were recorded by torque tester (Figure 1).

Retrieving process

In order to provide laboratory process similar to clinical situation, all removed mini-screws were irrigated with normal saline, dried, and coated with phosphoric acid (H3PO4) 37% gel (Ultradent product Inc, south Jordan, Utah), then immerged in 1ml of the same acid for ten minutes. Following, they were irrigated, dried and immerged in 10 ml 5.25% sodium hypochlorite (NaOCl, Sehat, Iran) for 30 minutes. Finally, they were irrigated, dried, and autoclaved at 121° C and 18 psi for 20 minutes. This process was recommended as an efficient cleaning procedure in clinical settings without adverse effect [9].

Second application

In order to find the effect of placement angle on initial stability of reused mini-screws, mini-screws with 90degree initial insertion angle were reinserted with 90 (group 90-90) and 50 degrees (group 90-50) into 3 mm thick polycarbonate plate. Similarly, mini-screws with 50 initial insertion angles were reinserted with 90 (group 50-90) and 50 degree (group 50-50) into 3 mm thick polycarbonate plate as well. Each subgroup contains 10 mini-screws. Maximum Insertion and Removal Torque (MIT_2 and MRT_2) in second application were recorded. Finally, all test and control groups were derived into polycarbonate plate with 8 mm thickness to evaluate maximum fracture torque (MFT) of mini-screws.

Mechanical properties

Maximum Insertion Torque (MIT) and Maximum Removal Torque (MRT) were recorded. These measures have been suggested as a well indicator for evaluating initial stability [3, 14-17]. In addition, Maximum Fracture Torque (MFT) was calculated as a good index for assessing structural integrity. Several studies also recommended this measure [8, 11, 15, 18]. For evaluating surface morphology of mini-screws under Scanning Electron Microscope (KYKY manufacture, EM 3200 model), nine mini-screws were divided in three equal groups randomly. One control and the other samples were inserted into 3mm thick polycarbonate plate with 90(group 1) and 50(group2) degrees insertion angle, respectively. Driving speed and retrieving process has been proved similar to torque testing samples. All mini screws were gold coated & their surface were examined under scanning Electron microscope. To make the study blind all data were recorded by a person who was not participant in this experiment Data were analyzed with independent T- test, Paired T- test & Repeated measuring ANOVA using the SPSS software package (Version 21). Significance was set at<0.05.

RESULTS

The mean amount of maximum insertion and removal torque in initial application were significantly higher in 50-degree insertion angle than 90 ($p<0.001$) (Table 1). The mean amount of maximum insertion and removal torque were changed between initial and second application in each test groups, however, this pattern for MIT ($P=0.23$) and MRT ($p=0.06$) were non-significant in group 90-90 (Figure2, and Figure 3).

The mean maximum fracture torque after second application in group 90-90, 90-50, 50-50, 50-90, and MFT in control were (37.2 ± 5.3), (39.6 ± 6.2), (35.9 ± 6.2), (41.1 ±3.8), (38.4 ±6.1),

and (38.4±5.7) respectively while the difference was not significant (p=0.29). Figure 4 illustrates surface morphology of as-received and retrieved mini-screws (group1 and 2). Group 1 and 2 showed extra surface roughness in comparison with control group, while group 2 displayed the highest surface roughness. The SEM exhibited no kind of major surface changes such as cracks and pores in retrieved mini-screws. Retrieved mini-screws showed some scratches and bevelled edge which was highest in group 2.

Figure 1. Mini-screw was placed by a custom made screw driver on Imada torque tester which was clasp in milling machine. With rotational movement of milling machine mini-screw was inserted to polycarbonate plate, and Imada torque tester showed torque values.

Table 1. Mean of the Maximum Insertion Torque (MIT_1) and the Maximum Removal Torque(MRT_1) in initial application

	90(n=20) Mean ±SD	50(n=20) Mean ±SD	P Value
MIT_1	9.275 ± 1.07	12.220 ± 1.23	<0.001
MRT_1	12.535 ± 2.12	20.470 ± 2.99	<0.001

Measurement unit= Ncm

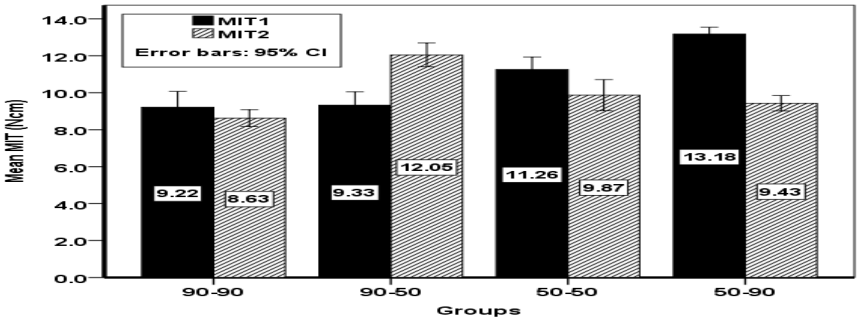

Figure 2. Mean of the Maximum Torque in initial and second insertion (MIT_1 and MIT_2) in all test groups

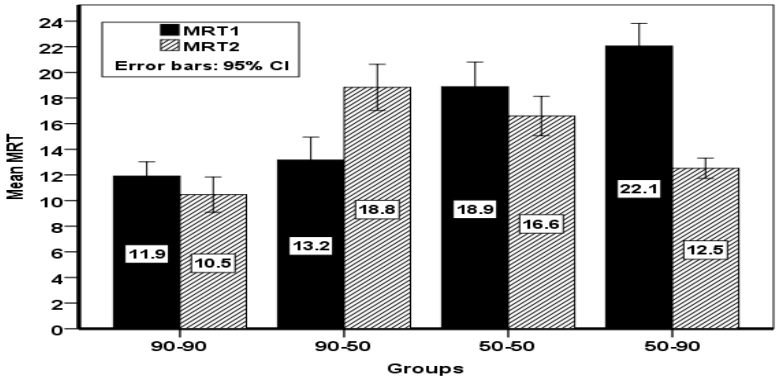

Figure 3. Mean of the Maximum Removal Torque in initial and second application (MRT_1 and MRT_2) in all test groups

Surface morphology of the tip/Magnification at 100× **Surface morphology of thread/ Magnification at 500×** **Surface morphology of thread/ Magnification at 1000×**

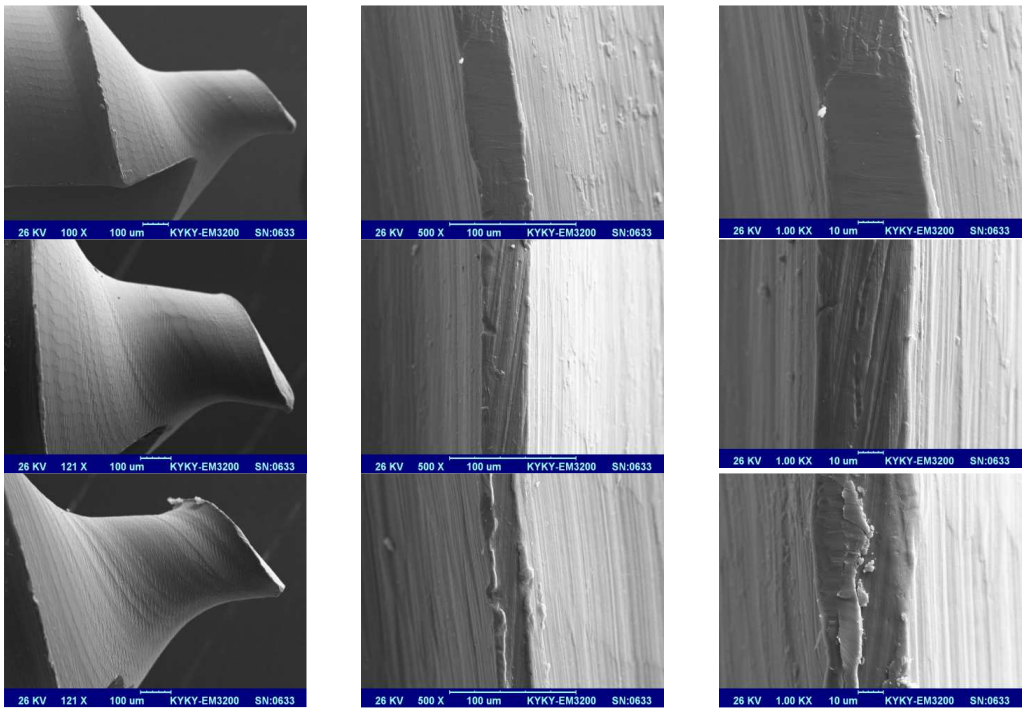

Figure 4. Scanning electron microscope micrographs of surface morphology of the mini-screw s tip and threads

DISCUSSION

Study results indicated that previous placement with different insertion angles, processing methods, and sterilization with autoclave was ineffective on fracture torque of mini-screws. Similarly Noorollahian *et al*. [9,10] found no significant difference between fracture torque of as-received and retrieved mini-screw. Estelita *et al*. [8] also agreed that fractural strength of mini-screws were not influenced by different recycling protocol such as autoclave sterilization, sonication or sandblasting. Differing from it, Mattosl *et al*. [11] revealed fracture torque resistance of retrieved mini-screws were reduced in comparison with new ones; however, their fracture torque records was higher than the recommended insertion and removal torque by Motoyoshi *et al*. [19]. Previous studies have been made evident that inclined mini-screws have more primary stability [3,7,20,21]. Similarly, our findings revealed initial placement of mini-screws with 50 degree insertion angle results to higher amount of maximum insertion and removal torque rather than perpendicular placement ($p<0.001$). This may be due to increasing cortical bone contact with surface of mini-screw in oblique placement [5,6]. Concerning to the Wilmes *et al*. [3] and Xu *et al*. [7] studies, we inserted mini-screws with 50 degree placement angle because it is the greatest oblique insertion angle with the highest initial stability. Our study data demonstrated when fifty degree insertion angle served for first and second application, the maximum insertion and removal torque between two phases were lessen significantly. Although this reduction may cause lower stability, it is not less than recommended insertion torque [19]. On the other hand, when insertion angle in first and second application was ninety degree, the maximum insertion and removal torque between two phases were changed insignificantly. Noorollahian *et al*. [9] and Defino *et al*. [17] revealed no significant difference between insertion and removal torque of new and retrieved mini-screws in perpendicular insertion as well. Major reduction however has been reported after third application [10,17]. These results proposed using mini-screws perpendicularly for at least two times has no harmful mechanical strength effects. In addition, samples with fifty degree insertion angle showed highest scratches on scanning electron microscope micro-photograph, which can be explained by increasing surface contact of mini-screw with plate during insertion and removal. Regarding no major surface defect, these findings advocate reusing mini-screws as well. In similar, Mattosl *et al*. [11] and Iijima *et al*.[22] found no gross defect , pores , thread striping and tip fracture or any sign of corrosion on retrieved mini-screws. Smoother threads, surface adsorption, and surface corrosion of mini screws however have been reported as a result of surface contact of

mini-screws with biological fluid [18]. In consistent with previous studies polycarbonate plate served for inserting mini-screws which has mechanical properties similar to natural bone and provides equal density and thicknesses in all sites [9, 20, 23]. Using milling machine for placing mini-screws increased the test's reliability such as equal rotational speed and insertion angle.

This study however limits to laboratory conditions. In clinical application multiple factor could influence on mini-screws' characteristics such as insertion sites in mouth and duration of remaining mini-screw in bone. Further researches are needed to examine effect of other factors on possibility of reusing mini-screws and biocompatibility of retrieved ones.

CONCLUSION

Using mini-screws perpendicularly for at least two times has no harmful mechanical strength effects. Although, maximum insertion and removal torque of retrieved mini-screws with fifty degree insertion angle in first and second application were reduced significantly, but this reduction may not have adverse effect on clinical application.

REFERENCES

1. Costa A, Raffainl M, Melsen B. Miniscrews as orthodontic anchorage: a preliminary report. The International journal of adult orthodontics and orthognathic surgery. 1998; 13(3):201-9.
2. Papadopoulos MA, Tarawneh F. The use of miniscrew implants for temporary skeletal anchorage in orthodontics: a comprehensive review. Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics. 2007; 103(5): e6-15.
3. Wilmes B, Su YY, Drescher D. Insertion angle impact on primary stability of orthodontic mini-implants. The Angle orthodontist. 2008; 78(6):1065-70.
4. Wilmes B, Rademacher C, Olthoff G, Drescher D. Parameters affecting primary stability of orthodontic mini-implants. Journal of orofacial orthopedics = Fortschritte der Kieferorthopadie: Organ/official journal Deutsche Gesellschaft fur Kieferorthopadie. 2006;67(3):162-74.
5. Min KI, Kim SC, Kang KH, Cho JH, Lee EH, Chang NY, *et al*. Root proximity and cortical bone thickness effects on the success rate of orthodontic micro-implants using cone beam computed tomography. The Angle orthodontist. 2012;82(6):1014-21.
6. Deguchi T, Nasu M, Murakami K, Yabuuchi T, Kamioka H, Takano-Yamamoto T. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics. 2006;129(6):721 e7-12.
7. Xu Z, Wu Y, Zhao L, Zhou Y, Wei X, Tang N, *et al*. Effect of placement angle on the stability of loaded titanium microscrews in beagle jaws. The Angle orthodontist. 2013;83(4):659-66.
8. Estelita S, Janson G, Chiqueto K, Ferreira ES. Effect of recycling protocol on mechanical strength of used mini-implants. International journal of dentistry. 2014; 4(2):424-923.
9. Noorollahian S, Alavi S, Monirifard M. A processing method for orthodontic mini-screws reuse. Dental research journal. 2012;9(4):447-51.
10. Noorollahian S, Alavi S, Rafiei E. The effect of multiple processing and re-use on orthodontic mini-screw torque values. Dental research journal. 2015;12(3):243-7.
11. Mattosl CT RA, Eliaslll CN. Is it posible to re-use mini-implants for orthodontic anchorage? result of an in vitro study. marerial research. 2010;13(20):521-5.
12. Chung KR, Choo H, Kim SH, Ngan P. Timely relocation of mini-implants for uninterrupted full-arch distalization. American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics. 2010;138(6):839-49.
13. Mattos CT, Ruellas AC, Sant'anna EF. Effect of autoclaving on the fracture torque of mini-implants used for orthodontic anchorage. Journal of orthodontics. 2011; 38(1):15-20.
14. Akyalcin S, McIver HP, English JD, Ontiveros JC, Gallerano RL. Effects of repeated sterilization cycles on primary stability of orthodontic mini-screws. The Angle orthodontist. 2013;83(4):674-9.
15. Adelson RT, DeFatta RJ, Ducic Y. Integrity of craniofacial plating systems after multiple sterilization procedures. Journal of oral and maxillofacial surgery: official journal of the

American Association of Oral and Maxillofacial Surgeons. 2007;65(5):940-4.
16. Gansukh O, Jeong JW, Kim JW, Kim YK, Lee JH, Kim TW. Effect of rotation bump on removal torque of orthodontic mini-implants. Journal of the Korean Association of Oral and Maxillofacial Surgeons. 2013;39(6):269-73.
17. Defino HL, Rosa RC, Silva P, Shimano AC, Albuquerque de Paula FJ, Volpon JB. Mechanical performance of cylindrical and dual-core pedicle screws after repeated insertion. Spine. 2012;37(14):1187-91.
18. Eliades T, Zinelis S, Papadopoulos MA, Eliades G. Characterization of retrieved orthodontic miniscrew implants. American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics. 2009;135(1):10 e1-7; discussion -1.
19. Motoyoshi M, Hirabayashi M, Uemura M, Shimizu N. Recommended placement torque when tightening an orthodontic mini-implant. Clinical oral implants research. 2006;17(1):109-14.
20. Raji SH, Noorollahian S, Niknam SM. The effect of insertion angle on orthodontic mini-screw torque. Dental research journal. 2014;11(4):448-51.
21. Inaba M. Evaluation of primary stability of inclined orthodontic mini-implants. Journal of oral science. 2009;51(3):347-53.
22. Iijima M, Muguruma T, Kawaguchi M, Yasuda Y, Mizoguchi I. In vivo degradation of orthodontic miniscrew implants: surface analysis of as-received and retrieved specimens. Journal of materials science Materials in medicine. 2015;26(2):71.
23. Jolley TH CC. Peak torque values at fracture of orthodontic miniscrews. JCO. 2007;41(6):326-8.