

## Original Article

### A processing method for orthodontic mini-screws reuse

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#### ABSTRACT

**Background:** The possibility of mini-screws reuse would reduce treatment cost. The aim of this study is to introduce a new method (application of phosphoric acid 37% for 10 minutes followed by sodium hypochlorite 5.25% for 30 minutes) for cleansing of mini-screws and assessing the efficacy of this method. The effects of this processing on the insertion, removal, and fracture torques of mini-screws were evaluated.

**Materials and Methods:** This experimental study was done in two parts. In part I the amount of calcium ion on mini-screws surfaces as an index of tissue remnants was assessed. In part II of this study, the effects of previous use, processing method, and resterilization on the insertion, removal, and fracture torques of mini-screws were assessed. Each part of this study had 3 groups; non-processed used (NP), processed used (P), and as-received (C). Each group had 16 samples in part I and 20 samples. Non parametric statistical tests were used in part I and one way ANOVA in part II.

**Results:** The mean amount of calcium ion in groups non-processed (NP1), processed (P1), and control (C1) were 4.7, 0.43, and 0.02 ppm, respectively. The amount of calcium ion in group NP1 was significantly greater than in the other groups ( $P = 0.000$ ), but the difference between groups P1 and C1 was not significant ( $P = 0.087$ ). The mean insertion torque of group NP2 was lower than that of other groups ( $P < 0.05$ ) but P2 and C2 did not have significant differences ( $P = 0.988$ ). The mean of removal and fracture torque did not have significant differences among all groups.

**Conclusion:** Cleaning of used mini-screws with phosphoric acid 37% (10 minutes) and sodium hypochlorite 5.25% (30 minutes) reduces tissue remnants to the level of as-received mini-screws. So it can be suggested as a processing method of used mini-screws. Previous insertion of mini-screws into the bone and above-mentioned processing method and resterilization with autoclave had no adverse effects on insertion, removal, and fracture torque values as mechanical properties indices.

**Key Words:** Atomic absorption spectrophotometry, fracture torque, insertion torque, Mini-screw, removal torque, reuse

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## INTRODUCTION

Anchorage preparation is mandatory for a successful orthodontic treatment.<sup>[1-3]</sup> The application of mini-screws as temporary skeletal anchorage devices has improved the quality and domain of orthodontic

treatments.<sup>[4]</sup> The possibility of their reuse would reduce treatment cost, so more patients could benefit from these devices. The minimum prerequisites for mini-screw reuse are the possibility of re-sterilization, avoiding tissue remnants on mini-screw surface, and not significantly affecting the mechanical properties of mini-screws during previous application and reuse process. Sterilization with autoclave has no significant effects on mini-screw mechanical properties.<sup>[5]</sup>

According to titanium's much higher hardness and strength compared with the bone, if correctly applied, mini-screws will suffer no damage.

Mini-screw's wide flutes, polished surface, and

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titanium-based material permit using stronger mechanical and chemical cleaning methods to reduce the possibility of tissue remnants.<sup>[6]</sup>

The present study introduced a new method for cleansing of mini-screws and assessed its efficacy. The effect of this processing on the insertion, removal, and fracture torques of mini-screws were evaluated.

## MATERIALS AND METHODS

This experimental study was done in two parts. In part I, the amount of calcium ion on mini-screw's surface as an index of tissue remnants was assessed.

Thirty-two mini-screws (Jeil Medical Corporation, Seoul, Korea) with a 1.4 mm diameter and 8 mm length were divided in two test groups randomly. These mini-screws had been applied in the palate of patients as skeletal indices and had been maintained for 3 years in another study.

In the first group (NP1; none processed), the mini-screws were irrigated with 10 mL distilled water and dried with light air stream for 5 s.

In the second group (P1; processed), the mini-screws were irrigated and dried as done for group NP1 and then were processed by the following method. First, they were fully covered with phosphoric acid ( $H_3PO_4$ ) 37% gel (Ultradent Product Inc, South Jordan, Utah) and then were immersed in 1 mL of the same acid for ten minutes.

Then they were irrigated, dried, and immersed in 10 mL sodium hypochlorite 5.25% (NaOCl, Raga, Pakrood Co., Isfahan, Iran) for 30 minutes. Finally, they were irrigated and dried again.

The third group (C1; control) included 16 as-received (new) mini-screws with the similar features of test groups. These samples were irrigated and dried as done for group NP1.

The head of all mini-screws were covered with cold cure methacrylate resin (Orthocryl Rapid, Dentaurem, Germany). This restricted the assessment to the threaded area of the mini-screw that was in contact with the bone. To provide blindness of the study, samples were coded before sending for Atomic Absorption Spectrophotometry.

The amount of calcium ion on the surface of each mini-screw was evaluated with Atomic Absorption Spectrophotometry (Perkin Elmer 300 Inc, Massachusetts USA). The data were analyzed with

Kruskal–Wallis and Mann-Whitney test. A *P* value of  $< 0.001$  was predetermined as statistically significant.

In part II of this study, the effects of previous use, processing method and re-sterilization on insertion, removal, and fracture torques of mini-screws were assessed. Forty mini-screws (Jeil Medical Corporation, Seoul, Korea) with a 2 mm diameter and 10 mm length, were divided into 2 test groups randomly. These mini-screws had been used in the palatal bone of patients in a previous study and had been maintained there for 7 months.

In the first group (NP2; none-processed) mini-screws were just irrigated and dried similar to group NP1. Two samples were omitted because of previous head defects. In the second group (P2; processed) mini-screws were processed with phosphoric acid 37% and sodium hypochlorite in the same way of group P1.

The third group (C2; control) included 20 as-received (new) mini-screws with similar features of group NP2 and P2. The screws of all groups were sterilized with autoclave (Prestige Medical 2100 classic) before testing. For the sake of blindness of the study, processing and coding of samples were done by the first author (SN) and torque testing was done by the third author (MM).

Torque metering was done with Imada DiD-4 torque tester (Imada Inc., Northbrook, IL, USA). A custom-made screwdriver was fabricated to mount mini-screws on torque tester. Mini-screw driving was done with milling machine (Jamco, CM6241. 2010, China). This setup can be observed in Figure 1.

Driving speed was 45 rounds per minute. Insertion and removal speed was 0.9 mm per round (compatible



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

with mini-screws pitches). Insertion and removal torque testing was done by driving mini-screws perpendicularly into the 3 mm thick polycarbonate plates (Raychung, Taiwan).

Insertion depth for all samples was 9 mm. Maximum torques during the insertion and removal was recorded. Fracture torque testing was carried out by driving the same mini-screws perpendicularly into 10 mm thick polycarbonate plates. Maximum torque before screw fracture or deforming of the head was recorded. Data were analyzed with one-way analysis of variance. A *P* value of  $< 0.05$  was predetermined as statistically significant.

## RESULTS

The mean amount of calcium ion in group NP1, P1, and control were 4.7, 0.43, and 0.02 ppm, respectively. The amount of calcium ion in group NP1 was significantly greater than other groups ( $P = 0.000$ ) but the difference between group P1 and C1 was not significant ( $P = 0.087$ ). The results of torque testing have been presented in Table 1. The mean insertion torque of group NP2 was statistically lower than other groups ( $P < 0.05$ ) but P2 and C2 didn't have a significant difference ( $P = 0.988$ ). The mean of removal and fracture torques did not have significant differences among all groups. During fracture test in 15 samples fracture happened at threaded area and in 43 samples the head was deformed.

## DISCUSSION

The application of mini-screws has expanded the domain of orthodontic treatments and has improved the quality of treatment results in many complicated cases.<sup>[1-3]</sup> In some situations such as molar distal driving, repositioning of mini-screws may be necessary.<sup>[7]</sup> The possibility of mini-screw reuse reduces treatment costs, increases mini-screws application, and finally improves the quality of orthodontic treatments. Reuse of medical devices has been experienced before as in the cases of cardiac pacemakers, intra-aortic balloons, hemodialysis membranes, and coronary angioplastic catheters. In orthodontics, reuse of bands, brackets and wires has been suggested.<sup>[8-11]</sup>

If previous application of mini-screw caused no significant mechanical properties changes and no increases in fracture chance, repositioning and reuse of mini-screw in the same patient can be suggested.

Insertion, removal, and fracture torque can be used as proper indices to assess the mechanical properties changes of mini-screws. Surface and micro hardness changes also have been used for this purpose in some studies.<sup>[5,12-14]</sup>

An extra prerequisite for mini-screw reuse in other patients is avoiding all possible tissue remnants. To omit tissue remnants from mini-screws surfaces, application of phosphoric acid 37% (10 min) followed by sodium hypochlorite 5%–25% (30 min) was suggested in the present study. Low PH of this acid (2.25–3.05) can delete mineral part of the bone.<sup>[15]</sup> Pérez -Heredia reported that phosphoric acid 5% removes  $10.6 \pm 4.25$  mg calcium from root canal dentin in 10–15 min.<sup>[16]</sup> This acid does not harm the titanium surface in room temperature.<sup>[17]</sup> Its other advantages are easily available and are at low risk during manipulation.

Sodium hypochlorite 5.25% also can dissolve organic parts. Sonja *et al.* reported that NaOCl dissolved 24.5 mg organic tissues in 5 minutes.<sup>[18]</sup> NaOCl does not harm titanium surface in room temperature,<sup>[19]</sup> is cheap and available. In part I of this study, the amount of calcium as an index of tissue remnants was assessed. The mini-screws used for this part had been applied to the palatal bone for at least 3 years,<sup>[20]</sup> So the tissues have enough and even more than routine time to attach to the surface of mini-screws.

The amount of calcium in group NP1 was more than group P1 and C1 but group P1 and C1 did not have significant difference. This means that processing of used mini-screws with phosphoric acid and NaOCl can clean the mini-screws surfaces up to the level of as-received mini-screw surface.

The high temperature during re-sterilization of mini-screws causes denaturation of probable protein remnants and decreases the risk of their allergenicity even if they remain.<sup>[21]</sup> More aggressive mechanical cleaning of mini-screws, such as brushing, scrubbing, and ultrasonic cleaning before the suggested processing method can reduce the possibility of

**Table 1: Torque testing data**

Groups	Mean (SE)		
	Insertion torque	Removal torque	Fracture torque
Non-processed (NP2)	21.91 (0.54)*	18.49 (0.67)	56.27 (0.90)
Processed (P2)	25.07 (0.41)	20.42 (0.42)	58.57 (0.61)
Control (C2)	25.16 (0.24)	19.24 (0.91)	57.78 (0.83)

\*Statistically significant. The torque values are presented in Ncm

tissue remnants.<sup>[22]</sup> In this study, we did not use them because we were to assess the efficacy of phosphoric acid and NaOCl.

In part II of this study, the effect of previous use and suggested processing method on insertion, removal, and fracture torques of mini-screws were evaluated.

Driving mini-screws with milling machine increased the accuracy of testing and had some advantages:

Providing the same moving and rotating speed for all samples.

Providing the rotating speed near the clinician's hand so that the effect of rotating speed on torque was controlled. Providing the linear movement perpendicular to the polycarbonate plates so that the effect of angle of mini-screws insertion on torque was controlled.

Providing moving speed compatible with mini-screw pitch (if they are not compatible, inward or outward vertical forces between interfaces of mini-screw threads and plates increase friction and alter torque values).

Using polycarbonate plates instead of natural bone omitted anatomic variations of bone thickness and density.

The mean torque value in group NP2 was not greater than group C2. This demonstrates that previous use or insertion into the bone does not have any adverse effects on the mechanical properties of mini-screws.

Insertion torque in group NP2 is less than that in groups P2 and C2. Although we did not find any logical explanation for this, it can be suggested that the presence of tissue remnants in surface porosities of mini-screws may have decreased friction and torque values relative to the processed and as-received mini-screws.

No significant differences among insertion, removal, and fracture torque values of group P2 and C2 demonstrate that previous insertion into the bone, suggested processing method, and re-sterilization have no adverse effects on the mechanical properties of mini-screws. This result can be explained by the large difference between hardness of mini-screw and bone and high chemical resistance of titanium oxide of mini-screw surface.

Large distance between insertion and fracture torques in all groups can be considered a good safety zone for reuse of mini-screws.

## CONCLUSIONS

- Cleaning of used mini-screws with phosphoric acid 37% (10 minutes) and sodium hypochlorite 5.25% (30 minutes) reduces tissue remnants to the level of as-received (new) mini-screws. So it can be suggested as a processing method of used mini-screws.
- Previous insertion of mini-screws into the bone and above-mentioned processing method and re-sterilization with autoclave had no adverse effect on insertion, removal, and fracture torque values as mechanical properties indices.
- Mini-screws reuse can be suggested if they are properly used, cleaned, and re-sterilized.

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