Original Article

Can Initial Torque Value Predict the Success of Orthodontic Mini-Screws?

Tolga Topcuoglu, DDS, PhD;[1,*] Ali Altug Bicakci, DDS, PhD;[2] Oral Sokucu, DDS, PhD;[3] N. Eren Isman, DDS, PhD[4]

ABSTRACT

Objective: To investigate the correlation between initial torque and removal torque of orthodontic mini-screws.

Materials and Method: Sixty-four orthodontic mini-screws (measuring 1.5 × 4.4 mm, 1.6 × 4.7 mm, 1.7 × 5.5 mm, and 1.8 × 5.6 mm) were used. All mini-screws were inserted into the fibulas of 8 male rabbits. The initial torque values were immediately recorded using a digital torque gauge. For 2 months, 115 g force was applied to mini-screws inserted into the right fibula of the rabbits. The same procedure was followed for inserting the mini-screws into the left fibula of the rabbits but without applying any force. After 2 months, the removal torque values were recorded for all mini-screws. All statistical analyses were performed using SPSS version 14.0 for Windows. Spearman's correlation coefficient was used to analyze the relationships between initial and removal torque values.

Results: Intragroup comparison of all brands of mini-screws showed similar features. There were no statistically significant differences between the initial torque values of all mini-screws ($p > 0.05$). The Spearman correlation coefficient showed that correlations between the initial and removal torque values were insignificant ($p>0.05$).

Conclusion: The results of this study suggest that the initial torque value is not a reliable method for predicting the success of a mini-screw. (*Turkish J Orthod* 2013;26:143–148)

KEY WORDS: Correlation, Initial torque, Removal torque

INTRODUCTION

In recent years, mini-screws have enabled practitioners to efficiently achieve treatment outcomes that were previously considered extremely difficult, such as control of tooth movement in adult patients who have insufficient periodontal bone support and have lost some natural permanent teeth.[1] For patients who refuse to use extraoral appliances, such as a headgear, mini-screws are an accepted and effective alternative for distalizing molars.[2] Furthermore, many studies have reported that mini-screws can be used as a stable skeletal anchorage device for various purposes, such as canine distalization, en masse anterior retraction, molar uprighting, molar protraction, and molar intrusion.[3]

Mini-screws are small enough to be placed at various locations in the alveolar bone, and they can be inserted with a less traumatic procedure than that required for other devices; they can also be loaded immediately after placement. Moreover, they are easy to remove, they do not require anesthesia or suturing, and treatment costs are relatively low.[1,4] Although mini-screws have many advantages over conventional skeletal anchorage systems, failures of mini-screws still occur. The clinical success rate of mini-screws is 83–91%.[2,5,6]

Insufficient primary stability is one reason for screw loosening.[2] The primary stability of mini-screws depends mainly on secure mechanical interlocking between the bone and screw interface because mini-screws are loaded immediately without waiting for osseointegration. Therefore, obtain-

[1]Private Orthodontist, Mersin, Turkey.
[2]Professor, Department of Orthodontics, School of Dentistry, University of Gaziosmanpasa, Tokat, Turkey.
[3]Associate Professor, Department of Orthodontics, School of Dentistry, Gaziantep University, Mersin, 33010, Turkey.
[4]Assistant Professor, Department of Orthodontics, School of Dentistry, Gaziantep University, Gaziantep, Turkey

***Corresponding author:** Tolga Topcuoglu, Bahce street 4601 Avenue Akdeniz, Mersin 33010, Turkey. Tel: +90-530-543-08-65 E-mail: dentisttolga@hotmail.com

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Table 1. Prescription of screws tested

Groups	No.	Subgroup	n	Measurements (mm)		Load (g)
				Diameter	Length	
Loaded	1	Neoanchor	8	1.8	4.7	115
	2	Dewimed	8	1.6	5.6	115
	3	Absoanchor	8	1.7	5.5	115
	4	Dual top	8	1.5	4.4	115
Unloaded	5	Neoanchor	8	1.8	4.7	None
	6	Dewimed	8	1.6	5.6	None
	7	Absoanchor	8	1.7	5.5	None
	8	Dual top	8	1.5	4.4	None

ing primary stability during insertion is a crucial factor associated with the success rate of mini-screws.[5,7,8]

There are several methods for evaluating the primary stability of mini-screws, including a Periotest, resonance frequency analysis,[9] insertional torque tests,[7,10] axial pullout tests,[11–18] and removal torque tests.[19] However, the most popular methods for measuring the biomechanical performance of mini-screws placed into bone are removal and initial torque tests.[2,14,20–23] Previous studies have shown that the insertional torque of mini-screws, which reflects frictional resistance between the threads of the mini-screws and the bone[24] during insertion, is an important indicator determining the relationship between initial stability and the success rate of mini-screws.[7,10] In contrast, the removal torque of a mini-screw indicates the response of the supporting bone to the load applied[25,26] during removal. Carlsson *et al*. [27] reported that the most useful indirect biomechanical method for evaluating the bone and screw interface is measurement of removal torque values.

If mini-screws have inadequate primary stability in the bone, the screws can loosen, which could lead to unsuccessful treatment results. Therefore, the ability to predict screw loosening immediately after insertion of a mini-screw is very important for preventing deleterious effects during orthodontic treatment. In the literature, most studies have measured removal and initial torque values to evaluate the primary stability of mini-screws[7,10,19] or factors affecting their primary stability, such as implant design, bone quality, and insertion modalities.[23] No studies have assessed the correlation between initial and removal torque values of mini-screws. Therefore, the aims of the present study were to determine (1) if insertional torque is correlated with removal torque and (2) if insertional torque can be used as an indicator of screw loosening.

MATERIALS AND METHOD

The protocol of this study was approved by the Experimental Animal Committee of Cumhuriyet University in Sivas, Turkey.

Sixty-four commercially available cylindrical, self-drilling, Ti6Al4V alloy orthodontic mini-screws (Dual-top, Jeil Medical Corporation, Seul-Korea; Absoanchor, Dentos, Daegu-Korea; Neoanchor, KJ, Meditech, Seul-Korea; Dewimed, Tuttlingen-Germany) with different diameters (1.5, 1.6, 1.7, and 1.8 mm) and lengths (4.4, 4.7, 5.5, and 5.6 mm) were used. Auto-Desk AutoCAD 2007 (Autodesk Inc., US) was used to measure the lengths and outer diameters of the mini-screws. Groups were formed according to loading procedure and size (Table 1).

Eight 6-month-old male New Zealand white rabbits weighing 3.0–3.5 kg were used in this study. All surgeries were performed under sterile conditions in a veterinary operating room. During surgery, the rabbits were anesthetized with an intramuscular injection of ketamine hydrochloride (100 mg/mg) and xylazine (5 mg/mg). Hair on the medial surface of the right and left fibula was clipped, and the skin was cleansed with iodinate surgical soap. A 50-mm incision was made parallel to the longitudinal axis of the fibula, and the periosteum was stripped, denuding the bone (Fig. 1).

The mini-screws were threaded into the first cortex of the fibula with their longitudinal axes parallel to each other and perpendicular to the external cortical fibula (without reaching the second cortex) (Fig. 2). The right fibulas of the rabbits were used for loading. One mini-screw from each brand (each with a different length and diameter) was placed into each right fibula and 115 g of force was immediately applied with a nickel-titanium closed-coil spring (TAD, C2 size, medium, 15 mm, GH Wire Company, Hanover, Germany) (Fig. 3). The left fibula of the

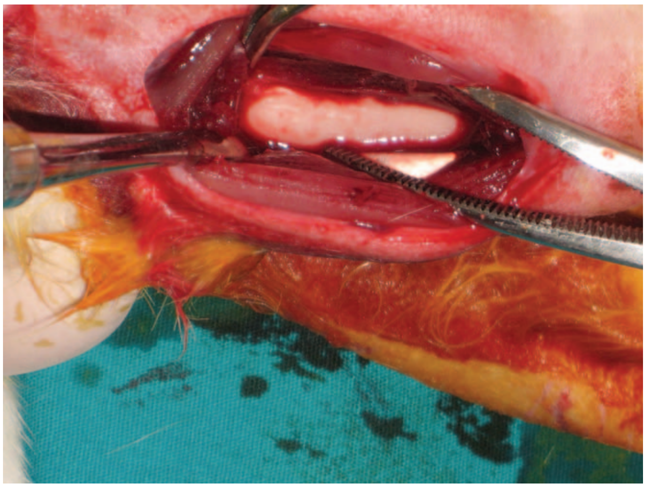

Figure 1. Image of the fibula after dissection.

same rabbits was used to assess unloaded effects. One mini-screw from each brand (each with a different length and diameter) was placed into the left fibula, but no force was applied.

In total, there were 4 subgroups of loaded mini-screws and 4 subgroups of unloaded mini-screws. Each subgroup consisted of 8 mini-screws. The mini-screws were manually inserted with a screw-driver. Measurements of the initial torque values were immediately recorded with a digital portable torque gauge (HTG-2N, IMADA, Toyohashi, Japan) (Fig. 4) connected to the screwdriver after two-thirds of the thread length of the mini-screw was inserted.

The tissues were closed with absorbable sutures. All animals were administered carprofen (4 mg/kg) for 3 days after surgery. After 2 months, the animals were killed by an intravenous overdose of sodium pentothal. After each fibula was dissected, removal

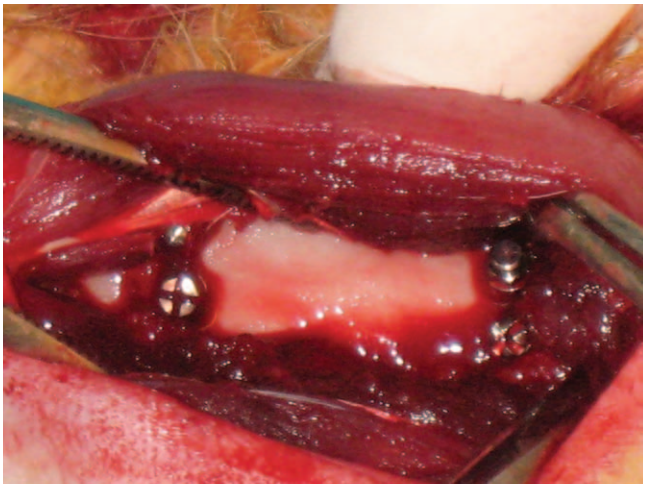

Figure 2. Four mini-screws placed in the fibula.

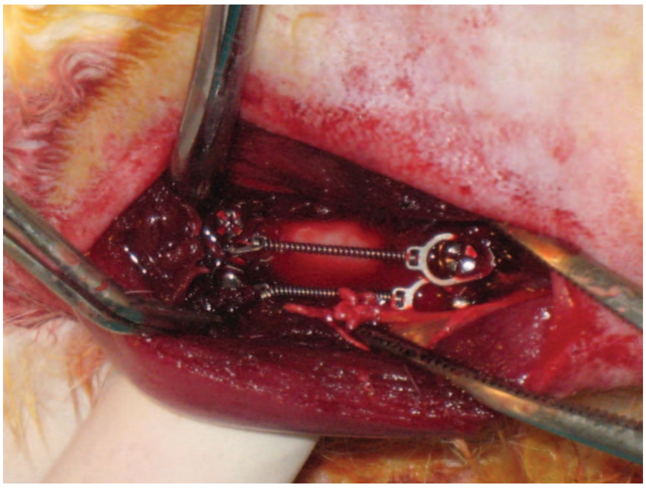

Figure 3. four mini-screws after 115 g force was applied with a nickel titanium coil spring.

torque values of the mini-screws were measured by the same operator using a digital portable torque gauge on bone blocks containing 4 mini-screws and at least 2 mm of the adjacent bone.

All statistical analyses were performed using SPSS version 14.0 for Windows (SPSS Inc, Chicago, IL, USA). Spearman's correlation coefficient was used to analyze the relationships between initial and removal torque values. A paired *t* test was used to calculate intragroup differences.

RESULTS

All mini-screws remained stable, and no signs of mobility were detected over 2 months. None of the mini-screws showed any deformation at the end of the study, at which point each animal had 8 mini-

Figure 4. Portable digital torque gauge (HTG-2N, IMADA, Toyohashi, Japan) and screwdrivers.

Table 2. Initial and removal torque values of mini-screws for all groups and correlations between them

Group	No	Subgroup (mm)	Initial Torque Values (N/cm)	Removal Torque Values (N/cm)	*P* Values*
Loaded	1	Neoanchor (1.8 × 4.7)	11.64 (7.37–18.72)	8.50 (2.41–10.05)	1
	2	Dewimed (1.6 × 5.6)	7.62 (6.32–14.18)	6.92 (2.76–8.48)	.385
	3	Absoanchor (1.7 × 5.5)	9.66 (6.98–13.78)	6.27 (3.99–9.87)	.651
	4	Dual Top (1.5 × 4.4)	9.42 (5.72–15.18)	5.78 (4.17–7.95)	.693
Unloaded	5	Neoanchor (1.8 × 4.7)	11.11 (8.50–15.22)	8.10 (4.94–9.35)	.57
	6	Dewimed (1.6 × 5.6)	8.36 (5.83–13.12)	4.63 (3.53–8.59)	.16
	7	Absoanchor (1.7 × 5.5)	8.40 (6.36–13.42)	4.59 (2.26–5.57)	.071
	8	Dual Top (1.5 × 4.4)	9.70 (5.47–21.27)	4.10 (2.59–5.53)	.456

* Results of the Spearman correlation coefficient test.

screws (4 loaded and 4 unloaded), resulting in a total of 64 mini-screws.

Although group 1 had a higher mean insertion torque value (Table 2), no statistically significant differences between the initial torque values of all loaded and unloaded mini-screws were found ($p>.05$).

Spearman rank-order correlation coefficients between initial and removal torque values for all unloaded and loaded mini-screws ranged from 0.09 to 0.444 and from 0.026 to 0.127, respectively ($p>.05$). Correlations between the initial and removal torque values were insignificant ($p>.05$) (Table 2).

DISCUSSION

Mini-screws, introduced by Kanomi[28] in 1997, have several advantages over other skeletal anchorage systems described in the literature, including dental implants,[29] onplants,[30] and miniplates.[31] If dental implants and onplants are used as an anchorage unit, a waiting period is required to ensure osseointegration before any force is applied.[29,30] In addition, for all methods except mini-screw application, an invasive surgical procedure is required for placement and removal. Another benefit of mini-screws is that their small size allows them to be placed at various sites on the alveolar bone, whereas only limited areas, such as the edentulous or retromolar region and the palatal bone, can be used to insert other skeletal anchorage systems.

Despite all these benefits, the clinical success rate of mini-screws is unsatisfactory compared with that of other skeletal anchorage systems. In recent studies, the clinical failure rate of palatal implants and mini-plates was found to be 10.5% and 7.3%, respectively.[32] However, mini-screws have a success rate of 83–91%.[2,5,6] The main reason for the high failure rate is inadequate primary stability of the mini-screw.[2] If primary stability is sufficient, immediate orthodontic force can be applied, improving the mini-screw success rate. In this context, the ability to predict future screw loosening immediately after placement has become an important issue for successful orthodontic treatment. Therefore, the purpose of this study was to find an objective means of predicting screw loosening using initial and removal torque values.

The mean insertion torque value obtained in this study was 9.48 Ncm for all mini-screw brands. There were no significant differences in initial torque values between all loaded and unloaded mini-screws ($p>.05$). Motoyoshi *et al.*[7] evaluated the initial stability of mini-implants with a diameter of 1.6 mm by measuring the initial torque values. They recommended that initial torque values of 5–10 Ncm be used for adequate primary stability for an orthodontic mini-implant, and noted that poor initial stability after surgical insertion and subsequent lower secondary stability and osseointegration were responsible for the failure of mini-implants.[33] Wilmes *et al.*[23] suggested that high insertion torque values could be used as an indicator of high primary stability of orthodontic mini-screws. However, excessive insertion torque may be detrimental for the surrounding bone and can increase the failure rate.[22] The results of the current study are in agreement with those of Motoyoshi *et al.*,[7] who recommended initial torque values of 5–10 Ncm. The probable explanation for the 100% success rate of the mini-screws in the present study may be due to the attainment of initial torque values in the range recommended by Motoyoshi *et al.*[7]

Several factors affect the stability of orthodontic mini-screws, including screw diameter, length, and design; bone density; soft tissue condition; insertion method; and loading protocol.[34] To eliminate these variables, we compared loaded mini-screws of the same length and diameter as unloaded mini-screws. We placed 4 mini-screws on the right fibula and 4 mini-screws on the left fibula of 8 rabbits to obtain homologous data.

In the present study, no correlation was found between the initial and removal torque values of the mini-screws. There were statistically insignificant correlations between the initial and removal torque values according to Spearman correlation coefficients. As no previous studies have evaluated correlations between initial and removal torque values of orthodontic mini-screws, we used data obtained from orthopedic surgery studies of pedicle screws, which are used for fixing vertebrae. These studies investigated the correlation between insertional and removal torque values of pedicle screws.[12,35–38] Some studies showed a strong correlation between the insertional torque of pedicle screws and stability.[12,35,36] They also asserted that the insertional torque of pedicle screws can be useful for predicting screw stability.[37] However, Ozawa *et al*.[38] and Okuyama *et al*.[39] reported that no significant correlation was found between the insertional torque of pedicle screws and stability. They concluded that insertional torque was not an objective method for predicting screw failure.[38,39] This is consistent with the findings of the present study, suggesting that initial torque values cannot be a reliable means of predicting screw failure.

CONCLUSION

The results of this study demonstrate that initial torque values reflect only the initial stability of the mini-screw at the time of placement. They are not an indicator of removal torque values or of the stability of mini-screws. Therefore, an adequate initial torque value does not guarantee the success of the mini-screw.

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