

Evaluation of insertion torque of different orthodontic miniscrews: An in vitro study

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Abstract

Background and objective: The purpose of this study was to evaluate the torque insertion for drill and non drill techniques of two commercially available miniscrews.

Methods: Eighty mini screws (forty Dentos miniscrews/Korea and forty 3M miniscrews/ USA), having the same length and diameter, were divided into two groups for each type. Two techniques, non-drill and drill, were used. In drill techniques, manufacturer recommended drill was used. Two bovine tibias were obtained. The first technique used pre drill hole, which was made in the bone using the recommended bur (1.0 diameter). The mini-screw was placed at 9 mm manually, then the remaining 1 mm was inserted through digital torque meter. The same procedure was repeated but without a pilot hole.

Results: 3M miniscerws gave high torque insertion in two techniques.

Conclusion: The shape, thread design and tip geometry of miniscerw play an important role in the torque insertion.

Keywords: Miniscerw, Dentos min screws, 3M miniscrews , Torque insertion.

Introduction

Conservation of anchorage in totality has been a perennial problem to the traditional orthodontist. Conventional means of supporting anchorage have been used by either intra oral sites or relying on extra oral means. Both of these have their limitations. The extra oral forces very difficult device and some time the patient is not able to wear it. On the other hand, strict reliance on intra oral areas.¹ Among the anchorage devices, micro screw implants have increasingly being used for orthodontic anchorage because of their absolute anchorage, easy placement and removal, and low cost. The small size of the miniscrew implants allows them to be placed into bone between the teeth, insertion is a less traumatic procedure, and they can be loaded soon after placement as there is no osseointegration around the screws but only fibrous integration. However, a notable complication is loosening of the screws even though they consist of a biocompatible titanium alloy.² Drill screws are most commonly used for

this purpose. A prerequisite for the insertion of screws is the preparation of a pilot hole with a minimum diameter equal to the screws core.³ Thermal necrosis of bone has also been observed. Another problem frequently encounters during the insertion of a screw after drilling is stripping of the bone threads when working in thin cortical bone.³⁻⁴ Drill-free screws or self-drilling screws are a recent development. They have a tip like a cork screw and specially formed cutting flute that enables them to be inserted without drilling. This results in less insertion time and more patient compliance. Drill-free screws can provide intensive screw bone contact and inserting them produces little bone debris and less thermal damage.²

Methods

Mini-Implant Sample

Eighty commercial drilling and non drilling orthodontic mini-screws from two international manufacturers (Dentos/Korea and 3M/USA) were investigated (Figure 1). An attempt was made to compare

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mini-implants of similar diameters and length but due to differing manufacturer designs, diameters 1.8mm and length 10 mm. To create the groups, 40 mini-implants from each manufacturer were used. The sample was divided into four groups which were named as: Twenty 3M drilling (3MD) miniscrew with 1.8mm in diameter and 10mm length from (3M, USA) and twenty Dentos drilling (DD) miniscrew with 1.8mm in diameter and 10mm in length from (Dentos, Korea). Twenty dentos non drilling (DND) with 1.8mm in diameter and 10mm length from (Dentos, Korea) and twenty 3M non drilling (3MND) miniscrew with

1.8mm in diameter and 10 mm in length from (3M), as summarized in Table 1.

Bone specimen preparation

Two bovine tibias were obtained from the same animal (age: 18 months). It was cross-sectionally cut in relation to their long axis by electrical saw using normal saline as a coolant liquid to prevent any necrosis or heat generation created during cutting. After that, it was stored in an isotonic solution in a water bath (38-39.3C°) to prevent dehydration of the bone. The length of two tibia bones was about 20 cm. Each bone was cut into 10 pieces (2 cm for each) as shown in Figure 2.

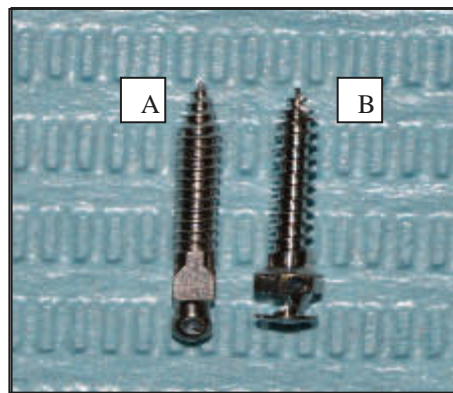


Figure 1: Two types of mini screws used (A: 3M/USA and B: Dentos /Korea).

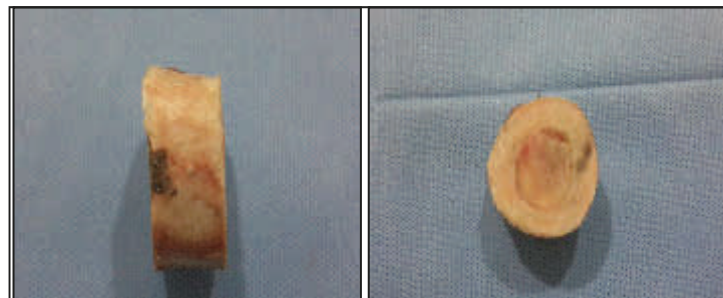


Figure 2 : Bone specimen preparation (2 cm in width).

Table 1: Description of mini-implants used in this study with division groups.

Dentos (D)/Ti6Al4Va*				3M/ Ti6A14V*			
20 drilling (DD)		20nondrilling (NDD)		20 drilling (3MD)		20 nondrilling (3MND)	
10mm length	1.8 Diameter	10mm length	1.8 diameter	10mm length	1.8 diameter	10mm length	1.8 diameter

*According to the manufacturer information.

Cortical bone measurement

The cortical bone thickness was measured for each of the bones using digital calipers (SanPaulo, Brazil) to decide on areas of mini screws insertion as standardization criteria. The cortical bone thickness less than 10 mm, the bone piece was discarded. The cortical bone range from 10 to 12 mm and this thickness is enough for this study and allowed for adequate placement of the mini screw into cortical bone.

Modification:

Two modifications were done in this study as follows :

- 1- Modification in custom made device to receive the hand piece and to be sure that the insertion of mini screws as right angle with bone (Figure 3).
- 2- Modification in screw driver (Manufacturer supplied) with mini screw to

be used with hand pieces (Figure 4).

Insertion of Mini screw:

The cortical bone was measured and identification was put in the area of mini screws insertion (standardization criteria). All mini screws were used in this study. A red indicator stopper (1mm thickness) was used at the last 1mm distance of mini screws to stopped used of hand piece for insertion. The bone pieces were attached using a custom-made device designed to secure the sample and stabilize the sample during experimentally test. In addition, using leveling measurement to ensure that the insertion area was straight and mini screws insertion angle with it about 90 degrees. The custom made device modified his head to allow him to receive the handpiece. The surgical motor (W&H for dental implant) 900 rpm with 50Ncm was used for the mini screw insertion experiment.

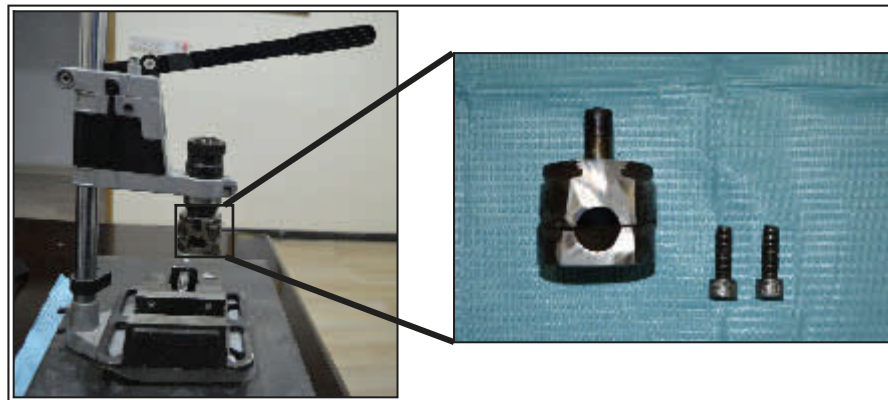


Figure 3: Custom made device after modification of the head to received hand piece and bone



Figure 4: Modification head of screw driver to be used with handpiece.

The insertion procedure was made in two ways (Figure 5). In the first way, before the insertion of mini screws, the pre drill hole was made in the bone with the use of the recommended bur (1.0 diameter) according to the manufacturer recommendation . After that, the insertion of mini screws was preformed with torque low speed hand piece and mini-screws insertion into bone alone. It was placed on the handpiece and drilling was performed self-irrigation with water. After the miniscrew had placed at length 9mm, then the digital torque meter (DID 4 digital torque meter/Korea) was used to insert the remaining 1mm of miniscerw manually. After that, reading of maximum torque insertion was recorded. Then, anti-clockwise was used with same digital torque meter manually to remove the mini screws. The reading of maximum torque removal was also recorded. For non-drilling technique, the same procedure was repeated but without pilot hole, and direct insertion of mini screws was done.

The screw was directly inserted 9mm by implant hand piece (red indicator stopper), then removed the stopper and stat manually insertion the remaining 1mm was inserted in clockwise direction. After that, reading of maximum torque insertion was recorded using digital torque meter and remove the screw and also the removal torque was recorded with anti-clockwise direction. The differences between the torque values for each mini-scerws group and for two companies were analyzed using a two-way analysis of variance (ANOVA) using the statistical package for the social sciences (version 13.0) program. A ranking order was established using Tukey's test.

Results

The descriptive statistics that includes mean, standard deviation, standard error, minimum and maximum value of torque insertion and removal of 3M and Dentos mini screws for both drill and non drill techniques are listed in Table 3.

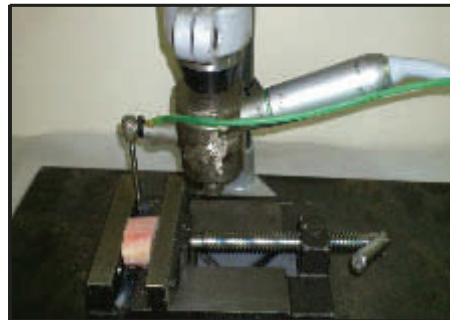


Figure 5: Experimental apparatus used for testing.

Table 3: Descriptive analysis and Duncan of multiple range test of tested Mini screws.

Types and Techniques	Mean*/**	Std. Deviation	N	P value
3MNDTI	44.375 ^a	0. 8789	20	0.05
DNDTI	38.285 ^b	0.6523	20	0.05
3MDTI	37.465 ^c	0.7407	20	0.05
DDTI	32.220 ^d	0.5238	20	0.05

*Mean unit (N/mm)
 3MNDTI: 3M non drill torque insertion
 3MDTI: 3M drill torque insertion

**Different letters mean significantly different at $P \leq 0.05$.
 DNDTI: Dentos non drill torque insertion
 DDTI: Dentos drill torque insertion

Discussion

The experimental method applied in this study used a bovine bone because it is difficult to test the torque in vivo, and it was problematic when it came to extracting the sample from human cadavers.⁶ In addition, this challenge occurs because of the variations in thickness and density of the cortical bone from the site of extraction. Hence, the amount of torque cannot be compared.⁷ The cortical bone thickness used in this study has covered all mini screws length as one of standardization procedures and to prevent this factor to affect the torque insertion and removal for all types of mini screws used. Torque is closely related to the factors that determine the stability of miniscrews, such as bone density⁸⁻⁹ and cortical bone thickness.¹⁰ In addition, the torque value is frequently used as an indirect method to assess the stability of an implant or miniscrew.¹¹⁻¹² In this research, non drilling groups showed significant increase of torque insertion in 3M mini screws in comparison with Dentos type. This result is due to the geometric shape of 3M type (cylindrical shape) which require a longer period of time to penetrate the bone than the tapered type screw (Dentos). This result disagrees with Jung-Y. Ch et al 2008,¹³ who found that the tapered type gave a high torque insertion than cylindrical. This is particularly true when penetrating the cortical bone. For this reason, selecting a bone contained cortical bone was enough for all length of mini screws, in addition, the length of screws and the dimension were the same in both types. The Dentos mini screws gave a low rate of torque insertion compared with 3M. This is due to the morphologic characteristics of the screw that are related to the driver generating a change in torque on the same side. Many causes make the Dentos mini screw giving low torque insertion and it includes knife edge of threads, best pitch and valley of thread and self drilling shape of tip of mini screws (according to manufacturer design). These features reduce the stresses on the bone

During insertion. However, further research is needed to prove this. Although these morphological features of mini screws help the dentist to insert the mini screw too easily and decrease the bone necrosis during insertion because the less amount of pressure will be applied during procedure. Research has showed that the mini screw giving low torque value during insertion has less amount of primary stability when compared with high torque one when the immediate load will be applied.¹⁴ From another hand, another research showed that after a period of time (secondary stability) the torque removal was the same with different shape of mini screw because the osseointegration occurred and the shape of mini screw became not important one as in primary stability.¹⁵⁻¹⁸ In drilling group, the mean of torque insertion was significantly different between groups and between the two types of mini screws but the difference between groups was very small. Although many biomechanical studies have reported that insertion torque affects screw stability, it is difficult to prove that the insertion torque is proportional to the stability of mini-screws.¹⁴ Lawes et al. suggested that a high insertion torque of a tapered bone screw decreases loosening at the bone interface.^{14,19} This is supported by our results, which showed that 3M mini-screws provide better primary stability regardless of the bone type. However, when torque values are excessive (more than the bone can withstand), bone cracks or bone necrosis may occur.^{14,20} In this study, the local maximum torque appeared at about 60s in the mini-screw insertion process, indicating that the cortical bone shell was penetrated, causing the torque to gradually increase. The extremely high torque insertion value for 3M mini-screws might reach the screw/implant inserted torque border and indicated that the physiologic limit was exceeded might induce bone resorption. The mini-screw mobilization mechanisms on the surrounding bone tissue might be related to the insertion and

removal torques, and energy required for insertion and removal.² However, the high insertion torque of the 3M design could lead to stress in the bone tissue. Some study on finite element analysis showed when some types of mini screws were examined micromotion at the screw/bone interface and bone strain development. Since the resistance of the micro-motion at the mini-screw/bone interface depends on the initial mechanical fixation between the screw and bone, it is likely that high¹⁴ and micro-motion might be caused by early loading.^{14,21} The small displacements also suggest that a mini-screw can be immediately loaded, thereby decreasing chair time for clinicians and treatment time for patients. A critical issue related to skeletal anchorage realized with orthodontic mini-screws is the mechanical behavior of mini-screws inserted into the bone. Strain is accepted as the mechanical stimuli for bone remodeling around an implant.²² Frost (1994)²³ suggested that bone remodeling is initiated at a critical strain level (the mechano-static theory) and that micro damage arises in normal lamellar bone when the strain exceeds 4000 micro strain.²³ An optimal mini-screw design for avoiding failure and minimizing the strain value in the surrounding bone to reduce screw loosening is needed.²² More living tissue studies are required for a better understanding of secondary stability, which includes osteo-integration and physiological reactions of the bone to external forces. Otherwise, suitable torque values should be continuously for evaluated to minimize bone damage in the human body and act as sufficient anchorage for orthodontic forces within a range that the bone sufficient support.

Conclusion

3M mini screws showed high insertion torque than Dentos one. The geometry of mini screws plays an important role in torque insertion. The thread design has a direct effect on the insertion of mini screws. The shape and design of the tip of mini

screws may increase or decrease the insertion torque.

Conflicts of interest

The authors report no conflicts of interest.

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