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COMPARISON OF FRACTURE TORQUE AND LEVEL OF FRACTURE OF TWO ORTHODONTIC MINI-SCREW (AN IN VITRO STUDY)

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Abstract:
Certain malocclusions may benefit from the use of mini-screw anchoring control during orthodontic treatment. In contrast, the failure of little screws will have a substantial influence on treatment efficiency and effectiveness. Twenty orthodontic mini-implants of (Tomas. Dentaurm. Germany; GNI, Korean) were inspected in an in-vitro study. A digital torque gauge was positioned perpendicular to the bone surface and placed into the 10 mm thick bovine femoral cortical bone in the same manner as mini-implants. The insertion done through the hand driver simulations of insertion intraorally. The Tomas offered a high fracture torque value compared with GNI. GNI gave a high percentage of fracture at an apical level while Tomas gave at the middle of it.
Keywords: *Mini Screws; Anchorage; GNI Mini Screws; Tomas Mini Screws.*

1. Introduction

For the treatment of various kinds of malocclusions, the tenable anchorage is the main necessity. For the previous few years, anchorage necessities were provided by intraoral (teeth) as well as intramaxillary appliances [1]. Nevertheless, these treatment modes might not be able to attain acceptable anchorage control. To overcome these restrictions, temporary anchorage devices were presented in the orthodontics [2] .

Mini screw implants, frequently stated to as temporary anchorage devices (TADs), are small stainless steel or titanium alloy surgical bone screws placed into palatal or buccal alveolar bone. The justification for their clinical use is the formation of a basis of rigid bone reinforced intra oral anchorage [3] . Cope describes a TAD as follows: 'A temporary anchorage device is a device that is momentarily secure to bone for improving orthodontic anchorage by supporting the teeth of the reactive component or by removing the need for the reactive component overall, and which is subsequently removed after use' [4].

The correction of moderate to severe cases of malocclusion with fixed orthodontic appliances frequently takes over 1.5 years [5]. Due to the physical and social discomfort and the extended use of fixed appliances, patients tend to avoid such treatment [6]. The increased request for rapid orthodontic correction has led to the starter of numerous approaches, which also decrease potential dangers of dental and periodontal problems such as external apical root resorption, high levels of dental caries, and subsequent gingivitis and periodontitis [7; 8].

Primary stability is essential for the mini screws, for the reason that direct loading on them, and varies rendering to the numerous patient, the design of the mini screws, and clinical method factors, also it is measured as the clinical condition of mini implant motionlessness and capability to resist loads in dissimilar directions [9].

Success of mini screws is linked to their slightly invasive nature, comfort of insertion and removal, low price, direct loading, adaptability, and slight discomfort to the patient [10]. General, their success frequency is more than 80%. Though, failure in the placement of these devices has been stated [11]. Study into reasons that affect with the stability of these devices and their resistance to fracture at insertion and removal has therefore been encouraged [12].

Depending on the level of mini screw fracture, removal can be problematic. Depending on the insertion spot, adjacent structures may be scratched at the time of removal. So, the extreme torque load capacity of mini screws at the time of insertion appears to be critical. Though, this aspect has not been scientifically examined and, to date, has been addressed frequently in the orthopaedic literature [13]. Some mini screws producers offer data on the fracture resistance of their products but deprived of presentation of the exact test protocols [11].

The aim of the present study was therefore to compare the torque fracture for two orthodontic mini screws available in the market and the level of fracture for two tested mini screws. And to investigate the effect of shape of two mini screws on the torque fracture and level of fracture.

The limitation of this research was the difficulty of using a human bone because still we have a difference in thickness of cortical bone. Fracture of t he mini screw can be happen at any level even at the tip of it.

2. Materials and Methods

2.1 Mini-Implant Sample

The commercial orthodontic mini-screws of two multinational manufacturers were examined. Table 1 provide an overview of the groups' characteristics. Different manufacturers' designs resulted in varying diameter and length measurements for the same batch of mini-implants that were tested (8 mm) (Figure 1). Sizes were selected to represent the most commonly used mini-implant from each company.

Table 1: Tomas and GNI used specifications

Type	Diameter	Length	Manufacturing	Type of alloy
Tomas	1.5 mm	8 mm	Germany	Ti6A14V
GNI	1.5 mm	8 mm	Korean	Ti6A14V

A. GNI B. Tomas

Figure 1: Two types of miniscrew (GNI and Tomas, Diameter 1.5mm, Length 8mm).

2.2 (Bone) Specimen Preparation

Two tibias were found in the carcass of the same calf (Age:18 months). An electrical saw cut it horizontal direction in respect to their long axis using a wood electric cutter, using a normal saline coolant liquid to prevent necrosis or heat development. After that, the bone is kept hydrated in a water bath using an isotonic solution (38-39.3Co). The two tibias bone have 20 cm. Each tibia was divided into 10 parts (2 cm for each). (Figure 2).

Figure 2: Bovine Tibia Acquired from Specimen.

2.3 Cortical Bone Measurement

Standardization criteria for the placement of mini-screws were established by measuring the cortical bone thickness with digital calipers on each individual piece of bone (Figure 3). (Sao Paulo, Brazil). Since the cortical bone's thickness was less than 10 millimeters, it was removed. As long as the cortical bone is between 10 and 12 millimeters thick, the micro screw can be successfully implanted into the cortical bone (Figure 4 and Figure 5).

Figure 3: Digital Calipers.

Figure 4: DID Digital Torque Meter.

Figure 5: Cortical Bone.

2.4 Mini Screw Placement

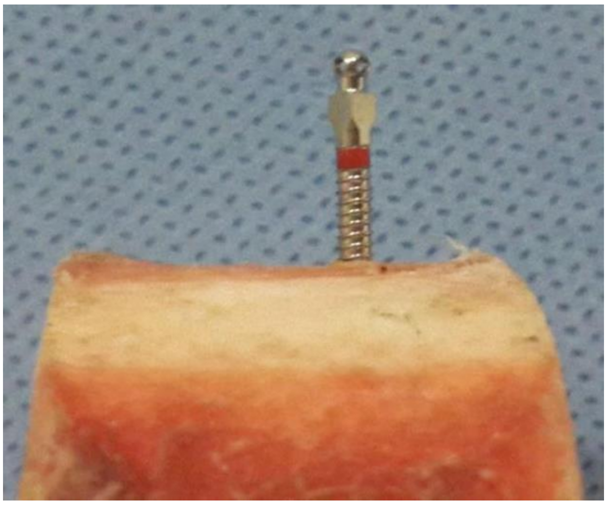


Figure 6: Mini-Screws Inserted into the Cortical Bone.

After measuring bone (cortical part) and identifying the spot where the mini-screws would be put, the procedure was completed. All mini-screws were used in this research, with a red stopper (1mm hight) put at neck of mini-screws to prevent insertion with a handpiece (Figure 2.6). As part of the experiment, a custom-made mechanism was constructed for the safety and stability of the bone sample. With this procedure, the screwdriver is used to simulate intraoral insertion until the maximum torque is reached, at which point the tiny screw fractures.

2.5 Scan Electron Microscope

The scan electron microscopy (SEM) used to magnify the shape and texture morphology of surface fracture of both miniscerws (Tomas and GNI). SEM MAG: 700 x, WD:14.90 mm, View field: 297 ums, Det: SE, BI: 10.00, Date(m/d/y): 04/03/22, 50um MIRA3 TESCAN

2.6 Standardization Criteria

Bone selection: For the placement of mini-screws, the tibia bone was taken from the same animal and preserved under the same conditions to prevent variations in bone structure due to differences in diet and time.

Cortical Bone thickness: The cortical bone was evaluated using a digital caliper and identifications were put on the areas of insertion to ensure the same cortical bone thickness.

Bone Holding: The two jaws of the custom-made gadget are used to hold the bone in place during the drilling process. Additional features include using two jaws to hold all bone parts, and ensuring that all surfaces received the same compression force during holding by using the same number of serrations in the holding piece

2.7 Statistical Analysis

Descriptive Statistics: To show the minimum and maximum values, mean standard deviation, and standard error for each variable and in each method of measurement.

Analysis of Variance (ANOVA): Data obtained from the previous measurement were initially analyzed using the one-way ANOVA test.

The Duncun's test: These data were then analyzed by the Duncun's multiple range test to locate the significant differences between the groups.

3. Results

3.1 Torque Fracture

The Descriptive Statistics that include mean, standard deviation, standard error, and minimum and maximum value of torque fracture of both tested mini-screws are listed in (Table 2). (Figure 6), which shows the Tomas mini-screws gave the highest torque fracture compared with GNI one. The results Duncan of multiple range test (Table 3) shows torque insertion has a significantly increased than torque removal.

Table 2: Descriptive Statistics of torque fracture of tested mini screw.

Type of Mini screws	Mean	Std. Deviation	Std. Error	Minimum	Maximum
GNI	50	0.34	0. 17	22	26
Tomas	60	0.54	0.41	29	33

Table 3: Duncan Analysis for fracture for two tested mini-screws.

Type of Mini screws	Mean*	Duncan**
GNI	50.21	B
Tomas	60.45	A

*The mean unit is (N.cm)

**Different letters mean significantly different at P<0.05.

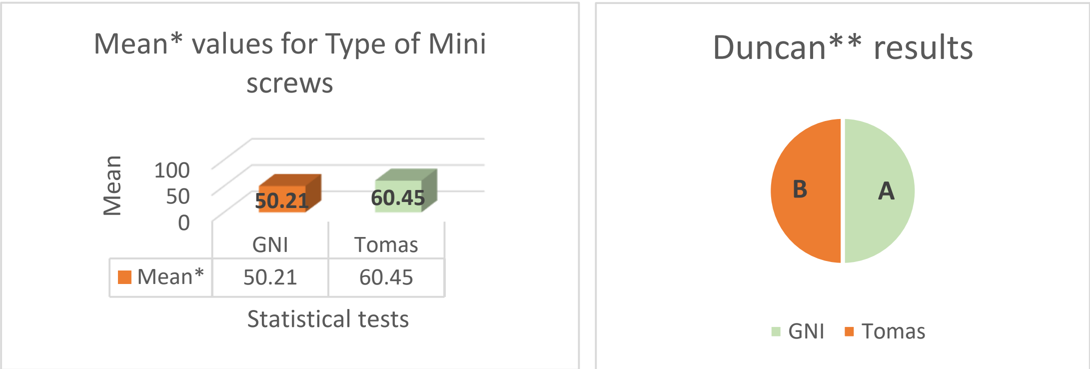


Figure 6: figure to show the Duncan Analysis for fracture for two tested mini-screws.

3.2 Level of Fracture

The percentage of fracture levels shown in the (Table 4). 80% of fractures happened in the middle third in the Tomas mini-screws and 10% in each apical and neck level. But in the GNI mini-screws %90 of the fractures happened in the apical third, 10% in middle third and there was no fracture in neck level (Figure 7).

Table 4: The percentage of fracture levels.

Type of mini-screws	Apical third	Middle third	Neck level
GNI	90%	10%	0%
Tomas	10%	80%	10%

Figure 7: Orthodontic mini-Implants, with different level of fracture.

3.3 Scan Electron Microscope Evaluation of fracture area

The scan electron microscopy showed the shape and texture morphology of surface fracture of both miniscerws. Both fracture surfaces of both mini screws at low magnification(100x) showed the direction of fracture refer to twisted force were received (Figure 8) At high magnification (700x) showed, surface morphology has many elevations and depressions in addition too much space like area like etched surface and this structure gave more strength to this type of mini scerw comparing with GNI that showed the level of elevation and depression. Less than that on Tomas in addition the spaces in the surfaces appeared less depth too. The SEM investigation of fracture areas of both mini-screws can be shown in these pictures (Figure 9).

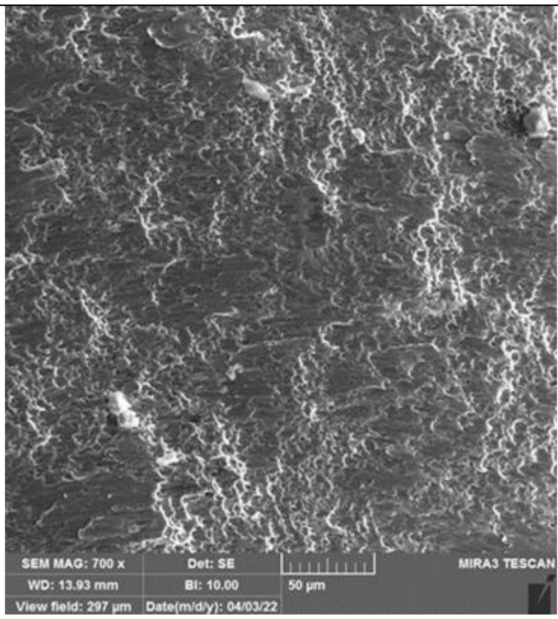
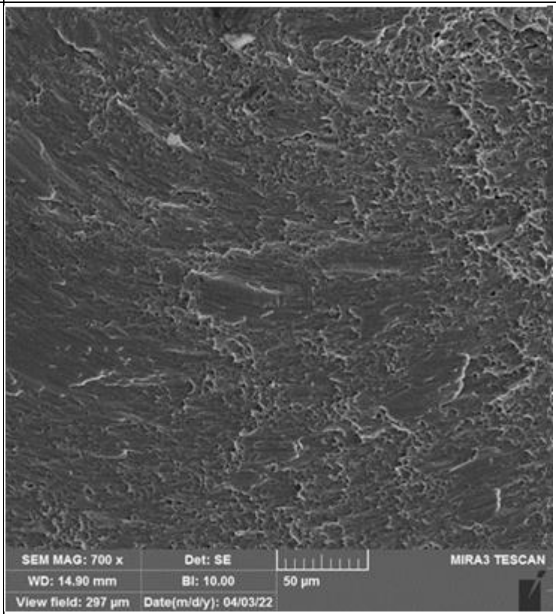
Tomas	GNI
	

Figure 8: SEM pictures shows surface morphology at 700 x magnification.

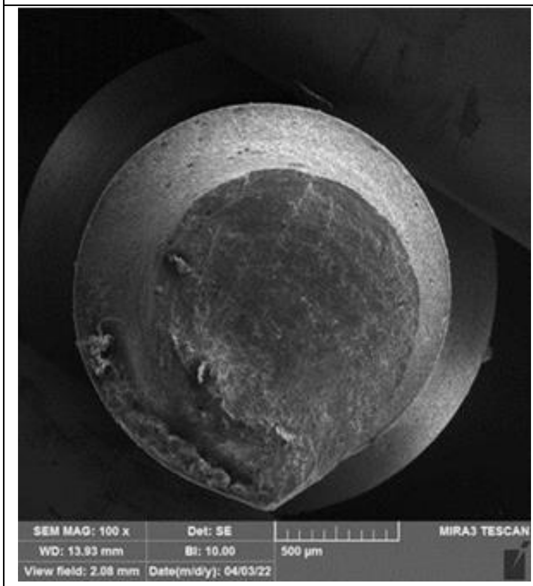
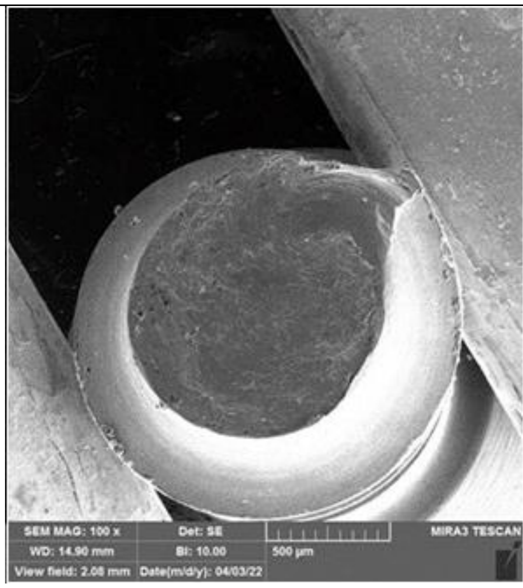
Tomas	GNI
	

Figure 9: Microscopic view of the orthodontic implants at fracture side.

4. Discussion

In this study, a bovine bone was employed because it was difficult to measure torque in vivo and extract samples from human cadavers. According to Jeffrey E Lim, Because of variances in bone thickness and density, this condition is more important for standardization criteria for compare the torque values

According to ChangChun-Li, this was in 2012. Cortical bone thickness was used in this study as a standardization factor to cover all mini-screw lengths and impacting torque insertion [14].

One of the characteristics that can affect the fracture torque of a mini-screw is its form. Straight screws are used to secure a core to the screw head. Typically, the diameter of a screw's core is measured at the halfway of its length, with the diameter decreasing gradually from its head to its tip in a tapered type (Tomas, Dentaurum, Germany). This could explain why the Tomas screws exhibited a higher mean fracture torque value despite having the same diameter as the GNI screws. In addition to thread design and material composition, the mini-screw strength may be affected by the alloy's hardness or softness of titanium. To begin with (1994)

GNI screw gave low fracture torque and most of the fracture level was near the tip and this result can be explained by the step change in diameter from the tip toward the head of it, in addition, the material itself that play a measuring rule in the fracture rate and level. In previous studies, the strength of several orthodontic mini-screws was assessed in vivo during insertion and removal. In a study of 41 patients, Motoyoshi and colleagues found mean peak insertiontorque values of 8.3 Ncm in the maxilla and 10 Ncm in the mandible for the ISA Orthodontic Implant (1.6mm diameter, 8mm long) [15]. A pilot hole of 1.3 mm in diameter and 8 mm in depth was drilled into the buccal plate before each mini-screw was installed. Seventy-six out of 102 AbsoAnchor mini-screws (1.1mm in diameter) and two from 98 Dual-Top mini-screws (1.6mm in diameter) cracked when inserted, according to the findings of Büchter and coworkers. 5 Torque values were not recorded during the fracture process. For the unfractured mini-screws, researchers found a mean removal torque of 2.99 Ncm for the unloaded Abs Anchor and 11.11 Ncm for the unloaded Dual-Top at day 70. No explanation was given as to how Carano and coworkers determined the mean torque strengths of 37.4 Ncm and 48.7 Ncm for their Mini-screw Anchorage System screws and 1.5mm-diameter screws respectively.

All of the mini-screws examined in this study had fracture peak torque values that were much higher than clinical values previously reported. Using mini-screws, on the other hand, can result in a broken screw when inserted or removed. Consider the location of the implant, the density of the bone, and whether or not a pilot hole is drilled. Drilling a pilot hole first before inserting a small-diameter mini-screw increases the risk of fracture in adults with high bone density. Fracture is more possible if the insertion angle is altered during installation. It is also possible to fracture a mini-screw when it comes into contact with an object such as a root, due to high torque necessary to overcome a barrier.

Screw fragments are surgically removed from the cortical bone when minis-crew fractures during implantation. A full-thickness flap is made, around the fractured screw bone is removed, and to remove the fragment reverse torque is applied to the screw. Biocompatible titanium is used in dental implants, thus any fragment that gets too close to vital structures should be left in place.

5. Conclusion

The use of two tiny screws resulted in a high fracture torque, and these screws are now widely recognized in clinical practice, particularly for the repair of minor bone fractures with a single screw, as in the case of metacarpal fractures. The Tomas mini-screws provided a larger fracture torque than the GNI one did, which led to improved structural stability of the fixation construct and positive clinical outcomes over the long term. The amount of fracture was significantly different between the two kinds, with the Tomas one giving near the head and the GNI one giving towards the tip of it. The Tomas one was far more likely to break. The configuration of the mini-screw has a significant impact on the fracture torque as well as the level at which the fracture occurs.

The optimal choice of implant length, tapering, diameter, and insertion location are critical factors in determining whether or not mini-implants will be successful. In addition, the quality of the insertion is evaluated according to the predrilling angle, the placement site, the main stability, the appropriate loading, the absence of inflammation at the placement site, the lack of movement, and the absence of damage. In addition, in order to achieve the main stability of orthodontic mini-implants, it is important to provide the appropriate amount of tension during insertion and removal. In order to obtain a conclusive finding, more research must be conducted with a larger number of patients over a longer length of time, using a variety of miniature screw designs. The fracture torque values that we observed in this research are higher than the limits that are advised by the manufacturers for clinical usage in orthodontics. However, the scope of our investigation restricts the applicability of these finding.

6. Author's Contribution

We confirm that the manuscript has been read and approved by all named authors. We also confirm that each author has the same contribution to the paper. We further confirm that the order of authors listed in the manuscript has been approved by all authors.

7. Conflict of Interest

The authors report no conflicts of interest.

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