

## Original Article

# Effect of steam and dry heat sterilization on the insertion and fracture torque of orthodontic miniscrews

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## ABSTRACT

**Background:** Titanium miniscrews are used at an ever-increasing rate to provide orthodontic anchorage. The aim of this study was to evaluate the mechanical performance of miniscrews after dry and steam sterilization.

**Materials and Methods:** In this experimental study, a total of 72 miniscrews from two different manufacturers with a diameter of 1.6 mm and height of 8 mm were divided into six groups ( $n = 12$ ). One group of screws from each manufacturer was considered as the control group; the second underwent steam sterilization; and the last group was subjected to dry sterilization. Insertion and fracture torques of each miniscrew were assessed by a torque tester. Data were analyzed using the Kruskal–Wallis and Mann–Whitney tests ( $P < 0.05$ ).

**Results:** For Jeil miniscrew, no statistically significant differences were detected between the steam-sterilized and control groups in their insertion torques ( $P > 0.05$ ). There was a statistically significant difference between the steam sterilized, dry sterilized and control groups with respect to their fracture torque ( $P < 0.001$ ). For Hubit miniscrew, there were no significant differences between steam sterilized, dry sterilized and control groups in their insertion torque ( $P > 0.05$ ) and between steam sterilized and control groups with respect to their fracture torque ( $P > 0.05$ ). There were significant differences in the mean values of insertion and fracture torques between the two different manufacturers ( $P < 0.001$ ).

**Conclusion:** Steam sterilization had no detrimental effects on torque values of miniscrews, but dry heat sterilization affected their mechanical properties.

**Key Words:** Anchorage technique, orthodontic, sterilization, torque

Received: April 2019

Accepted: June 2019

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## INTRODUCTION

Successful orthodontic treatment depends on anchorage control.<sup>[1-3]</sup> Miniscrews, as temporary anchorage devices, have been used extensively for reinforcing anchorage and facilitating tooth movements in difficult cases.<sup>[4,5]</sup> The success of miniscrews is dependent on their easy insertion and

removal with minimal or no discomfort for patients, low cost, immediate loading, and decreasing the need for patient compliance.<sup>[3,6,7]</sup>

Due to the popularity of miniscrews, infection control and sterilization of these tools are of utmost

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**How to cite this article:** Alavi S, Asadi F, Raji SA, Samie S. Effect of steam and dry heat sterilization on the insertion and fracture torque of orthodontic miniscrews. *Dent Res J* 2020;17:219-24.

importance.<sup>[6]</sup> Even though some TAD products are available as single-dose sterile packages, many still consist of clinical kits with different screw lengths and diameters or as single units requiring sterilization in the clinic. Nonsterile conditions and/or improper placement technique are problems with the use of miniscrews. Therefore, it might be necessary to sterilize unused miniscrews.<sup>[8]</sup> Sterilization procedures might give rise to changes in surface texture and mechanical resistance of miniscrews.<sup>[9]</sup>

The effects of various sterilization techniques on orthodontic tools, including pliers, archwires, and ligatures have already been investigated.<sup>[10,11]</sup> However, there are insufficient data available on the effects of chemical and physical sterilization techniques on the surface texture and mechanical properties of miniscrews used in orthodontic treatment. The most important parameters that should be tested in relation to the stability and mechanical properties of miniimplant are the insertion and fracture torques.<sup>[4,5]</sup>

One of the most commonly used techniques for sterilization in dental offices is heat sterilization.<sup>[10]</sup> Dry heat results in destructive oxidation of the constituents and denaturation of bacterial proteins, with oxidative damage and toxic effects on the bacteria. Moist heat sterilization gives rise to denaturation and coagulation of bacterial enzymes and proteins. Autoclaves are the most commonly used devices for sterilization and are considered the gold standard of sterilization procedures.<sup>[12]</sup> It has been reported that the autoclave sterilization technique has no effects on the mechanical properties, fracture torque, and primary stability of miniscrews.<sup>[8,13,14]</sup> Aarash *et al.* showed that reusing miniscrews with 90° insertion angle for at least two times have no harmful effects on mechanical properties.<sup>[15]</sup> Noorollahian *et al.* reported that in relation to the required torque, there was no significant difference between new miniscrews and the retrieve ones sterilized by autoclave.<sup>[14]</sup> Mattos *et al.* affirmed that the autoclave sterilization of the miniscrews did not affect their fracture torque.<sup>[16]</sup>

The aim of this *in vitro* study was to assess the effect of dry and steam sterilization on the insertion and fracture torques of miniscrews.

## MATERIALS AND METHODS

In this *in vitro* experimental study, two groups of new miniscrews ( $n = 36$ ) from two manufacturers (Jeil, Medical Corp, Seoul, Korea; and Hubit, Seoul,

Korea) with a diameter of 1.6 mm and a height of 8 mm were used.<sup>[14]</sup> Each group was divided into three groups of miniscrews randomly ( $n = 12$ ) by a blinded clinician. The screws were observed to ensure they had no structural defects. Miniscrews with defects or reused ones were excluded. One of these three groups was considered as the control group; the second group underwent steam sterilization (Autoclave-MELAG, Euroklav, 29 VS+, Germany) at 121°C, 15 Psi, for 15 min;<sup>[17]</sup> and the third group was subjected to dry thermal sterilization (Bender, Thermoelectric, Tutlingen, Germany) at 161°C for 2 h.<sup>[17]</sup>

Imada DiD-4 Torque tester (Imada Inc., Northbrook, IL, USA) was used to assess the torque value. A custom-made screwdriver was used to mount the miniscrews in the torque tester and a milling machine precisely to eliminate the eccentric movement of miniscrews; the milling machine (Jamco, CM6241. 2010, China) was used to control the rotation, insertion speed, and the depth of insertion.

The torque tester was placed in the milling machine, and the miniscrews were inserted in the torque tester by the custom-made screwdriver. This complex was positioned exactly in the center to minimize eccentric movements. The miniscrews were screwed into polycarbonate (PC 100) plates with a width of 1 cm.<sup>[18]</sup>

The insertion depth of all the screws was the same. We considered the maximum recorded torque during insertion as the maximum insertion torque and the maximum recorded torque before fracture or bending of miniscrews as the fracture torque value. Statistical analysis was performed using the SPSS version 22 (IBM Corporation, USA). Due to the lack of normality in some groups and existence of the interaction effect between mini-screw type and sterilization method, the Kruskal–Wallis and Mann–Whitney tests were used.

## RESULTS

The results of insertion and fracture torque values of the study groups are presented in Ncm [Table 1 and Figures 1, 2].

The Kruskal–Wallis test revealed that there was a statistically significant difference between six mentioned groups in relation to insertion torque ( $P < 0.001$ ) and fracture torque ( $P < 0.001$ ). In the completion, the Mann–Whitney test showed a significant difference between some groups [Table 2]. For Jeil miniscrew, no significant differences were detected between the

**Table 1: Mean and standard deviation of insertion torque (Ncm) and fracture torque (Ncm)**

Type of screw	Type of interaction	Mean±SD	
		Insertion torque	Fracture torque
Jeil	Control (n=12)	12.67±1.00	25.51±2.03
	Steam heat sterilization (n=12)	12.00±0.98	29.25±1.69
	Dry heat sterilization (n=12)	10.73±0.98	22.68±1.55
Hubit	Control (n=12)	6.70±0.88	20.82±2.05
	Steam heat sterilization (n=12)	6.47±1.04	20.78±1.85
	Dry heat sterilization (n=12)	6.22±0.82	17.30±1.06

SD: Standard deviation

**Table 2: P values for comparison test between groups (using the Mann-Whitney test)**

Comparison group	Insertion torque, P	Fracture torque, P
1-2	0.132	<0.001
1-3	<0.001	<0.001
1-4	<0.001	<0.001
1-5	<0.001	<0.001
1-6	<0.001	<0.001
2-3	0.005	<0.001
2-4	<0.001	<0.001
2-5	<0.001	<0.001
2-6	<0.001	<0.001
3-4	<0.001	0.04
3-5	<0.001	0.22
3-6	<0.001	<0.001
4-5	0.750	0.729
4-6	0.193	<0.001
5-6	0.506	<0.001

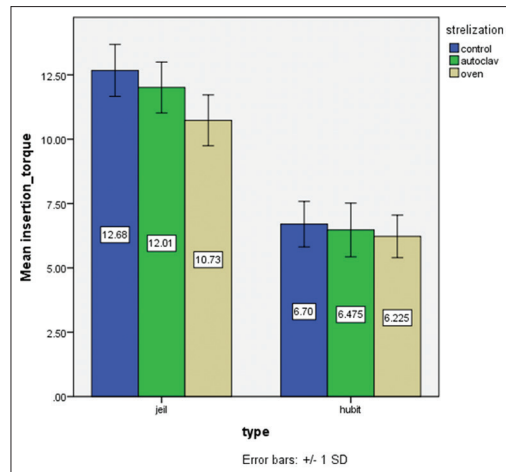
1: Jeil control; 2: Jeil steam heat sterilization; 3: Jeil dry heat sterilization; 4: Hubit control; 5: Hubit steam heat sterilization; 6: Hubit dry heat sterilization

steam sterilized and control groups in their insertion torques ( $P > 0.05$ ). However, there was a significant difference between the dry sterilized and control groups with respect to their insertion torque ( $P < 0.001$ ) and between the steam sterilized, dry sterilized and control groups with respect to their fracture torque ( $P < 0.001$ ). For Hubit miniscrew, there were no significant differences between steam sterilized, dry sterilized and control groups in their insertion torque ( $P > 0.05$ ) and between steam sterilized and control groups with respect to their fracture torque ( $P > 0.05$ ). There were significant differences in the mean values of insertion and fracture torques between the two different manufacturers ( $P < 0.001$ ).

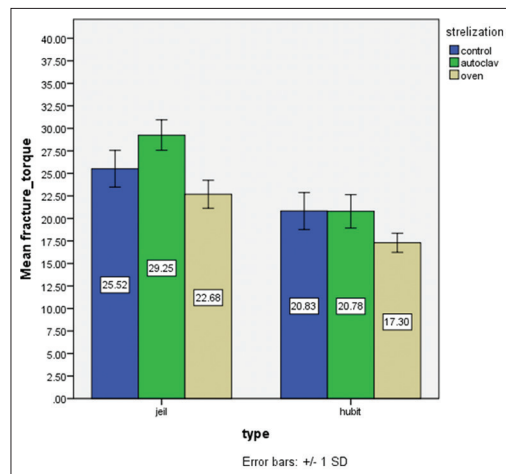
For items with  $P < 0/001$ , the differences were still significant even with the use of Dunn method.

## DISCUSSION

Orthodontic miniscrews were introduced to be used as



**Figure 1: Mean and standard deviation of insertion torque (Ncm) between Jeil and Hubit mini-screws with three different methods of sterilization.**



**Figure 2: Mean and standard deviation of fracture torque (Ncm) between Jeil and Hubit mini-screws with three different methods of sterilization.**

temporary anchorage devices; they make it possible to use skeletal anchorage for tooth movements, thereby decreasing the complications arising from anchorage loss.<sup>[19]</sup>

It is mandatory to sterilize miniscrews before insertion. Since the sterilization process might give rise to changes in the mechanical properties and surface texture of materials,<sup>[20]</sup> the present study was undertaken to assess the effects of sterilization procedures on the mechanical properties of screws. Both miniscrews included in the present study were made of titanium alloy (Ti6Al4V) with the same diameter and length. Successful use of miniimplants depends on factors related to the patient, insertion site, mini-implant insertion procedure, and orthodontic loading.<sup>[21]</sup>

Insertion torque is related to the type of implant and insertion procedure.<sup>[22]</sup> Maximum insertion torque has been defined as the maximum torque recorded during insertion of a miniscrew in Ncm. It results from the friction between the mini-screw threads and bone and is considered a reliable parameter for determining whether or not it is possible to achieve primary mini-implant stability.<sup>[4]</sup>

Implant stability can be categorized as primary and secondary; the primary stability is defined as the mechanical stability achieved immediately after insertion, and the secondary stability is achieved as the new bone forms around the implant. Primary stability requires a certain level of maximum insertion torque.<sup>[22]</sup>

Several studies have been undertaken on the importance of insertion torque value. Suzuki and Suzuki assessed the maximum insertion and removal torques in orthodontic patients and reported an inverse relationship between these two variables.<sup>[23]</sup> In contrast, McManus *et al.* evaluated the effect of insertion torque on the resistance of miniscrews to movement under load and reported a direct relationship between them.<sup>[24]</sup> Ricci *et al.* reported no significant relationship between the insertion torque and pullout strength of miniscrews.<sup>[25]</sup>

In this study, the miniscrews were screwed on PC plates by the milling machine with no use of hands to increase the accuracy of torque value measurement. The milling machine has advantages such as uniform rotation speed and simulation of the speed of clinician's hand. As a result, apart from clinical simulation, the effect of rotation speed as a confounding variable is eliminated. Similarly, use of a PC plate to simulate the bone structure is advantageous for decreasing the confounding effect of anatomic variations.

Another important mechanical property of miniscrews is their fracture torque, which might occur due to various factors, including the diameter and length of the miniscrew, milling in the apical region, surgical procedure, and insertion and removal torques.<sup>[3,26]</sup>

The incidence of the insertion fracture is 4%, which occurs due to excessive forces and the inability of miniscrews to resist rotational forces.<sup>[27]</sup> Therefore, it is advisable to be aware of the function and features of miniscrews to avoid excessive torques.

Furthermore, factors affecting the insertion and fracture torques include the diameter, shape, length, depth of screw thread, and chemical factors

such as microstructure and the processing of the miniscrew.<sup>[3,16,18,27]</sup>

The results of the present study revealed significant differences between the miniscrews from the two manufacturers in their insertion and fracture torques ( $P < 0.001$ ). However, we only matched the length and diameter of the miniscrews, whereas other features such as thread depth, shape of screws, and cutting end might be important too.

Some studies have evaluated the effects of different variables on screw properties with the use of different mini-screw types marketed by different manufacturers. As a result, it is not possible to reach a conclusion in this respect. Mattos *et al.* reported that the miniscrews marketed by different manufacturers exhibited different fracture torque values.<sup>[16]</sup> Migliorati *et al.* reported that the thread depth and shape significantly determined the maximum insertion torque and maximum pullout strength.<sup>[27]</sup>

Assad-Loss *et al.* reported different fracture torques at the neck and the tip of five different brands of orthodontic miniscrews, indicating that the fracture torques of the tip and neck were higher than the torque required to insert miniscrews.<sup>[26]</sup>

Dalla Rosa *et al.* studied the fracture torque of orthodontic miniscrews from five different manufacturers and reported that miniimplants with larger diameters exhibited higher fracture torques.<sup>[3]</sup> Kim *et al.* reported that tapered, dual-threaded and longer screws required higher insertion torques. In addition, they reported that the dual-threaded screws required higher removal torques.<sup>[28]</sup>

Sterilization procedures might affect the mechanical properties, surface texture, and hardness of metals. Several studies have evaluated this effect on cellular reactions around Ti implants, reporting that sterilization procedures result in changes in the surface chemistry of implants, with effects on osteogenic cells.<sup>[29]</sup> This affects secondary stability. The results of the present study showed no significant differences between the control group and steam-sterilized miniscrews in their insertion and fracture torques, suggesting that miniscrews have proper mechanical performance after steam sterilization, consistent with the results of a study by Mattos *et al.*<sup>[16]</sup>

Noorollahian *et al.* observed that in relation to the required torque, there was no significant difference between new miniscrews and the second-hand ones sterilized by autoclave and used again.<sup>[14,18]</sup>

Currently, dry heat sterilization is rarely used. However, we evaluated the effect of this sterilization technique to evaluate its possible effects on the mechanical properties of miniscrews. We observed a significant difference between the control group and dry-sterilized miniscrews in their insertion and fracture torques. This might be due to structural changes caused by dry heat application. Therefore, we do not suggest dry sterilization of miniscrews. However, Testarelli *et al.*<sup>[30]</sup> and Silvaggio and Hicks<sup>[31]</sup> reported that dry sterilization had no detrimental effects on the fracture of Nickel–Ti files.

In the present study, we evaluated only two mechanical properties (insertion and fracture torques). We strongly recommend that the effect of sterilization on the surface texture and hardness should be studied.

## CONCLUSION

- Steam sterilization (autoclaving) had no detrimental effects on the mechanical properties of miniscrews
- Dry heat sterilization might have a negative effect on the mechanical properties of miniscrews, especially on their fracture torque.

## Financial support and sponsorship

Nil.

## Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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