

RESEARCH ARTICLE

Is there a difference between the primary stability of anodized and non-anodized mini screws subjected to repeated cycles of autoclave sterilization?

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ABSTRACT

Objectives: To determine if autoclave sterilization has any deleterious effects on the clinical stability of anodized versus non-anodized mini-screws.

Materials and Methods: Thirty anodized and thirty non-anodized Aarhus System mini-screws (American Orthodontics, Sheboygan, WI) were utilized. Each group was divided into three test groups. In each group, mini-screws that were sterilized once using a steam autoclave (Statim 5000, SciCan USA, Canonsburg, Pa) served as the control group (n=10). The other two test groups involved mini-screws that were subjected to a repeated cycles of sterilization for five (n=10) and ten (n=10) times. All sixty mini-screws were inserted at a 90° angle into custom-designed synthetic blocks that simulated the average mandible of a healthy adult. The maximum insertion torque and the lateral displacement at 0.025, 0.05, 0.1, 0.25, 0.5, and 1 mm were recorded for each sample and subjected to statistical testing. A two-way ANOVA, and a three-way mixed ANOVA were used for statistical analyses.

Results: Maximum insertion torque values displayed significant differences between the anodized and non-anodized groups (p<0.001) as well as the sterilization cycles (p<0.001). No significant group and cycle interaction was observed. No significant differences were found between the groups and sterilization cycles in the evaluation of the lateral displacement test. However, there was a significant group/cycle/displacement interaction (p<0.001).

Conclusions: Surface treatment of mini-screws with anodization produced differences when compared to standard surface mini-screws following autoclave sterilization. The differences between the two types of mini-screws did not indicate a potential stability concern.

Keywords: Stability, mini-screws, sterilization.

INTRODUCTION

Skeletal anchorage systems, such as osseointegrated implants and miniplates have been used for obtaining absolute

anchorage for orthodontic treatment since early 1990's. Unfortunately, implant systems require osseointegration before orthodontic force can be applied; in addition, they may increase treatment time, they are expensive and their size limits placement location.^{1,2} In recent years, temporary anchorage devices such as mini-screws have become an increasingly popular means.^{3,4} This is in part due to

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their ease of use, relatively low cost, and reduced need for patient compliance. As mini-screws gain popularity and become more ubiquitous, it is important to understand the proper protocol for placement⁴⁻⁶ and procedures for infection control and sterilization.^{7,8}

Mini-screws are commercially available in two main forms: as single-dose sterile units or as part of a clinician's kit, which includes a variety of screw diameters and lengths. The kit offers more chair side flexibility for the practitioner and reduces overhead. However, the entire kit may be exposed to non-sterile conditions during use and thus necessitates sterilization of the unused mini-screws. It is well documented that autoclave sterilization can affect dental hardware such as orthodontic arch wires, dental implants, and orthodontic pliers.⁹⁻¹² It is also recently reported that different brands of mini-screws and the number of sterilization cycles revealed significant differences for the insertion torque values when subjected to autoclave sterilization.¹³ Although the authors reported that these changes were minimal and an increased number of sterilization cycles might not be detrimental to clinical stability, it follows that mini-screw surface could be affected by autoclave sterilization. It may be of potential clinical interest to determine whether repeated sterilization could also affect the surface treatment i.e. anodization of the mini screws, thereby leading to negative consequences in their stability. Therefore, the aim of this investigation was to investigate the effects of autoclave sterilization on the primary stability of the mini-screws.

MATERIALS AND METHODS

Aarhus (American Orthodontics Sheboygan, WI) mini-screws were chosen for this investigation. This was due to the availability of the same kind of mini-screw by the manufacturer in both anodized and

non-anodized forms thus allowing for an exact comparison. The mini-screws measured 11.6 mm in overall length; 8.0 mm in thread length, 1.5 mm long tissue collar and 1.5 mm in diameter. Thirty mini-screws were selected from each surface treatment groups for a total of sixty. For the purposes of the study thirty non-anodized mini-screws were obtained from the company prior to standard anodization process. Each group was then randomly divided into three subgroups. In each group, the first group (n=10) served as the control and was sterilized once using a steam autoclave (Statim 5000, SciCan USA, Canonsburg, Pa). The experimental groups were subjected to five (n=10) and ten (n=10) times of consecutive sterilizations on the same autoclave. Each autoclave cycle was performed at 132°C for 6 minutes.

Following the sterilization cycles, the mini-screws were randomly inserted at a 90-degree angle into synthetic bone blocks. The synthetic bone blocks used in this study were custom made to simulate the density and physical properties of alveolar cancellous and cortical bone and were manufactured by Sawbones Worldwide (Vashon, Washington) (Figure 1). The blocks were prepared in 170 mm X 20 mm X 20 mm dimensions and were composed of two layers: cortical bone layer of 1.5 mm (0.48 g/cc) and trabecular bone layer of 18.5 mm. Compressive, tensile, and shear strength for the cortical bone layer were 18, 12, and 7.6 MPa and for the cancellous bone layer were 2.2, 2.1, and 1.6 MPa, respectively.

In order to measure the maximum insertion torque (MIT), corresponding driver attachments from the individual manufacturers were inserted into the chuck of an Imada HTG-2 Torque Wrench (Northbrook, IL). Data was recorded for MIT for the individual mini-screws using the peak mode setting of the torque wrench. The operator was blinded from the

data collection during the insertion of the mini-screws and a second observer



Figure 1. The mini-screws were randomly inserted at a 90-degree angle into custom-made synthetic bone blocks.

recorded readings at the time of insertion. Once this procedure was completed, the strips of synthetic bone were cut into cubes measuring 17 mm X 20 mm X 20 mm and were mounted in acrylic bases to perform the lateral displacement test. An Instron machine (Instron 4655; Instron Co, Norwood, MA) was used to apply uniform compression force perpendicular to the mini-screws and the force, in milligrams, needed to displace the mini-screws at the preset levels of 0.025 mm, 0.05 mm, 0.10 mm, 0.25 mm, 0.50 mm and 1.00 mm was measured. Maximum insertion torque and lateral displacement data were analyzed using Two-way ANOVA and Three-way Mixed ANOVA analyses, respectively. The level of significance was defined as $p < 0.05$.

RESULTS

The descriptive statistics for maximum insertion torque and lateral displacement force data are presented in Tables 1 and 2, respectively.

Table 3 presents the results of analysis of variance of the maximum insertion torque data. There was a significant main effect of the anodization (group) on the maximum insertion torque, $F(1,54) = 114.3$, $P < 0.001$. Sterilization cycle, as a main

effect, also was significant, $F(2,54) = 11.8$, $p < 0.001$. However, there was no significant group/cycle interaction. This means that the effect of surface treatment with anodization was not different for any of the three sterilization cycles.

Table 1. Descriptive statistics of the maximum insertion torque at one, five and ten sterilization cycles for anodized and non-anodized mini-screws.

Group	Cycle	Mean (Ncm)	SD
Non-anodized mini-screws	1	5.1	0.8
	5	3.9	0.4
	10	5.1	0.6
Anodized mini-screws	1	6.8	0.4
	5	6.1	0.5
	10	6.4	0.6

Table 4 summarizes the Analysis of Variance of the lateral displacement force data. No significant differences were found for the main effects: groups and the cycle. However, there was a significant interaction of group/cycle/displacement, $F(10,180) = 4.3$, $p < 0.001$. This finding suggests that the number of sterilization cycles and force required for lateral displacement of the mini-screws were not the same for anodized and non-anodized mini-screws.

DISCUSSION

The statistical evaluation revealed significant differences for the group and the sterilization cycle, as the main effects. In a recent article¹³, the same trend was observed for the different brand of mini-screws. These findings altogether might suggest that altering the surface with anodization causes significant differences similar to the differences between different

brands of mini-screws. Motoyoshi et al.⁴ suggested that mini-screws placed with
Table 2. Descriptive statistics of the lateral displacement force at preset displacement distances for the groups.

Group	Cycle	0.025 mm		0.05 mm		0.1 mm		0.25 mm		0.5 mm		1.0 mm	
		Mean (gm)	SD	Mean (gm)	SD	Mean (gm)	SD	Mean (gm)	SD	Mean (gm)	SD	Mean (gm)	SD
Non-anodized	1	113.0	114.9	431.1	138.3	979.7	376.7	1913.8	1017.5	3442.9	1492.8	5910.5	1003.3
	5	134.7	120.4	518.9	115.2	1238.1	362.6	2675.1	882.9	4457.4	970.2	5600.0	469.4
	10	185.7	179.9	609.5	259.5	1373.0	394.4	2931.6	808.0	5307.7	667.6	6636.1	657.6
Anodized	1	173.3	177.6	615.9	232.5	1419.8	321.5	3141.1	600.2	5132.4	812.4	6336.9	400.5
	5	112.7	106.1	479.1	137.1	1140.5	286.0	2327.1	704.5	3954.9	908.8	5403.4	725.5
	10	138.1	145.2	530.2	179.2	1254.7	349.9	2912.4	682.2	4871.5	1001.0	5923.7	447.6

Table 3. Analysis of Variance of the maximum insertion torque data.

Source	SS	df	MS	F	p
Group	46.008	1	46.008	114.33	<0.001
Cycle	9.513	2	4.756	114.33	<0.001
Group * Cycle	1.998	2	0.99	2.483	.093

maximum insertion torques ranging from 5 Ncm to 10 Ncm had significantly higher success than those placed above or below that range. Based on this information and the mean values of the maximum insertion

torque of the two groups observed in our study, anodized mini-screws might offer better stability as evidenced by the consistency of the insertion torque in this group between the three cycles. However, the absence of group/cycle interaction for the maximum insertion torque revealed that throughout the experiment the sterilization affected the mini-screw surface characteristics similarly and the final outcome was not negative at all.

The statistical data from our study showed that lateral displacement force test resulted in a slightly contrary outcome compared to the maximum insertion torque test. It appeared that there was a slight deterioration in the anodized group after the first cycle and non-anodized mini-screws actually performed better after repeated cycles of sterilization. In this study, we investigated a broad range of

lateral displacement force values. Studies conducted with mini-screws indicated

orthodontic force applications of 80 g¹⁴ to 600 g¹⁵ for various applications. According

Table 4. Analysis of Variance of the lateral displacement force data.

Source	SS	df	MS	F	p
Group	.551	1	.551	.550	0.46
Cycle	9.251	2	4.626	4.514	0.18
Displacement	1631.9	1.69	964.3	1405.13	p<0.001
Group*Cycle*Displacement	11.092	10	1.109	4.369	p<0.001

to our results, force applications within this range might displace the mini-screws laterally up to/or slightly more than 0.05 mm in both groups, which may be considered negligible. It is also crucial to note that in a clinical scenario where there is a waiting time^{16,17} before the loading, much better results could be attained. Therefore, despite the statistical variability observed in our study, both mini-screw groups should be able to resist the lateral forces quite similarly. It is, though, of potential interest to perform this experiment in smaller increment presets up to 0.1 mm of displacement with a larger sample size and increased number of sterilization cycles to confirm our findings.

CONCLUSIONS

Based on the results of this study, it can be argued that autoclave sterilization affects the primary stability measures of both the anodized and non-anodized screws. However, these differences are not likely to produce a potential clinical problem for their use.

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