The Effects Of Various Sterlization Procedures On Primary Stability Of Orthodontic Mini-implants

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Abstract

Introduction: The orthodontic mini-implants are commercially available in sterile individual packets. The sterilization procedure usually followed by the manufacturer is autoclaving of the implants before its packaging and supply. However, sterilization process may affect the primary stability of implants, as the primary stability of implants depends upon the mechanical interlocking rather than osseo-integration. This study was hence carried out to study the effect of various sterilization procedures on primary stability of orthodontic mini-implants.

Material and method: In this study, total 48 Titanium Grade V mini- implants of size 1.5 mm X 8 mm were used. The mini-implants were randomly divided into 4 groups of 12 each. These mini-implants were subjected to sterilization methods like autoclave, hot air oven and UV radiation. All these implants were inserted in goat jaw at D2 Density site (as per 3D Spiral CT Scan) by drill method. The stability of the mini-implants was measured and compared with Osstell ISQ Implant stability meter.

Results: The recordings were subjected to ANOVA and Tukey's post hoc test. The statistically significant difference was noted in the primary stability of the orthodontic mini-implants among various groups.

Conclusion: The sterilized mini-implants showed more stability than the non-sterile one. Among the various sterilization methods performed, autoclave sterilization showed the best results.

Keywords: Mini-implants, stability, sterilization.

Introduction:

The use of the orthodontic mini-implants to obtain absolute anchorage has recently become very popular in clinical orthodontic approaches[(1)]. The mode of anchorage facilitated by these mini-implant systems has a unique characteristic owing to their temporary use, which results in a transient, albeit absolute anchorage. The foregoing properties together with the recently achieved simple application of these mini-implants have increased their popularity, establishing them as a necessary treatment option in complex cases that would have otherwise been impossible to treat[(2)].

The basic requirement for the success of orthodontic mini-implants is sufficient primary stability[(3)]. Primary stability basically comes from mechanical interlocking with the cortical bone when the mini-implant is placed[(4)]. Primary stability is influenced by bone quality and quantity, surgical technique, and screw geometry and augmentation techniques in order to increase success rate of the treatment [(5)-(7)].

The orthodontic mini-implants are commercially available in sterile individual packets. The sterilization procedure usually followed by the manufacturer is autoclaving of the implants before its packaging and supply. However, sterilization process may affect the primary stability of implants, as the primary stability of implants depends upon the mechanical interlocking rather than osseo-integration.

The commonly used sterilization procedure in dental clinics are autoclave/moist heat sterilization, hot air oven/dry heat sterilization, ultraviolet radiation, etc. Various sterilization procedure may have different effect on surfaces of mini-implant, altering the primary stability. When searched, no such data was found in literature. Hence this study was undertaken, to compare the effects various sterilization procedures on the primary stability of orthodontic mini-implants.

Material And Method:

For the matter of successful orthodontic mini- implant placement, bone quality is of great significance. Sufficient bone density and quality of bone are crucial factors for the success of an orthodontic mini-implant. In 1988, **Misch** described five groups, based on macroscopic cortical and trabecular bone characteristics as D1, D2, D3, D4 and D5[(8)] out of which D2 bone is found most commonly in the region where implant placement is most feasible[(9)]. D2 bone exhibited a 47%-68% greater ultimate compressive strength compared to D3 bone[(7)].

Out of these 5 categories described by **Misch**, the implants placed in D2 type of bone shows a very predictable

osseointegration. The bone implant interface contact is much predictable in D2 bone than D3 and D4 types. The trabeculae in the D2 type of bone are 50% stronger than the D3 type. Hence D2 type bone was selected for placement of implants.[7]

In this study, 2 goat jaws of freshly sacrificed animal (sacrificed for meat purpose only) was collected. Hence as per NIH guidelines, no animal was harmed or sacrificed for conducting this study. An institutional ethical committee approval was granted for this study vide letter no. CSMSS/DCH/EC/2020/ORTHO/04 (Figure 1).

Fig No. 1: Goat jaw specimen

The goat jaw specimen was subjected to spiral 3D CT scan for density matching. The jaws were thoroughly cleaned of all the soft tissues. The bone whose density matched with the D2 density of human bone was considered for the study. Marking for the D2 bone density done on either side of the goat jaw (Figure 2, 3). A grid with squares were drawn on each side of jaw bone (right and left) for the placement of mini-implants according to various groups of sterilization

Fig No 2: CT scan used for scanning goat jaw for detection of bone density.

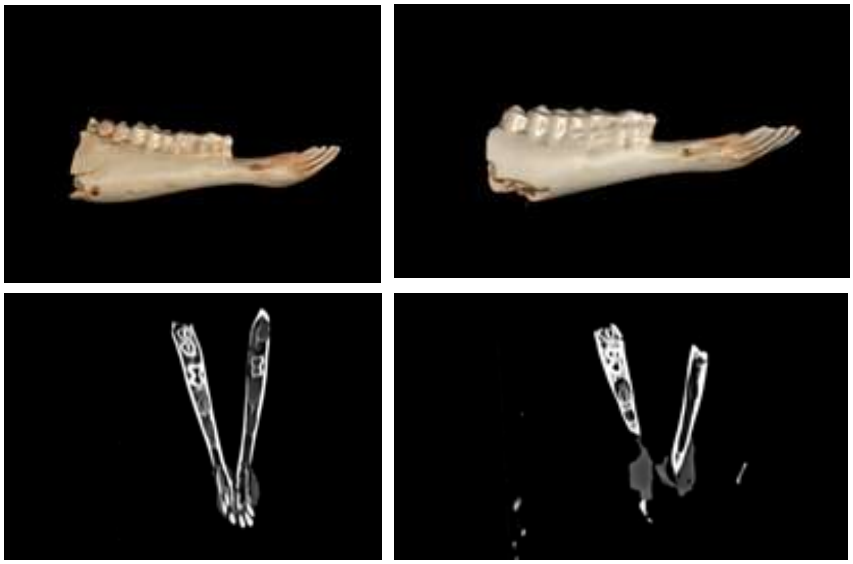


Fig No. 3: Spiral 3D CT scan image of the goat jaw specimen

48 Titanium (Grade V) alloy non sterile orthodontic mini-implant of diameter 1.5 mm and length 8 mm were used for the study. These mini-implants were randomly divided into 4 groups. Each group consisted of 12 mini-implants. The groups of mini-implants are Group A: Control group consisting of implants not subjected to sterilization procedure, Group B: Autoclave group consisting of implants subjected to autoclaving, Group C: Hot air oven group consisting of implants subjected to hot air oven and Group D: UV radiation group consisting of implants subjected to UV radiation (Figure 4).

Fig No. 4: Osstell ISQ implant stability meter with Smartpeg

The 48 mini-implants were placed in the bone by drill method using orthodontic mini-implant hand driver in respected grid and their primary stability was measured by Resonance frequency analyzer using Osstell ISQ stability meter. To avoid bias, 5 readings were taken for each implant in 5 directions i.e. right, left, front, back and above and their average value was considered as final readings (Figure 5).

Fig No.5: Primary stability of each mini-implant measured using Osstell ISQ on Jaw 1 and 2.

Result:

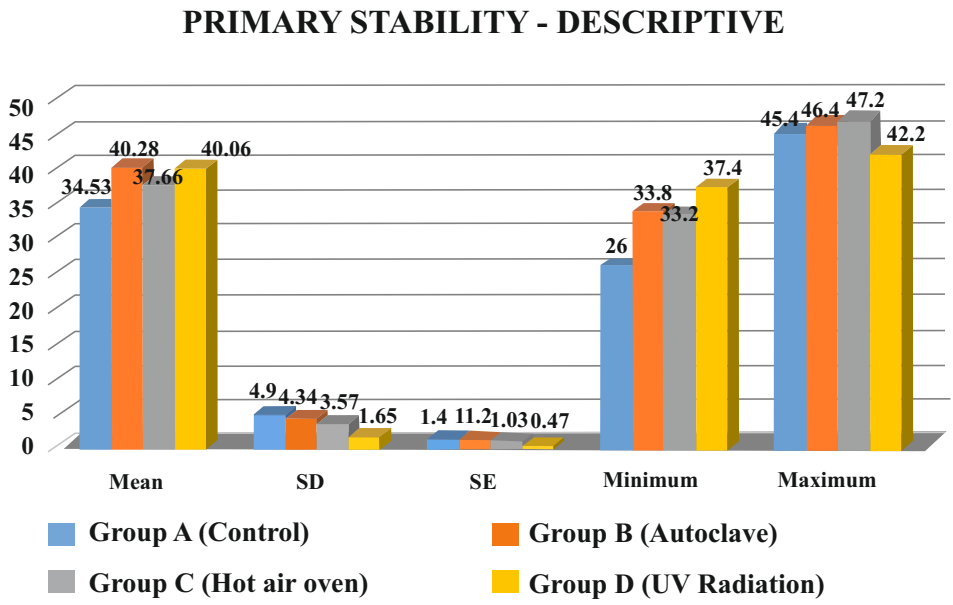
The readings of the study were subjected to statistical analysis (Statistical Package for Social Science (SPSS) version 21 for Windows, Armonk, NY: IBM corp.), so as to get their interpretation.

Table 1 and Graph 1: Mean, Standard deviation and Standard error for various groups of mini-implants:

Mean, Standard Deviation and Standard Error for Group A (Control group) was found to be 34.53, 4.90 and 1.41 respectively. Mean, Standard Deviation and Standard Error for Group B(Autoclave group) was found to be 40.28, 4.34 and 1.25 respectively. Mean, Standard Deviation and Standard Error for Group C (Hot air oven group) was found to be 37.66, 3.57 and 1.03 respectively. Mean, Standard Deviation and Standard Error for Group D (UV radiation group) was found to be 40.06, 1.65 and 0.47 respectively (Table 1, Graph 1).

Table 1: Descriptive statistics of primary stability of orthodontic mini – implants after various sterilization procedures respectively showing Mean, Standard Deviation and Standard Error of various groups studied

	Mean	SD	SE	Minimum	Maximum
Group A (Control)	**34.53**	**4.90**	**1.41**	**26.0**	**45.40**
Group B (Autoclave)	**40.28**	**4.34**	**1.25**	**33.80**	**46.4**
Group C (Hot air oven)	**37.66**	**3.57**	**1.03 3**	**3.20**	**47.2**
Group D (UV Radiation)	**40.06**	**1.65**	**0.47**	**37.40**	**42.20**



Graph 1: Descriptive statistics of primary stability of orthodontic mini – implants after various sterilization procedures respectively showing mean, standard deviation and standard error of various groups studied.

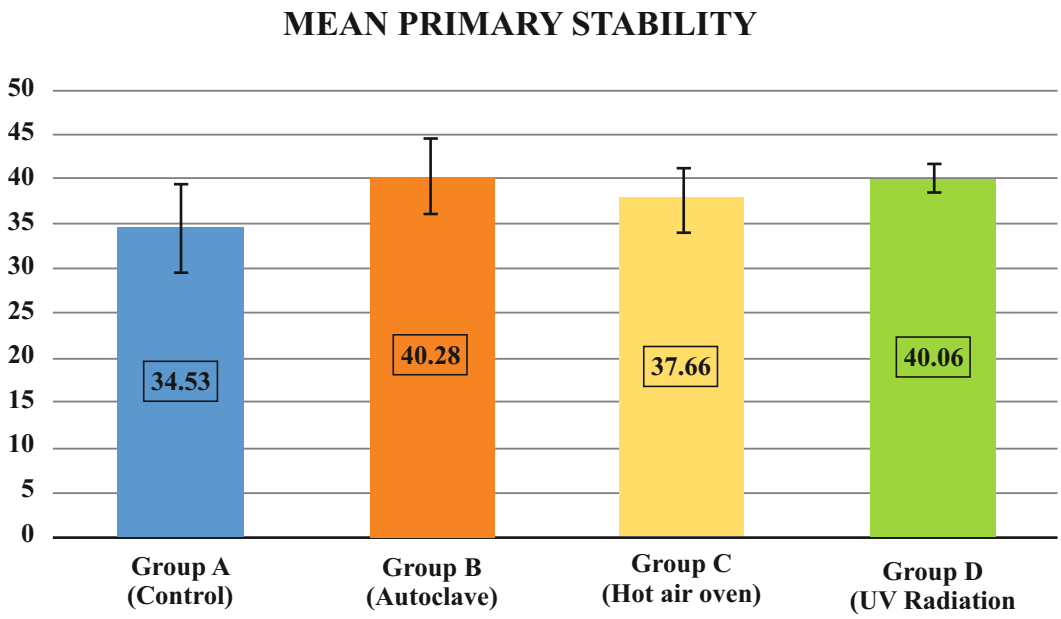
Table 2 and Graph 2: Overall inter-group comparison of mini-implants:

ANOVA One way Test was used to compare the Mean of all the four groups studied. The results were found to be F= 5.892. P value was found to be 0.002 which suggested it to be highly significant. There was statistical significant difference was noted in overall groups comparison of the primary stability of orthodontic mini-implants after the various sterilization procedures by using the ANOVA test (Table No and Graph No 2).

Table 2: Overall inter group comparison of the primary stability of orthodontic mini – implants after various sterilization procedures respectively using One way ANOVA test

Primary Stability	Mean	SD	One way ANOVA test	P value, Significance
Group A (Control)	34.53	4.90	F = 5.892	p = 0.002*
Group B (Autoclave)	40.28	4.34		
Group C (Hot air oven)	37.66	3.57		
Group D (UV Radiation)	40.06	1.65		

*p<0.05 – significant difference



Graph 2: Overall inter group comparison of the primary stability of orthodontic mini – implants after various sterilization procedures respectively using one way ANOVA test

Table 3 and Graph 3: Pairwise group comparison of mini-implants :

Tukey's Post Hoc test is used for pairwise comparison of all the groups of the mini-implants.

1. Group A (Control group) with Group B (Autoclave group):

   When Mean of Group A (Control group) was compared with Mean of Group B (Autoclave group) using Tukey's Post Hoc test, result was found to be 5.75. The p value was found to be 0.003 which suggested it to be highly significant.

2. Group A (Control group) with Group C (Hot air oven group):

   When mean of Group A (Control group) was compared with mean of Group C (Hot air oven group) using Tukey's Post Hoc test, result was found to be 3.13. The p value was found to be 0.201 which was not significant.

3. Group A (Control group) with Group D (UV radiation group):

   When mean of Group A(Control group) was compared with mean of Group D (UV radiation group) using Tukey's Post Hoc test, result was found to be 5.53. The p value was found to be 0.005 which suggested it to be highly significant.

4. Group B (Autoclave group) with Group C (Hot air oven group):

   When mean of Group B (Autoclave group) was compared with mean of Group C (Hot air oven group) using Tukey's Post Hoc test, result was found to be 2.61. The p value was found to be 0.348 which was not significant.

5. Group B (Autoclave group) with Group D (UV radiation group):

   When mean of Group B (Autoclave group) was compared with mean of Group D (UV radiation group) using Tukey's Post Hoc test, result 0.21. The p value was found to be 0.999 which was not significant.

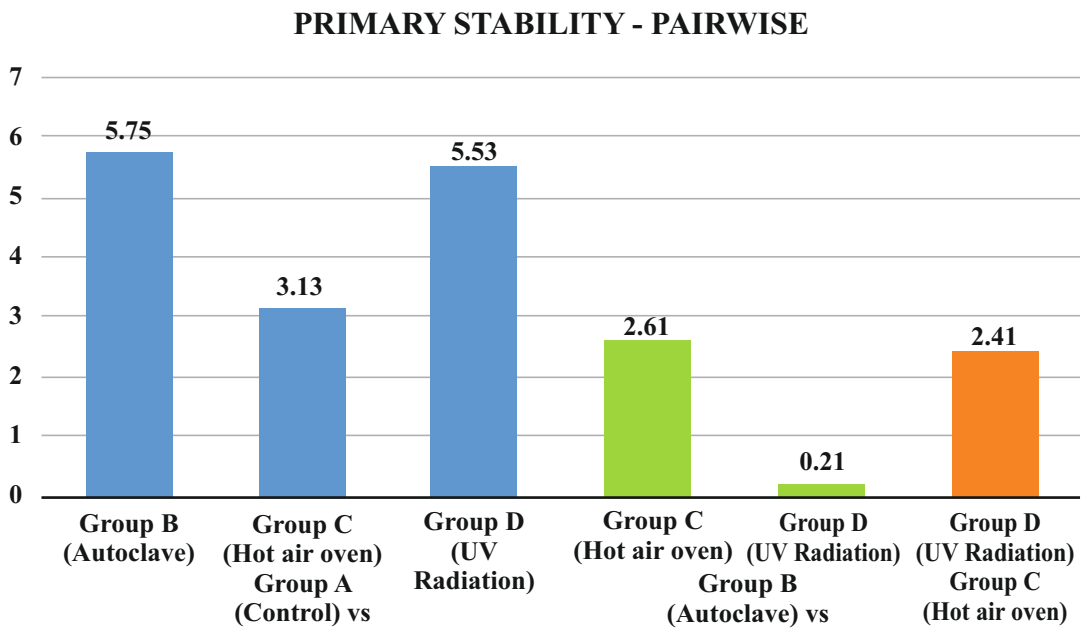
6. Group C (Hot air oven group) with Group D (UV radiation group):

   When mean of Group C (Hot air oven group) was compared with mean of Group D (UV radiation group) using Tukey's Post Hoc test, result was found to be 2.41. The p value was found to be 0.424 which was not significant

Table 3: Pairwise inter group comparison of the primary stability of orthodontic mini – implants after various sterilization procedures respectively using Tukey's post hoc test

Tukey's post hoc test for pairwise comparison			
Group	**Comparison Group**	**Mean Difference**	**P value, Significance**
Group A (Control) vs	**Group B (Autoclave)**	**5.75**	**p =0.003***
	Group C (Hot air oven)	**3.13**	**p=0.201 (ns)**
	Group D (UV Radiation)	**5.53**	**p=0.005***
Group B (Autoclave)	**Group C (Hot air oven)**	**2.61**	**p=0.348 (ns)**
	Group D (UV Radiation)	**0.21**	**p=0.999 (ns)**
Group C (Hot air oven) vs	**Group D (UV Radiation)**	**2.41**	**p =0.424 (ns)**

p>0.05 – no significant difference (ns) *p<0.05 – significant **p<0.001 – highly significant



Graph 3: Pairwise inter group comparison of the primary stability of orthodontic mini – implants after various sterilization procedures respectively using Tukey's post hoc test

Discussion:

In our study, least primary stability was seen with control group (non-sterilized) mini- implants, sterilization process improved the primary stability. Highest primary stability was found autoclave procedure followed by UV radiation procedure and Hot air oven subsequently.

The primary stability depends upon the surface roughness of mini-implants, as the mini-implants are mechanically interlocking with the bone rather than osseointegration. This may be explained by studies by **Noha El- Wassefy et al**[10], **Shiva Alavi et al**[11] and **Hoi -Jeong Lim et al**[12] who reported that sterilization procedure changed the surface morphology, mechanical properties and surface chemistry of implants which inturn affected the osteogenic cellular reaction around Ti implants. **Afsheen Tabassum et al**[13], in a simulated laboratory model, reported that implants with rough surfaces showed significantly higher primary stability compared to implant with smooth surfaces.

Conclusion:

In our study, least primary stability was seen with control group (non-sterilized) implants, Sterilization process improved the primary stability. Highest primary stability was found autoclave procedure followed by UV radiation procedure and Hot air oven subsequently.

The result of our study indicate that autoclaving improves the primary stability and hence is recommended.

Limitations of our study:

However, it be noted that

1. Only single cycle of autoclaving has been conducted in our study. Repeated autoclaving procedure may further alter the primary stability. And hence more studies in this manner are recommended.
2. Also, this study was done by simulation method on goat jaw with D2 bone density.
3. Study on limited implants (12 in each group) was done.
4. This study did not include the surface morphology alteration of the mini-implants following various sterilization procedures.

   Hence Clinical trials with more mini-implants along with SEM study are warranted.

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