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Resin cement around tissue and bone level dental implants after two cementation techniques (an in vitro study)

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Abstract---Purpose: To detect the retained excess resin cement around tissue and bone level dental implants following two different cementation techniques. Methods: Fourteen tissue level and fourteen bone level implants (OCO Biomedical, U.S.A.) were embedded in models (Salvin Dental Specialties, U.S.A.) having rubber surface simulating the gingiva. Twenty-eight metal copings were fabricated and cemented to the implant's abutments by RelyX U200 resin cement (3M, U.S.A.). Each group was subdivided according to the cementation technique into two subgroups: A₁ and B₁: Tack cure of the excess cement for three seconds, the partially set resin cement was carefully removed before complete cure. A₂ and B₂: 1mm vent was performed on the occlusal surfaces. Excess cement was carefully removed followed by a final cure. Rubber coverage was removed, retained cement net weight was determined. All specimens were visually examined under 30x magnification using Stereomicroscope (SZ-11, Japan). Results: Tissue level implants following the tack cure protocol had less retained excess cement percentage than the occlusal vent protocol. Statistical comparison showed a significant difference in the excess cement percentage within the tissue level subgroups (p=0.018), No significant difference observed within the bone level subgroups (p=0.096). There was significant difference between non-vented tack cure and occlusal vent techniques regardless of the implant type (P=0.004), with more retained cement percentage with the vent technique. Conclusions: tack curing of excess resin cement reduces the cement residue, but couldn't solve the problem of retained excess resin cement. Implants inserted at the bone level need extra precautions during the cementation process.

Keywords---Bone level implants, excess resin cement, occlusal vent,

tissue level implant, tack cure.

Introduction

Cement retained restorations is the most commonly used implant fixed prosthetic option. However, cement retained implants restorations still have limitations. Complete removal of the excess cement is generally a challenge, especially with subgingival margins [1-3]. Residual cement may lead to peri-implantitis and implant failure [1,4,5].

Different cement types have been used to lute fixed restorations on implant abutments [6]. Resin cements are increasingly used nowadays because of their high retention, decreased dissolution in the oral fluids, and the ability to reduce microleakage compared with other traditional luting cements [7-10]. However, the complete removal of resin cement is difficult, and scratches from the removal of excess cement with sharp instruments leads to the increase of the surface roughness of the implant surface [11,12].

Several techniques to minimize the excess cement have been proposed in the literature, such as partial photo polymerization of the cement before removal of the excess (tack curing) [13] and crown venting techniques [14].

The purpose of the present study was to find a technique for cementing implant-supported restorations without leaving any excess cement, and if excess cement was found to determine which method of cementation will show less amount of retained excess resin cement around tissue level and bone level dental implants.

The null hypothesis was that there is no difference between the non-vented tack cure and the occlusal vent technique in the amount of the excess cement retained around tissue level and bone level dental implants.

2. Materials and Methods

2.1 Model Preparation

Four special models (Salvin Dental Specialties, Inc. Charlotte, U.S.A.) simulating the bone of the mandible in the biomechanical properties with 1.5mm rubber surface simulating the gingiva were used. Twenty-eight non-sterile dental implants (4.0 mm in diameter X 12mm in length) (OCO Biomedical, Inc. Albuquerque, U.S.A.) were used, Fourteen ERI tissue-level implants and Fourteen ENGAGE bone-level implants. Seven holes were drilled in each model following a flapless protocol using a tissue punch with a sequence of 2mm, 3mm and 3.7 mm drills (OCO Biomedical, Inc. Albuquerque, U.S.A.). A ratchet wrench was engaged to ERI driver to drive the tissue level implants to its final position just below the gum level while for the bone level implants Engage driver was engaged to drive the implants to its final position at the level of the bone or just below it.

2.2 Grouping:

The implants (n=28) were divided into two main groups according to the implants design (n=14): Group A: fourteen tissue level implants further subdivided according to the cementation technique into two subgroups (n = 7):

- Subgroup A₁: Seven copings were cemented using the non-vented tack cure technique.
- Subgroup A₂: Seven copings were cemented using the occlusal vent hole technique.

Group B: fourteen bone level implants further subdivided according to the cementation technique into two subgroups (n = 7):

- Subgroup B₁: Seven copings were cemented using the non-vented tack cure technique.
- Subgroup B₂: Seven copings that were cemented using the occlusal vent hole technique.

2.3 Fabrication of the metal coping

For fabrication of the metal copings, the plastic copings for subgroups A₁ and B₁ were left intact without drilling any vent holes but for subgroups A₂ and B₂ vent holes were drilled occlusally with 1mm round bur [15] on the castable plastic copings. All the copings were sprued, invested and casted in non-precious nickel-chromium metal alloy (Realloy e.k, Sliemsky 50, Krefeld, Germany). Devesting and ultrasonic cleaning was performed and airborne-particle abraded using 50-Mm aluminum oxide particles.

2.4 Cementation technique of sub groups A₁ B₁

The metal copings were weighted before cement loading using analytical digital balance with readability of 0.0001 g (AS220.R2, RADWAG BALANCES AND SCALES, Radom, Poland). One click of RelyX U200 resin cement clicker dispenser (™3M, ESPE Dental Products. St. Paul, U.S.A.) was dispensed to standardize the amount of cement used. The metal copings were loaded with the cement and their weights were recorded. The exact amount of cement loaded was calculated. For subgroups A₁ and B₁ (non-vented tack cure technique), metal copings were cemented to the corresponding abutments with a fixed load of 5kg and kept in place for 3 minutes using a static load applicator (Device used to hold the specimen under static load designed by Dr. Amir Azer, Conservative Dentistry Department consisting of strong metal coil attached from the upper end to plastic plate to put the load on, and from its lower end to a loading member to transfer the load to the specimen) [16] (figure 1 A). The excess resin cement was initially light cured for 3 seconds [17] with Elipar™ LED curing unit (3M-ESPE, St. Paul, MN, USA.) with a light output (1200) mW/cm², then excess cement on the margins were peeled off at a gel state by a Teflon coated scaler (Figure 1 B and C).

2.5 Cementation technique of sub groups A₂ B₂

For subgroups A₂ and B₂ (occlusal vent technique), the excess cement that flowed out from the vent was removed using cotton pellet [15] then a fixed load of 5 kg was applied and kept in place for 3 minutes to cement the copings to the abutments using a static load applicator. Excess cement on the margins after application of the load was removed by Teflon coated scaler and super floss (Figure 2).

2.6 Examination of coping implant interface for both groups A and B

A proper visual examination of all groups at the coping implant interface was done, then complete light curing of the dual cure resin cement was performed for 20 seconds for each surface. The rubber surfaces on the models were sectioned using a scalpel and removed for the inspection of the cervical part of each implant for any residual excess cements (Figure 3). Cement remnants were carefully cleared with scalpel and weighted using the digital scale [16, 18].

2.7 Retained excess cement percentage calculation

The weight of excess cement for each implant was recorded and excess cement percentage was calculated (as following: excess cement remnants weight / amount of cement loaded weight X 100) and statistically analyzed.

2.8 Stereomicroscope

All specimens were visually examined from all sides under 30x magnification using Stereomicroscope (SZ-11, Olympus, Japan). Any remnants of cement were documented and photographed using a digital camera (E-330, Olympus, Japan) attached to the microscope.

3. Results

When sectioning the rubber surfaces, excess cement that escaped in the tissue level implants around the finish line and in the bone level implants also around the finish line and to the summit of the bone was found. The amount of cement loaded for each tissue level implant in group (A) was: 0.0455 g. The tissue level vent subgroup (A₂) showed more excess cement percentage than the tissue level tack cure subgroup (A₁) and the difference was statistically significant. ($Z_{(MW)}=2.366$ $p=0.018$) (Table 1) (Figure 4).

The amount of cement loaded for each bone level implant in group (B) was: 0.0236 g. The bone level vent subgroup (B₂) showed more excess cement percentage than the bone level tack cure subgroup (B₁) but the difference was not statistically significant. ($Z_{(MW)}=1.665$, $p=0.096$). (Table 2) (Figure 5) Excess cement in bone level implants showed more apical spread toward the bone than the tissue level implants (Figure 6).

The comparative study between tack cure and vent techniques regardless of the implant type showed that the excess cement percentage was more with the vent

technique and the difference was statistically significant ($Z = 2.873$, $P = 0.004$). (Table 3) (Figure 7)

Stereomicroscope examination at 30x magnification showed all the implants of both group A and B had small amounts of cement remnants remained microscopically. Subgroups A₂ and B₂ had completely seated copings margins in all the implants while subgroups A₁ and B₁ showed gap in four implants between the coping margins and the implants (Figure 8)

4. Discussion

This study was an attempt to find the approach to use the resin cement in bonding the casted copings to the abutments of implants at the tissue level and bone level without leaving any resin cement remnants that may affect the periodontium and implant health. Special models simulating the bone of the mandible with an artificial gingiva covering were selected for our study to imitate the clinical situation to get comparable results.

Tissue level and bone level non-sterile implants were selected for this study because of their different implant-abutment junction positions as the bone level implants were screwed at flush edge to the crestal bone, whereas, the tissue level implants were inserted up to the level of the micro-threads leaving a machined neck projecting above the bone level. [19]

The removal of excess cement material during the cementing procedure of the dental restorations is carried out in different ways. The available literature does not contain much data on the influence of the existing methods for removing the excess cement materials on the amount of excess cement retained after cementation.

Two techniques of cementation were selected for the current study; the first technique was the tack cure non-vented technique by removal of the extruded resin cement at the margins after partial photo-activation for 3 seconds, which let the cement reach a rubbery consistency to facilitate the cleaning of the excess. This technique was introduced by Hornbook [20] allowing the cement to achieve enough body for the excess to be easily peeled off in a semi-gel state.

The second technique was to vent the coping [21,15,22,23] expecting cement excess to escape occlusally. While at the margins of the vented copings, the excess cement was removed by non-metal scaler and super floss while the cement is still soft.

Although we tried to remove all the excess resin cement before final curing with two different techniques at two different levels of implants inside the bone, different amounts of excess resin cement that escaped subgingivally was found.

The results of our study showed that within the tissue level implant group, the non-vented tack cure technique showed less retained excess cement percentage than the occlusal vent technique and the difference was statistically significant. This could be due to the difficulty in removing the excess resin cement at the

margins whether by teflon scaler or super floss while it is still soft and sticky in the occlusal vent technique, while tack curing the excess resin cement transforms the sticky cement remnants into a rubbery state, which allow the clinician to remove more excess cement without causing much damage to the periodontium.

This coincides with Pereira et al [24] who found that the photo-activation prior to cement removal had facilitated the explorer to remove the excess cement before the final photo-activation. Also with Michelle Sunico and Armin [17] and Kaufman [25] who advised the use of tack curing to ease the excess resin cement removal.

The results of the bone level implant group in our study showed that the non-vented tack cure technique showed less retained excess cement percentage than the occlusal vent technique, but the difference was statistically not significant. This maybe due to the deep location of the implant-abutment interface; which make it more difficult to clean the excess cement in both techniques, thus leaving excess cement in both techniques that couldn't be seen or reached by the clinician during the cementation process. These results coincides with Carl Misch [26] who agreed and stated that when excess cement extrudes from the subgingival crown margins, the dentist has difficulty removing it especially when the implant body is countersunk below the crest of the residual bone, as in this type of implants the implant abutment flare is often placed near the crest of the residual bone which allow the excess cement to extends into a subgingival undercut of the abutment several millimeters below the free gingival margin and in an undercut below the flare.

Our results also showed that the apical spread of the excess cement in the bone level implants was more than in the tissue level implants, as it was found on the micro-threads of the implants inside the bone. This could be due to the position of this type of implants flushed with the level of the bone, which makes the excess cement directed easily towards the bone. While in the tissue level implants the smooth neck projecting above the bone prevented the cement from reaching such a deep position. Theses results coincide with Linkevicius et al [3] who found that the deeper the position of the cementation margin, the greater the amount of undetected cement on the implant was discovered.

When comparing the two methods of cementation used in the current study regardless of the type of the implant used, the results showed that the excess cement percentage was less with the non-vented tack cure technique than with the occlusal vent technique, and the difference was statistically significant. This might be due to removing the excess soft resin cement from the margins of the occlusal vent subgroups was a difficult and an uncontrolled procedure that may pushed the cement unintentionally further more subgingivally. This coincides with Hill et al[27] who agreed that excess resin cement removal is very difficult and usually done after a 2 to 5 seconds light cure to ease the clean up before final curing. And also with Hatrick et al[28] who advised the light curing of the excess resin cement for several seconds to facilitate the excess removal. And also with Mansour et al[29] who found that flicking-off the partially polymerized excess luting resin cement with a plastic hand instrument had removed the cement cleanly away from the surface of the tooth.

The stereomicroscope examination in the present study showed a space between the copings and the abutment margins in the tack subgroups in both implant types, while the occlusal vent subgroups showed completely seated copings margins on the implants abutments which maybe due to the effect of the vent in decreasing the hydraulic pressure created during seating of the restoration.[30] This finding was in accordance with Clark et al[31] who recommended the use of vents to reduce the excess cement pressure in the ceramic crowns, and also with Yeung et al[32] who found that the use of venting significantly decreased the cement excess and enhanced the marginal fit of implant abutments. Jones et al[33], Cooper et al[34] and Yeun and Wilson[35] also agreed with this finding as they found that the marginal adaptation of vented crowns was significantly better than that observed for non-vented crowns.

5. Conclusions

Following removal of excess luting resin cement using two methods of cementation, small amounts of cement remained adherent to the surface of all specimens at the coping-implant interface. Within the limitations of this in vitro study, it was concluded that tack curing of excess resin cement during the cementation of implant-supported restorations will reduce the cement residue, but still couldn't remove the problem of excess resin cement around dental implants. Implants inserted at the bone level might need extra precautions to avoid the problem of retained excess cement that may cause implant failure.

Conflict of interest

The authors declare that they have no conflicts of interest.

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Tables :**Table (1):**

Cement excess percentage (%)	Group	
	Tissue level implants non vented tack cure technique	Tissue level implants occlusal vent technique
n	7	7
Min-Max	3.5165-18.0220	13.6264-24.1758
Mean $\pm$ S.D.	8.5400 $\pm$ 6.0275	18.9953 $\pm$ 4.8978
95% CI of the mean	2.9655-14.1145	14.465-23.5249
Median (IQR)	5.0549 (4.3956-16.0440)	19.7802 (13.8462-23.7363)
KS test of normality	D=0.290, p=0.077 NS	D=0.249, p=0.200 NS
Test of significance (p value)	Z _(MW) =2.366 p=0.018*	

n: number of specimens

Min-Max: Minimum-Maximum

CI: Confidence interval

IQR: Inter-quartile range

KS: Kolmogorov-Smirnov test of normality

MW: Mann-Whitney U test

NS: Statistically not significant ($p \geq 0.05$)*: Statistically significant ($p < 0.05$)

Table (2):

Cement excess percentage (%)	Group	
	Bone level implants non vented tack cure technique	Bone level implants occlusal vent technique
n	7	7
Min-Max	4.2373-16.9492	6.3559-25.8475
Mean $\pm$ S.D.	11.1380 $\pm$ 5.0298	17.0097 $\pm$ 5.9746
95% CI of the mean	6.486-15.7898	11.4841-22.5352
Median (IQR)	9.3220 (7.6271-16.1017)	17.3729 (15.2542-21.1864)
KS test of normality	D=0.245, p=0.200 NS	D=0.242, p=0.200 NS
Test of significance (p value)	Z _(MW) =1.665 p=0.096 NS	

n: number of specimens

Min-Max: Minimum-Maximum

CI: Confidence interval

IQR: Inter-quartile range

KS: Kolmogorov-Smirnov test of normality

MW: Mann-Whitney U test

NS: Statistically not significant (p>0.05)

*: Statistically significant (p<0.05)

Table (3):

Cement excess percentage (%)	Group	
	Non vented Tack cure technique	Occlusal Vent technique
n	14	14
Min-Max	3.5165-18.0220	6.3559-25.8475
Mean $\pm$ S.D.	9.8390 $\pm$ 5.5011	18.0025 $\pm$ 5.3486
95% CI of the mean	6.6628-13.0152	14.9142-21.0906
Median (IQR)	8.2012 (4.3956-16.0440)	17.3729 (14.5055-23.2967)
KS test of normality	D=0.213, p=0.085 NS	D=0.135, p=0.200 NS
Test of significance (p value)	Z _(MW) =2.873 p=0.004*	

n: number of specimens

Min-Max: Minimum-Maximum

CI: Confidence interval

IQR: Inter-quartile range

KS: Kolmogorov-Smirnov test of normality

MW: Mann-Whitney U test

NS: Statistically not significant (p>0.05)

* : Statistically significant (p<0.05)

Legends for tables:

Table (1): Comparative study between tissue level non vented tack cure subgroup A₁ and occlusal vent subgroup A₂ in the excess cement percentages.

Table (2): Comparative study between bone level non vented tack cure subgroup B₁ and bone level occlusal vent subgroup B₂ in the excess cement percentages.

Table (3): Comparative study between non-vented tack cure technique and occlusal vent technique in the excess cement percentage regardless of the implant type.

Figures:

Figure 1:

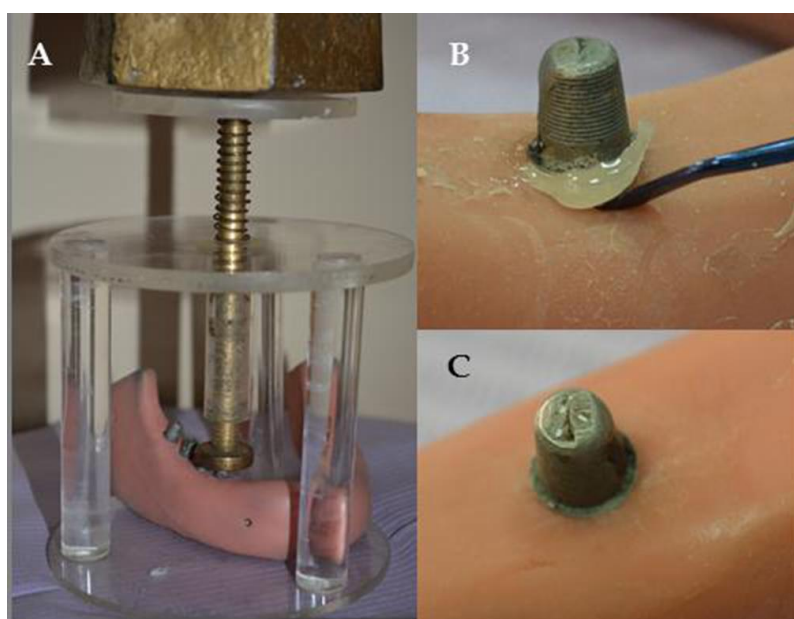


Figure 2:

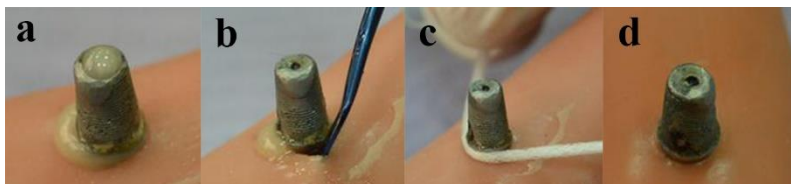


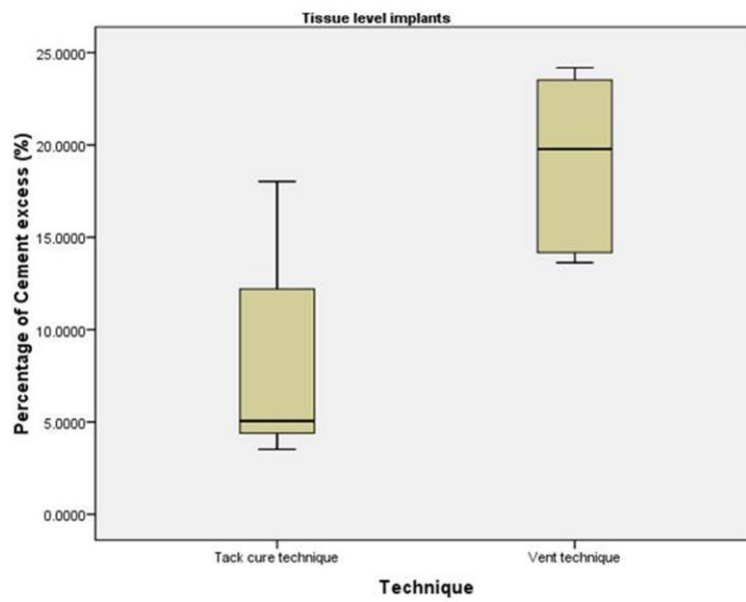
Figure 3:**Figure 4:**

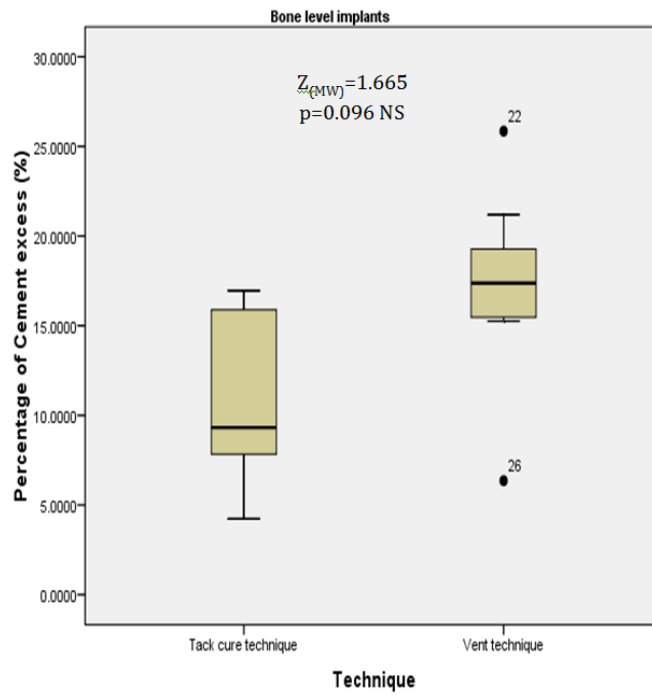
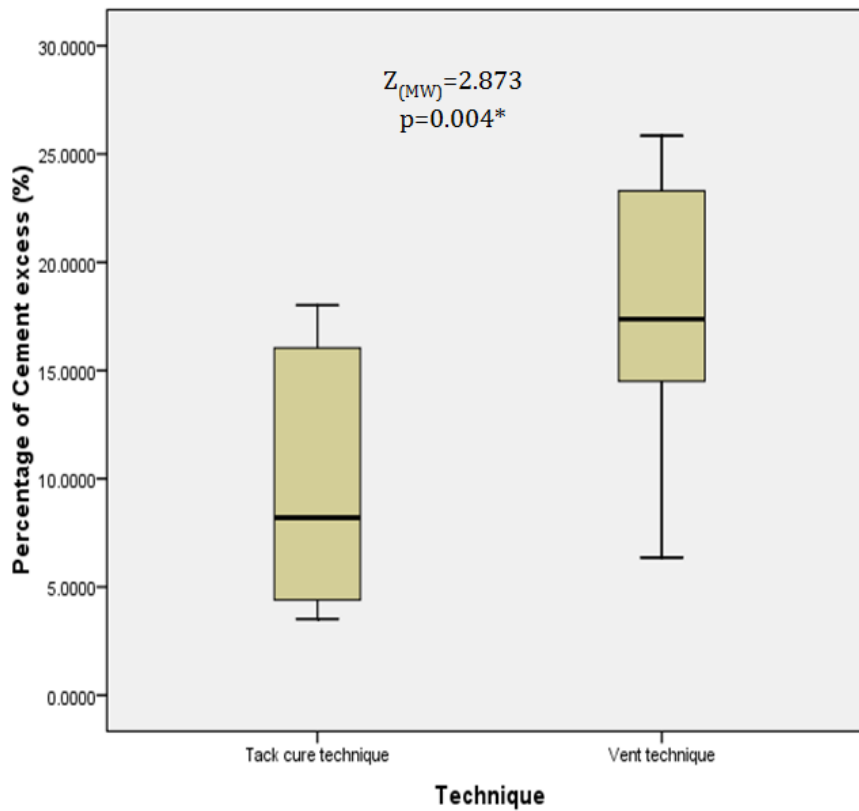
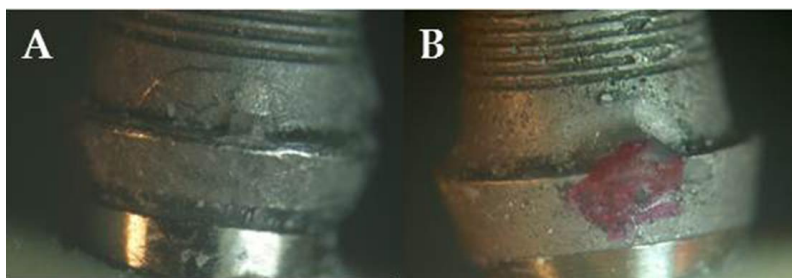
Figure 5:**Figure (6):**

Figure (7):**Figure 8:****Legends for figures:****Figure 1:**

(A) The static load device. (B) Excess cement peeled after tack cure cementation of subgroups A₁ and B₁. (C) The coping after cleaning and removal of the excess cement.

Figure 2:

(A) Excess cement flow out of the vent before removing it with cotton. (B) Excess cement on the margins removed by Teflon coated scaler. (C) Super floss used to remove the remaining excess cement. (D) The coping after total cleaning of the excess cement with Teflon coated scaler and super floss.

Figure 3:

Excess resin cement found after removal of the artificial gingiva.

Figure 4:

Box and whisker graph of cement excess percentage (%) in the tissue level implant subgroups, the thick line in the middle of the box represents the median, the box represents the inter-quartile range (from 25th to 75th percentiles), the whiskers represents the minimum and maximum.

Figure 5:

Box and whisker graph of cement excess percentage (%) in the bone level implant subgroups, the thick line in the middle of the box represents the median, the box represents the inter-quartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum.

Figure (6):

Excess cement extended under the bone to the implant micro-threads in bone level implants.

Figure (7):

Box and whisker graph of cement excess (g) in the studied groups, the thick line in the middle of the box represents the median, the box represents the inter-quartile range (from 25th to 75th percentiles), and the whiskers represent the minimum and maximum

Figure (8):

Stereomicroscope image (A) For subgroups A₁ and B₁ showing a gap between the coping margins and the implant. (B) For subgroups A₂ B₂ showing complete seating of the coping margins on the implant.