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THE EFFECT OF DIFFERENT METAL CLEANING METHODS ON RETENTION OF CAST CROWNS

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ABSTRACT

Statement of problem: Residual zinc oxide-eugenol cement may adversely affect retention of zinc phosphate cement. **Purpose of this study:** was to measure retention of cast restorations cemented with zinc phosphate cement after cleaning the fitting (internal) surfaces from residues of zinc oxide-eugenol provisional cement using different cleaning methods. Material and methods: Sixty standard stainless steel models of a standard complete crown preparation were prepared. Cast crowns using Type III dental alloy (Midas, Jclenko, N.Y, USA) were fabricated then cemented on their respective models using zinc oxide-eugenol cement (Temp Bond, Kerr, CA, USA). They were stored in artificial saliva at 37° for 7 days. The castings were separated from their models using a universal testing machine (Model 1197, Instron, UK). Cleaning of all models was done with a spoon excavator. Specimens were then equally divided into 6 groups of different cleaning methods of residues of zinc oxide-eugenol cement on the fitting surfaces of the cast restorations (hand cleaning, hand cleaning/ultrasonic cleaning, airborne-particle abrasion/ultrasonic cleaning, hand cleaning/ steam cleaning, airborne-particle abrasion/steam cleaning and chemical cleaning). Castings were cemented back using zinc phosphate cement then stored in artificial saliva at 37° for 7 days. Retention was measured using a universal testing machine. Data were statistically analyzed using Kruskal-Wallis, non-parametric one-way ANOVA and post-Hoc, non-parametric Tukey Type test. (Alpha value was set at 0.05). **Results:** Airborne-particle abrasion/ultrasonic cleaning showed the highest crown retention among other methods. Only airborne-particle abrasion/ultrasonic cleaning, hand cleaning/ultrasonic cleaning and hand cleaning/steam cleaning showed significantly higher crown retention than that of only hand cleaning (P=0.027). **Conclusion:** A combination of airborne-particle abrasion /ultrasonic cleaning, hand cleaning/steam cleaning and hand cleaning/ultrasonic cleaning produced significantly higher crown retention values than that of only hand cleaning.

INTRODUCTION:

Clinically, a cast restoration may be provisionally cemented using zinc oxide-eugenol (ZOE) cement. Later, it is carefully removed. Residues of ZOE cement on tooth surfaces, core materials and fitting surfaces of cast restorations should be cleaned prior to definitive cementation. Worley et al[1] found that the retention achieved with zinc phosphate cement residues on the tooth. It was found that ZOE pretreatment of a core buildup adversely affected the bond strength between the core and the definitive cement in all combinations of materials except the amalgam/zinc phosphate cement.[2] They concluded that zinc phosphate cement

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was the least affected by the presence of residual ZOE.[2] However, when resin core was pretreated with ZOE cement, studies showed that the crown that was luted with zinc phosphate cement did not have reduced retention.[34] The adverse effect of the provisional cement on the definitive bond strength of the porcelain laminate veneers was also reported.[5]

On a dentin surface, a provisional cement could not be mechanically removed, but actually it remained on the dentin surface.[6] However, Abo-Hamar et al [7] found that only the removal of the provisional cement from dentin surface by an excavator produced significantly higher bond strength than its removal by an intra-oral sandblasting. Ayad et al [8] used a spoon excavator followed by polishing with a prophylaxis paste to clean the tooth preparation from definitive cement. On the other hand, the use of soaps to remove remnants of provisional cement on dentin prior to adhesive cementation does not seem to be recommendable.[9] It was found that when the ZOE cement was removed from tooth surface with pumice and water, the bond strength was not affected by the residual eugenol as might be expected.[10]

Different cleaning methods of fitting surfaces of cast restorations is usually done to remove different contaminants and to improve retention of the castings. These methods are airborne-particle abrasion (microblasting),[11,16] steam cleaning,[14,15] ultrasonic cleaning,[13]- [14] organic solvent application [4,17] and combination of methods.[9,11,13] Since the residual provisional cement is a common contaminant of the fitting surface of the cast restoration, a more thorough cleansing method of residues of ZOE should be performed without adversely affecting the bond strength between the core material and the definitive cement.

The- aim of the study was to measure the retention of the cast restorations that were cemented with zinc phosphate cement after cleaning their internal surfaces from residues of zinc oxide-eugenol provisional cement using different cleaning methods.

MATERIAL AND METHODS

Sixty standard models of a standard complete crown preparation (Fig 1) were prepared on a milling machine (Universal Centre Lathe SN 40C-50C, TRENS, 911 32 Trencin, Slovak Republic) in stainless steel as was used by Glantz et al. [18] A uniform thickness of die spacer (Die Spacer Kit, CA, USA) was directly applied on each model. Blue inlay wax (Casting Wax, Whip Mix Corp., Kentucky, USA) was used to directly fabricate the wax pattern of the crown restoration. A wax loop was attached to-the occlusal surface of the wax pattern to facilitate testing of the tensile bond strength. The upper surface of the loop was made flat for application of the seating force during cementation. All wax patterns were sprued, immediately invested and cast using Type III dental alloy (Midas, Jelenko, N.Y, USA) by one operator. Internal surface of all castings received airborne-particle abrasion using 50um aluminum oxide at 60 psi. Fitting and marginal adaptation of all castings were checked and evaluated (Fig 1) by one operator. All cast crowns were provisionally cemented to their respective stainless metal models using zinc oxide-eugenol cement (Temp Bond, Kerr, CA, USA) that was mixed at room temperature following the manufacturer's directions. The cement was uniformly applied on'the internal surfaces of the cast crown that was seated on its respective model then a finger pressure was used followed by a static load of 5kg. Excess cement was carefully removed after complete setting. All specimens were stored in artificial saliva at 37°C for 7 days. The selection of the 7-day period of storage was supported by Abo-Hamar et al.[7] The cast crowns were then separated from their respective models using a universal testing machine (Model 1197, Instron, UK). All stainless steel models were cleaned using a spoon excavator (Excavator, Hu-Friedy, Chicago, USA) engaging res-

idues of ZOE cement followed by a water-air spray then dried well. The specimens were randomly and equally divided into 6 groups of 6 cleaning methods of the provisional cement. The cleaning methods are listed in table 1 as follows: hand cleaning using an excavator, hand cleaning followed by ultrasonic cleaning in distilled water for 10 minutes, airborne-particle abrasion of the internal surfaces of the castings using 50 urn aluminum oxide at 60 psi followed by ultrasonic cleaning in distilled water for 10 minutes, hand cleaning followed by steam cleaning for 5 minutes, airborne-particle abrasion of the internal surfaces of the castings using 50 um aluminum oxide at 60 psi followed by steam cleaning for 5 minutes and chemical cleaning using a solvent (Orange Solvent, Henry Schein Inc., N.Y, USA). Cleaning of all specimens was performed by one operator. Zinc phosphate cement (Fleck's cement, Mizzy, USA) was mixed on a glass slab at room temperature following the manufacturer's directions. The cement was uniformly applied on the clean and dry internal surfaces of all cast crowns that were seated on their respective models using a finger pressure followed by a static load of 5kg. Excess cement was carefully removed after complete setting. Cementation of all specimens was performed by one operator. All specimens were stored in artificial saliva at 37°C for 7 days. The base of each stainless steel model was mounted firmly to the lower jaw of a universal testing machine (Model 1197, Instron, UK). A hook engaging the u-shaped loop of the cast crown was connected to the upper member of the testing machine. Each specimen was then subjected to tensile forces along its long axis at a cross-head speed of 0.05 mm/min. All specimens were tested by one operator. The force required to dislodge each cast crown was recorded in N and the bond strength value (MPa) was calculated by dividing the force at which bond failure occurred (in N) by the prepared surface area of the model (in mm^2). The data were analyzed using SPASS (Ver.10). Kruskal-Wallis, non-parametric one-way ANOVA was utilized to analyze the data. post-Hoc, non-parametric Tukey Type test was also used.

Table 1: Groups of different methods of cleaning of zinc oxidc-eugenol provisional cement prior to definitive cementation with zinc phosphate cement

Group	Method of Cleaning
1	Hand Cleaning
2	Hand Cleaning/Ultrasonic Cleaning
3	Airborne-Particle Abrasion/Ultrasonic Cleaning
4	Hand Cleaning/Steam Cleaning
5	Airborne-Particle Abrasion/Steam Cleaning
6	Chemical Cleaning

RESULTS

Table 2 shows the bond strengths for the six groups. In general, combination of cleaning methods showed higher crown retention values than single cleaning methods. The highest mean shear stress value was found when airborne-particle abrasion was combined with ultrasonic cleaning (9.26MPa). A slightly less mean shear stress value was obtained when hand cleaning was combined with steam cleaning (9.12MPa). Almost similar mean shear stress values were found when airborne-particle abrasion/steam cleaning and hand cleaning/ultrasonic cleaning were compared (8.95MPa and 8.90MPa respectively). Chemical cleaning had a much lower mean shear stress value (8.38MPa) than those of the previous groups. The lowest mean shear stress value was found when only hand cleaning of-the fitting surface of the cast crowns was performed (7.24MPa). One-way non-parametric ANOVA showed that there was a significant difference between the groups (P=0.027). The post-Hoc non-parametric Tukey Type test showed that group 1 (hand cleaning) has sig-

Table 2: Descriptive statistics of bond strengths (in MPa).

Group No.	No. of Samples	Mean*	Std. Deviatior	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
1	8	7.2388[a]	1.3479	6.1119	8.3656
2	10	8.8950[b]	1.7563	7.6386	10.1514
3	9	9.2567[b]	1.4069	8.1752	10.3381
4	10	9.1170[b]	0.8477	8.5106	9.7234
5	10	8.9480[ab]	1.0548	8.1934	9.7026
6	10	8.3800[ab]	0.8912	7.7425	9.0175
Total	57	8.6775	1.3598	8.3167	9.0383

* Different alphabets show statistical significant difference.
Two specimens in group 1 and one specimen in group 3 were excluded.

Fig 1: Left: A standard stainless sleei model of a standard complete crown preparation. Right: A well-fitting cast crown seated on the stainless steel model with a loop for testing the tensile bond strength. Note the flat upper surface of the loop for application of seating force during cementation.

nificantly less mean shear stress than only groups 2, 3 and 4 (hand cleaning/ultrasonic cleaning, air-borne-particle abrasion/ultrasonic cleaning and hand cleaning/steam cleaning respectively).

DISCUSSION

In the present study, a stainless steel material was used as a model of prepared tooth structure. This material was selected by Glantz et al [18] as one of the artificial post materials because it is easier to prepare into standardized non-porous posts than other post materials such as amalgam. It should be noted that most clinical cores are a combination of a core material and a tooth structure. In such a combination, the dental cement may produce bond strengths quite different from those obtained with core material alone.[2] Also a higher retention of zinc phosphate cement was reported on metallic surfaces than on dentin and higher retention on steel than dental gold alloy. This was probably due to formation of chemical reaction substances bridging the cement-steel interface or portion of it.[18]

In the present study, provisional ZOE cementation was done for all cast restorations that were then stored for 7 days prior to their preparation for definitive cementation. A period of 7 days was considered appropriate for two reasons. First was to allow eugenol to diffuse into denim and eventually affect the bond strength. [7] But this is not considered in this study because a stainless steel core material was used. Second, was to allow an appropriate period of time a provisional restoration would be used under clinical conditions.[7]

In the present study, remnants of ZOE cement on all stainless steel cores were removed using a spoon excavator. Because cores of samples of this study were made in a stainless steel material that produces a relatively non-porous smoother surface texture than the dentin, mechanical cleaning using a spoon excavator may be quite sufficient.

In the present study, hand cleaning of residues of ZOE cement on the fitting surfaces of the cast restorations by the excavator resulted in the lowest crown retention (7.24MPa). Chemical cleaning with a solvent resulted in a higher crown retention (8.38MPa) than that of the hand cleaning, but not statistically significant. Although Hammad [14] studied the effect of different cleaning methods for removing residual materials other than ZOE cement, he also reported that mechanical and chemical cleaning with an organic solvent were not relatively efficient in removing them from the metal surfaces of the crowns. The two methods were also found to be not effective in improving retention.[14]

Several investigators used combinations of cleaning methods of the fitting surfaces of cast restorations. [8,13,14] In this study, all combinations of cleaning methods showed higher crown retention values than single ones. It was found that airborne-particle abrasion of the internal surface of type III gold crowns with 50um aluminum oxide improved the retention of the cast restoration cemented with zinc phosphate cement.[12] This is because debris and chemical contaminants are removed and at the same time minute roughness needed for mechanical interlocking is provided with the greatest resistance to shear stress.[13-19] It was also found that airborne-particle abrasion with aluminum oxide alone resulted in an increased concentration of alumina on the metal surface, as documented by x-ray EDA and microanalysis.[13-16] On the other hand, ultrasonic cleaning resulted in only a slight decrease in alumina contents of the metal by removing only loose alumina particles from its surface.[13] Thus the major part of alumina is firmly attached to the alloy surface.[13] In this study when a combination of airborne-particle abrasion and ultrasonic cleaning was used, the advantages of both cleaning methods were obtained which resulted in the highest crown retention (9.26MPa) that was significantly higher than that of only hand cleaning. Steam cleaning can also be used to clean the fitting surface of the cast restoration from debris[15] and residues of fit indicating materials.[14] A significantly highest crown retention was reported when only steam cleaning was used to clean the disclosing wax.[14] Although retention values of the combinations of airborne-particle abrasion /steam cleaning (8.95MPa) and hand cleaning/ultrasonic cleaning (8.90MPa) were almost similar in the present study, only the retention of the hand cleaning/ultrasonic cleaning was significantly higher than hand cleaning. However, Hammad [14] reported a significantly highest retention when a combination of airborne-particle abrasion and steam cleaning were used to clean the silicone fit indicator. Therefore, selection of .the best cleaning method of different contaminants on the fitting surfaces of the cast restorations is highly dependent on the type of the contaminant that could be saliva, different fit indicators or provisional cementing agents.

CONCLUSIONS

Within the limitations of this study, the following conclusions were drawn:

1. A combination of airborne-particle abrasion /ultrasonic cleaning, hand cleaning/steam cleaning and hand cleaning/ultrasonic cleaning can be used as alternative cleaning methods that produced significantly higher retention values than that of only hand cleaning method. Care should be taken to protect margins of cast restorations prior to airborne-particle abrasion.

2. Hand cleaning of the residues of ZOE cement on the fitting surface of the cast restoration produced the lowest retention value, but was not statistically significant when compared to airborne-particle abrasion/steam cleaning and to chemical cleaning.

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