Cumhuriyet Dental Journal, 26(4): 359-366, 2023
DOI: https://doi.org/10.7126/cumudj.1228240

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 Publisher: Sivas Cumhuriyet Üniversitesi

Investigation of the Effect of Mouthwash on Bonding Temporary Crown Materials with Various Temporary Cements

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Research Article

History

Received: 02/01/2023
Accepted: 13/12/2023

ABSTRACT

Objectives: This study aimed to investigate the effects of surface treatments and mouthwash on the shear bond strength of various temporary restorative materials using temporary cements.
Material and Methods: A total of 252 samples, measuring 10 mm in diameter and 2 mm in thickness, were prepared from three different temporary restorative materials, including polymethylmethacrylate with the CAD/CAM technique (Tempo Cad). and polymethylmethacrylate with the conventional method (Imicryl), nano-filled bis-acrylic composite (Protemp). Each temporary crown material was randomly divided into three separate groups, and surface treatments were applied. (Group1: no surface treatment, Group 2: air abrasion, Group3: hydrofluoric acid etching.) Two types of temporary cements (Tempbond and Dycal) were bonded to the surfaceof samples. Half of them were kept in mouthwash, while the other half were kept in distilled water as a control group (n=7). Shear bond strenght values of specimens were measured. To analyze the data, the Shapiro-Wilk test was used to assess compliance with a normal distribution. The data was then evaluated using a 3-Way Variance Analysis and a post-hoc multiple comparison test.
Results: The analysis of variance revealed that the interaction between the material used, the type of cement, and the material*cement*mouthwash was statistically significant ($p<0.001$). Additionally, the interaction between the mouthwash, material*mouthwash, and the mouthwash*cement was also found to be statistically significant ($p<0.05$).
Conclusions: Within the limitations of this in vitro study, it was found that sandblasting surface treatment increased shear bond strength. Mouthwash had a positive effect on the shear bond strength of polymethylmethacrylate-based temporary crown materials when calcium hydroxide-based temporary cements were used (CAD/CAM Group 1Bd, Group 2Bd and Imicryl Group 1Bd, Group 2Bd, Group 3Bd).

Keywords: Temporary Dental Restoration, Luting Agents, Dental Bonding, Surface Properties, Mouth Wash.

Gargaranın Geçici Kron Malzemelerinin Çeşitli Geçici Simanlarla Bağlanmasına Etkisinin Araştırılması

Süreç

Geliş: 02/01/2023
Kabul: 13/12/2023

ÖZ

Amaç: Bu çalışma farklı geçici restoratif materyallerin geçici simanlarla bağlanma dayanımına yüzey işlemleri ve ağız gargarasının etkisinin değerlendirilmesi amacıyla yapılmıştır.
Gereç ve Yöntemler: Üç farklı geçici restoratif materyal (polimetilmetakrilat esaslı CAD/CAM ile üretilen (Tempo Cad.) ve polimetilmetaktilat esaslı konvansiyonel metodla üretilen (Imicryl), kompozit esaslı (Protemp)) kullanılarak 10 mm çapında ve 2 mm kalınlığında toplam 252 örnek hazırlandı. Her bir geçici kuron materyali rastgele üç ayrı gruba ayrıldı ve yüzey işlemleri uygulandı (Grup 1: yüzey işlemi uygulanmayan grup, Grup 2: kumlama uygulanan grup ve Grup 3: hidroflorik asit uygulanan grup). Her yüzey işlem grubunun yarısına Tempbond, diğer yarısına Dycal geçici simanı uygulandı. Bu alt grupların da yarısı gargarada bekletildi; diğer yarısı distile suda bekletildi (n=7). Bağlanma dayanımı testi uygulandı. Normal dağılıma uygunluğu, verilerin Shapiro-Wilk testi ile incelenen verilerin analizi 3'lü varyans analizi ve çoklu karşılaştırma testi ile değerlendirildi.
Bulgular: Varyans analizi sonucunda; kullanılan materyal, siman türü ve materyal*siman*gargara etkileşiminin anlamlı ($p<0{,}001$), gargaranın, materyal*gargara ve gargara*siman etkileşimin istatistiksel olarak anlamlı ($p<0{,}05$) olduğu saptanmıştır.
Sonuçlar: Bu in vitro çalışmanın sınırlamaları dahilinde, kumlama yüzey işleminin, bağlanma dayanımını artırdığı tespit edilmiştir. Ağız gargarası, kalsiyum hidroksit esaslı geçici simanların kullanıldığı polimetilmetakrilat esaslı geçici kuron materyallerinde bağlanma dayanımına olumlu etki göstermiştir (CAD/CAM Grup 1Bd, Grup 2Bd and Imicryl Grup 1Bd, Grup 2Bd, Grup 3Bd).

Anahtar Kelimeler: Geçici restoratif materyaller, Geçici simanlar, Bağlanma dayanım direnci, Yüzey işlemi, Ağız gargarası.

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How to Cite: *Findik Aydiner S, Yesil Duymus Z, Yanıkoglu N. (2023) Investigation of the Effect of Mouthwash on Bonding Temporary Crown Materials with Various Temporary Cements, Cumhuriyet Dental Journal, 26(4):359-366.*

Introduction

Fixed prosthesis applications mostly involve tooth preparation using acrylic until the permanent restoration is delivered. In some cases, temporary restorations made of composite resin may be used. Temporary restorations serve to protect the prepared teeth from external factors and maintain the proper positioning of the teeth, ensuring the continuity of chewing function. It is essential for temporary restorations to maintain their physical integrity in the mouth in order to preserve the continuity of soft tissues and ensure the success of the planned treatment.[1]

Materials that can be used for fixed temporary prosthesis include polymethylmethacrylate (PMMA), urethane dimethacrylate (UDMA), polyethyl methacrylate, polyvinyl methacrylate, and bis-acryl composite resin materials.[2] PMMA and bis-acryl composite resin materials are commonly used in prosthetic dentistry.[3] These temporary restorative materials can be produced using conventional methods and can be polymerized using chemical, light, or both light and chemical methods.[4] Conventional methods for production include direct production in the oral environment or indirect production in the laboratory.[5] Additionally, digital design and production with CAD/CAM have significantly increased in recent years.[6]

Tooth preparation for fixed prosthetic restorations may be terminated at the gum margin or at the subgingival or supra-gingival margin. In tooth preparation, it is important to preserve the gingival tissues until the fixed prosthesis is cemented. The continuity of periodontal tissues is important for achieving an aesthetic appearance and ensuring the longevity of restorations. Thus, a proper temporary restoration is just as important as developing the patient's home care skills. In cases where oral hygiene cannot be maintained, the presence of gingival inflammation can lead to the deterioration of periodontal health. This can also result in the functional and aesthetic failure of restorations, as it can alter the color and shape of the gingiva.[7]

Mouthwashes with antimicrobial activity are used to control infections in the mouth, as well as to manage plaque and maintain the health of periodontal tissues. For this purpose, mouthwashes containing chlorhexidine gluconate and benzydamine hydrochloride are frequently preferred.[8] During prosthetic rehabilitation, especially for individuals who have undergone radiotherapy and chemotherapy, where the prevention of infection is crucial, the use of antibacterial agents such as mouthwash may be necessary until the final prosthesis is attached to the mouth after tooth preparation.[9]

Mouthwashes, which can be obtained from pharmacies without a prescription, contain organic acids, salts, antimicrobial agents, and dyes.[10] The hydroxyl groups found in alcohols such as Zr+4, Si+4 and Zn+2 can react with the cations of the composites. They dissolve in liquids and cause material loss.[11,12] Additionally, it is believed that benzydamine hydrochloride, an organic acid, can alter the surface of ceramic composites.[12]

Adhesive cements play a crucial role in enhancing the durability of restorative materials against the forces exerted during chewing in the oral environment.[13] Temporary cements, typically composed of a base and catalyst, commonly include calcium hydroxide and zinc oxide. There are also dual-cure temporary cements that are considered translucent resins.[14]

Cements should provide sufficient adhesion and sealing properties and should not be affected by fluids in the oral cavity. When removing restorations, it is preferable for the cements to remain on the restoration rather than the tooth, and for them to be easy to clean outside of the mouth.[14] This is why it is important to choose temporary cements that bond well to the restoration but have a weaker bond to the dentin. This helps to reduce the time spent with the patient during the trying on session.

Many factors are important for the success of restorations. Although *in vitro* studies have investigated the shear bond strength of cements to restorative materials, no study has been found that evaluates the effect of mouthwashes, which are frequently used in clinical practice, on this resistance. It is also observed that the impact of various surface treatments on the adhesion of temporary cements to temporary restorations has not been assessed. However, it is important to determine whether the use of a mouthwash, intended for maintaining the health of periodontal tissues, affects the shear bond strength when different surface treatments are applied. This is particularly relevant in the treatment of gingival damage that may occur both prophylactically and during the initial preparation period while temporary prostheses are in place in the oral cavity.

The aim of the current study was to assess the impact of surface treatments and mouthwashes on the shear bond strength of various temporary restorative materials using temporary cements.

The null hypothesis (H0) of this study is that the use of mouthwash will decrease the shear bond strength between temporary cements and temporary restorations. The H1 hypothesis is that surface treatments will enhance the shear bond strength.

Material and Methods

This study was approved by the Ethics Committee during the meeting held at Atatürk University Faculty of Dentistry (Date: 03.09.2021 Issue No: 50).

In the main hypotheses of the research, the differences, and interactions between multiple-group independent parameters (with 8 degrees of freedom and 3 parameters) were planned to be investigated, and the sample size was calculated at a 95% confidence level using the G Power-3.1.9.2 program. According to the analysis result, the minimum sample size calculated as 249, based on a theoretical power of 0.80, α value of 0.05, and a standardized effect size of 0.25. The sample size was taken as 252 to ensure that the number of observations in the groups was equal.

In the study, a total of 252 specimens were prepared from three different temporary restorative materials. Each specimen had a diameter of 10 mm and a thickness of 2 mm. The specimens were divided into three groups, with 84 pieces of Tempo Cad., 84 pieces of Imicryl, and 84 pieces of Protemp. Sample sizes were controlled by measuring with a digital caliper (Muva Dijital Kumpas IP54).

With the CAD/CAM technique, samples were prepared from polymethylmethacrylate (PMMA) blocks (Tempo Cad., On-Dent Ltd, Izmir, Turkey) following digital design.

In the conventional method, materials were prepared according to the manufacturer's instructions and then placed in metal molds with circular cavities. Cadmium-free polymethylmethacrylate (Imicryl Imident, Konya, Turkey) was prepared using this method.

Nano-filled bis-acrylic composite (3M ESPE Protemp™ 4, 3M Deutschland GmbH Dental Products, Carl-Schurz-Str. 1, 41453 Neuss, Germany) was prepared by mixing with an automatic mixer.

In order to eliminate any irregularities on the surfaces of the samples and achieve a smooth surface, the specimens were polished using a 600-grit silicon carbide paper under water for 15 seconds. After polishing, the specimens were cleaned in a distilled water bath using ultrasonic waves for 5 minutes. The temporary restorative material groups were then randomly divided into three groups (n=28) for surface treatment: no treatment, air abrasion, and hydrofluoric acid etching.

- Group 1 (No Surface Treatment): No surface treatment was applied to the samples.
- Group 2 (Air Abrasion): The samples were sandblasted using an abrasion device (Zhermack, Rovigo, Italy) for 10 seconds. 50 µm aluminum oxide (Al2O3) particles were applied at a pressure of 2.8 bar from a distance of 10 mm.
- Group 3 (Hydrofluoric Acid Etching): After applying a 4% hydrofluoric acid gel as a thin layer (Porcelain etchant, Bisco, Schaumburg, IL, USA) to the samples for 120 seconds, they were washed for 120 seconds and dried.[15]

Two different temporary cements (Temp-Bond, Dycal) are applied to the samples after surface treatments. The descriptions of the cement and temporary restorative materials included in this study are summarized in Table 1.

Temporary cements containing eugenol (Temp-Bond™, Kerr, Italy) and calcium hydroxide cement (Life Regular Set, Kerr, Italy) were mixed and prepared according to the manufacturer's recommendations. To apply the cement, a silicone mold with an inner cavity diameter of 5 mm and a height of 4 mm was prepared. The cylindrical mold was prepared and positioned in the center of the samples. The cement was then placed in each mold, covered with cellulose tape, and left to harden while the same operator applied pressure with a finger. By cutting the silicone mold with a scalpel, the samples were carefully removed and placed in distilled water at 37°C for 24 hours.

Half of the samples (n=7) were soaked in distilled water at 37°C for one week before measuring the shear bond strength. This group served as the control group. The other half of the samples (n=7) were soaked with mouthwash for four minutes daily for one week. They were kept in 20 ml of mouthwash (Kloroben, Drogsan, Turkey) for a total of 28 minutes, which is considered equivalent to the same time.[16] This procedure resulted in 12 different treatment subgroups for each temporary restorative material, as shown in Figure 1.

Samples were prepared using auto-polymerizing acrylic resin (Imicryl, SC, Konya, Turkey) in silicone molds with a diameter of 15 mm and a height of 20 mm. The samples were embedded in accordance with the test device in which the experiment would be conducted. Subsequently, they were washed in an ultrasonic cleaner for 15 minutes and dried with blotting paper.

To measure the shear bond strength, the samples were affixed to the bottom of the universal tester (Instron, Model 2710-003, Instron Corp., USA). A knife-edge tip was placed on the opposite end of the test device. Loading was done with a head speed of 0.5 mm/min. The maximum load was recorded when the fracture occurred. Shear bond strength was calculated by using the following formula.[15]

The shear bond strength (σ) is calculated using the formula $\sigma = F / A$, where σ represents the shear bond strength in MPa, F represents the load at failure in N, and A represents the repaired area in mm^2.

Statistical Analysis

Statistical analysis was performed using the SPSS Statistics 20.00 software (SPSS Inc., Chicago, IL, USA) at a 95% confidence interval and a significance level of p=0.05. The normal distribution conformity of the variables was examined using the Shapiro-Wilk test, which is one of the analytical methods, and it was found to be appropriate. The data obtained in this study were evaluated using a 3-Way Variance Analysis and a post-hoc multiple comparison test.

Results

According to the analysis of variance (Table 2), a significant triple interaction was found between material type, mouthwash, and cement (p<0.001). The interactions between mouthwash and material, mouthwash and cement, and material and mouthwash had a statistically significant effect on the shear bond strength (p<0.05). Other interactions were not significant (p>0.05).

The mean shear bond strength values and the corresponding standard deviations for all groups are presented in Table 3. The highest shear bond strength (0.85 MPa) was found in the Imicryl Group 3Bd samples, while the lowest shear bond strength (0.11 MPa) was determined in the Protemp Group 3Ac samples.

As a result of the multiple comparison (Tukey) test conducted on the samples adhered with Tempbond (a cement containing eugenol), a statistically significant difference was observed at the p<0.001 level in the following cases:

- In the CAD/CAM Group 1Ad samples,
- In the Imicryl Group 3Ad samples,

As a result of the multiple comparison (Tukey) test of the samples adhered with Dycal (calcium hydroxide cements), a statistically significant difference was detected at the p<0.001 level in the following variables:

- In the CAD/CAM Group 3Bc samples,
- In the CAD/CAM Group 3Bd samples,
- In the Protemp Group 1Bc samples,
- In the Protemp Group 3Bd samples,
- In the Imicryl Group 3Bd samples,

As a result of the multiple comparison (Tukey) test of the interaction between material, mouthwash, and cement, a statistically significant difference was detected at the p<0.001 level in the following variables:

- In the Imicryl Group 1Bd samples,
- In the Imicryl Group 3Bd samples,
- In the Imicryl Group 2Bd samples,
- In the Imicryl Group 2Bc samples,
- In the Protemp Group 2Bc samples.

Figure 2 shows the distribution of the shear bond strength among the subgroups in this study.

In the polymethylmethacrylate material prepared with CAD/CAM, the highest bond strength value was obtained as 0.84 MPa in Group 1Bd samples, and the lowest bond strength value was obtained as 0.12 MPa in Group 3Ad samples.

In the polymethylmethacrylate-based Imicryl material prepared by the conventional method, the highest bond strength value was obtained in Group 3Bd samples (0.85 MPa), while the lowest bond strength value was obtained in Group 1Ad samples (0.33 MPa).

In bis-acrylic composite-based Protemp samples, the highest bond strength value was obtained in Group 2Bc samples (0.67 MPa), while the lowest bond strength value was obtained in Group 1Ad and Group 3Ac samples (0.11 MPa).

The highest bond strength value in the control group (Group 1), where no surface treatment was applied, was obtained in the CAD/CAM Group 1Bd samples (0.84 MPa). This group was followed by Imicryl Group 1Bd (0.73 MPa) and Protemp Group 1Bd (0.39 MPa).

Among the sandblasted Group 2 samples, the highest bond strength value was obtained as 0.78 MPa in the CAD/CAM Group 2Bd and Imicryl Group 2Bc samples. These groups were followed by Imicryl Group 2Bd with a value of 0.75 MPa and Protemp Group 2Bc with a value of 0.67 MPa.

The highest bond strength value in Group 3 samples treated with hydrofluoric acid was obtained in Imicryl Group 3Bd samples (0.85 MPa). This group was followed by Protemp Group 3Bc (0.59 MPa) and CAD/CAM Group 3Bd (0.47 MPa).

Discussion

The null hypothesis (H0) of this study was rejected because it was found that the use of mouthwash had varying effects on the bond strength of temporary cements to temporary restorations. In some groups, it increased the bond strength, while in others, it decreased it. Sandblasting surface treatment increased the shear bond strength. However, the hydrofluoric acid applied groups yielded lower results compared to the control group. As a result, the H1 hypothesis was partially accepted and partially rejected.

The type of luting cement used and the surface properties of the temporary material, as well as the liquids they are exposed to in the mouth, can affect the performance of temporary restorative materials, preventing them from being dislodged during their time in the mouth.[17] This study's findings confirm this situation and establish that the type of material, the cement used, and the use of mouthwash are statistically significant factors. The temporary restorative materials used in this study are polymethylmethacrylate-based and composite-based materials. These temporary restorative materials are frequently used in the clinic.[3] As temporary cement, it is preferred to use cements that are easy to apply and readily available in every clinic. Sandblasting is an easy-to-apply and effective surface treatment method used to increase bond strength.[18] It has been found to enhance the bond strength between the polymer and the surface by promoting micromechanical adhesion.[19,20,21]

The study has shown that the application of hydrofluoric acid softens the surface of polymethylmethacrylate and makes it smoother.[15] In this study, it was found that the bond strength increased in CAD/CAM Group 3Ac compared to CAD/CAM Group 1Ac, but decreased in CAD/CAM Group 3Bc and Group 3Bd when using calcium hydroxide cement. A decrease in cement bond was detected in Protemp Group 3Ac. An increase in cement bonding was observed in Protemp Group 3Ad when mouthwash was used. This may be due to the difference in the chemical composition of the cements and their potential interaction with mouthwash, rather than the surface properties of the samples.

Cements containing calcium hydroxide are tissue-friendly cements that can neutralize acids. It acts as a barrier by preventing the passage of acid through neutralization and blocking agents such as methyl methacrylate from entering the pulp. These cements contribute to the remineralization of the carious dentin structure and exhibit antibacterial activity when the calcium hydroxide (CaOH) present in the cement is released.[22] Eugenol-containing cements harden through the substitution of eugenol with water. It has several disadvantages, including low strength, poor abrasion resistance, and dissolution in oral liquids.[23] Chlorhexidine binds to surfaces in the oral cavity and continues to have an effect through slow release.[24] A study found that Chlorhexidine significantly reduced bond strength, which was attributed to the increase in chlorine detected in the

SEM and EDS analyses conducted for surface analysis.[25] It has been suggested that chlorine reduces the connection through chemical interaction. It has also been reported that chlorhexidine increases the release of calcium from dentin surfaces and leads to a decrease in calcium levels.[25] However, another study found that chlorhexidine did not have any negative impact on shear bond strength.[26]

In this study, the bond strength of CAD/CAM Group 3Ac samples (0.40 MPa) increased compared to the bond strength of CAD/CAM Group 1Ac samples (0.23 MPa). However, the bond strength of CAD/CAM Group 3Bc samples using calcium hydroxide cement (0.27 MPa) decreased. It was determined that the bond strength of group 1Bc samples decreased by 0.37 MPa. It is observed that the decrease in bond strength is proportionally greater when using mouthwash (CAD/CAM Group 1Bd: 0.84MPa, CAD/CAM Group 3Bd: 0.47MPa). The presence of chlorhexidine in mouthwash may have had a detrimental impact on the bond strength by causing the release of calcium from the calcium hydroxide-based cement.

In this study, an increase was found in the shear bond strength of all the sandblasted samples compared to the samples in the control group. This finding is consistent with studies that have indicated that sandblasted surfaces create micro-retention areas by enhancing the adhesion of cements through mechanical locking.[27-29]

In a study assessing the retentive properties of various temporary cements on temporary crowns, it was found that calcium hydroxide cements exhibited greater retention on polymethylmethacrylate resins compared to Tempond (Ca(OH)2: 795 kPa; Temp-Bond: 714 kPa).[30] The study also revealed that the shear bond strengths of calcium hydroxide cements, with the exception of CAD/CAM Group 3Bc and Imicryl Group 3Bc, were higher than those of Tempbond. The fact that the temporary crown is more retentive may be related to proper preparation, as well as its shear bond strength.

According to the results of this in vitro study, the choice of material type and cement should be made in accordance with each other. It is known that cements containing eugenol are incompatible with resin polymers.[17] As Protemp is based on bis-acrylic composite, it has been advised not to use a cement that contains eugenol should not be used.[29] The findings of this study support this recommendation. It was also found in this study that the sandblasting surface treatment applied to the bisacryl composite-based temporary restorative material increased the bonding of the eugenol-containing cement.

Only one type of mouthwash was used in the study. Mouthwash containing 0.12% chlorhexidine gluconate and 0.15% benzydamine hydrochloride was used because it is considered the "gold standard" in such studies and is widely used in the clinic.[8] Chlorhexidine gluconate is a commonly used agent known for its high antimicrobial activity against bacteria, viruses, and fungi.[31,32]

In previous studies, it has been stated that exposing the samples to a mouthwash for 24 hours is equivalent to gargling for two minutes twice a day for one year.[16] The chosen 28-minute period in this study corresponds to one week of use. According to the manufacturer's instructions, it is recommended not to use the mouthwash for longer than one week.[33] It is important to note that prolonged use of mouthwash may result in taste disturbances and allergic reactions, in addition to tooth and restorative material discoloration.[34] It was observed that while the use of mouthwash decreased shear bond strength in certain samples, it actually increased it in others.

If mouthwash is not used, there are numerous foods and beverages that can increase acidity at different temperatures. One limitation of the research is that it was an *in vitro* study, which means it was unable to fully simulate the conditions inside the mouth. However, the use of the shear test is important for ensuring the reliability of the study, as shear bond strength results are commonly used in testing.[35]

Conclusions

It is important to consider changes that may adversely affect the shear bond strength of temporary restorative materials. Many factors, other than the use of mouthwash, can cause changes in the teeth and restorative materials in the mouth. Better bond strength can be achieved in temporary crowns with sandblasting compared to those without any surface treatment. In cases where mouthwash is recommended, it is advisable to use sandblasting surface treatment. Additionally, it is preferable to use temporary crown materials that are based on polymethylmethacrylate, and temporary cements that are based on calcium hydroxide. It is necessary to support the potential surface treatments with alternative temporary crown materials and conduct additional studies that encompass various temporary cements.

Acknowledgements

The authors received no financial support for the research, authorship, and/or publication of this article.

Conflicts of Interest Statement

The authors have no conflicts of interest

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Table 1. Compositions, manufacturers and manufacturing type of the cement and temporary restorative materials used in the study.

	Compositions	Manufacturer	Manufacturing Type
Temporary Restorative Materials	polymethylmethacrylate	Tempo Cad., On-Dent Ltd, Izmir, Turkey	CAD/CAM
	cadmium-free polymethylmethacrylate	Imicryl Imident; Konya, Turkey	Conventional Method (powder and liquid)
	nano-filled bis-acrylic composite	3M ESPE Protemp™ 4, 3M Deutschland GmbH Dental Products Carl-Schurz-Str.1 41453 Neuss-Germany	Conventional Method (with gun system that provides automatic mixing)
Temporary Cements	containing eugenol	Temp-Bond™, Kerr, Italy)	Self-curing(base and catalyst)
	calcium hydroxide cement	Life Regular Set, Kerr, Italy	Self-curing(base and catalyst)

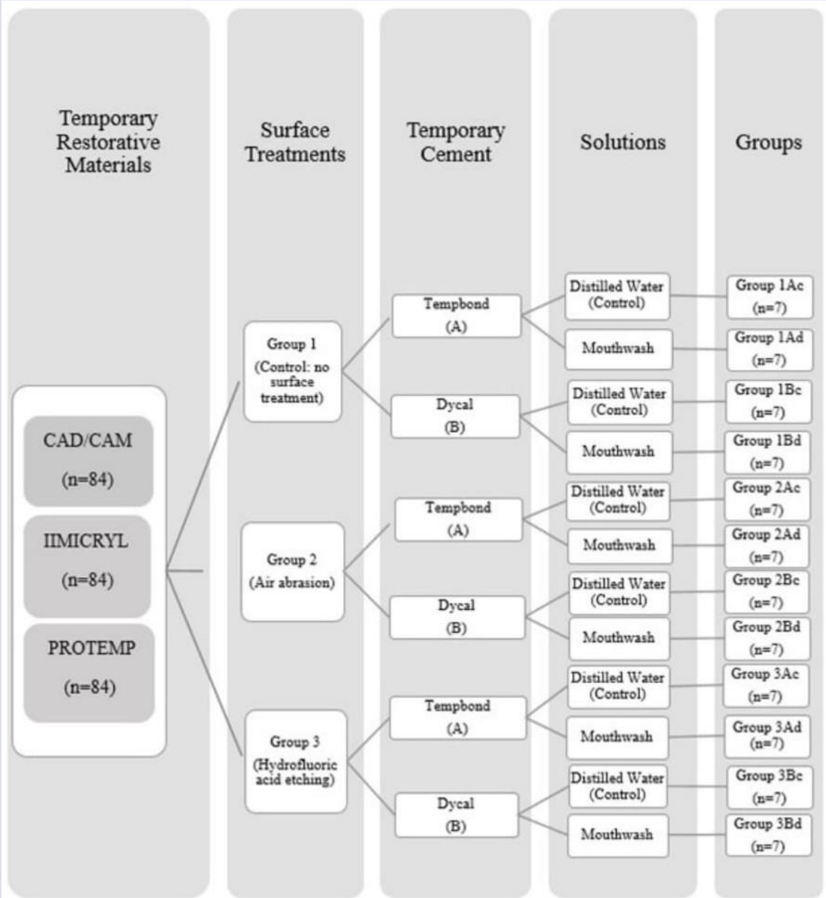
Table 2. Varyans analys of shear bond strenght

	Sum of Squares	df	Mean Square	F	p
Material	4.62	8	0.58	12.70	< .001
Mouthwash	0.25	1	0.25	5.48	0.020
Cement	2.49	1	2.49	54.72	< .001
Material x Mouthwash	0.76	8	0.10	2.09	0.038
Material x Siman	0.39	8	0.05	1.07	0.384
Mouthwash x Siman	0.25	1	0.25	5.59	0.019
Material x Mouthwash x Cement	1.56	8	0.20	4.30	< .001

Table 3. Mean (MPa) and standard deviation results of the obtained data.

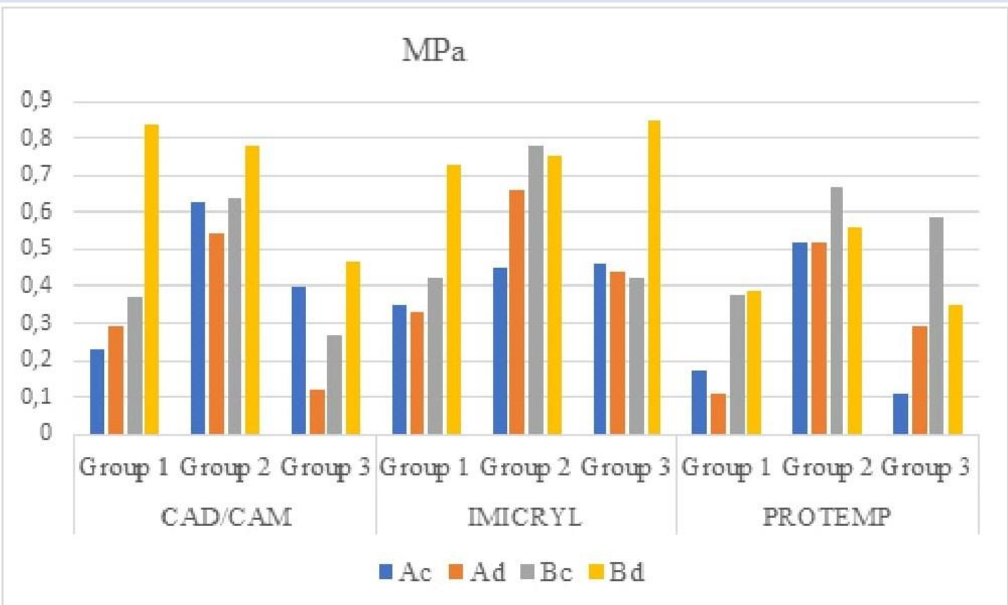
		Tempbond (A)				Dycal (B)			
		Distilled Water (Ac)		Mouthwash (Ad)		Distilled Water (Bc)		Mouthwash (Bd)	
MATERIALS	SURFACE TREATMENTS GROUPS	Means	SD	Means	SD	Means	SD	Means	SD
CAD/CAM	Group 1	0.23	0.13	0.29	0.13	0.37	0.26	0.84	0.13
	Group 2	0.63	0.18	0.54	0.13	0.64	0.19	0.78	0.37
	Group 3	0.40	0.16	0.12	0.04	0.27	0.12	0.47	0.27
IMICRYL	Group 1	0.35	0.18	0.33	0.14	0.42	0.23	0.73	0.24
	Group 2	0.45	0.22	0.66	0.20	0.78	0.9	0.75	0.27
	Group 3	0.46	0.10	0.44	0.29	0.42	0.14	0.85	0.29
PROTEMP	Group 1	0.17	0.21	0.11	0.13	0.38	0.16	0.39	0.20
	Group 2	0.52	0.20	0.52	0.14	0.67	0.23	0.56	0.36
	Group 3	0.11	0.14	0.29	0.22	0.59	0.14	0.35	0.15

((Group1: no surface treatment, Group 2: air abrasion, Group 3: hydrofluoric acid; A: Tempbond, B: Dycal; C: distilled water, d: mouthwash)



(A: Tempbond, B: Dycal; c:distilled water, d: mouthwash code)

Figure 1. Procedures overview of the study



(Group1: no surface treatment, Group 2: air abrasion, Group 3: hydrofluoric acid; Ac: Tempbond in distilled water, Ad: Tempbond in mouthwash, Bc: Dycal in distilled water, Bd: Dycal in mouthwash)

Figure 2. Distribution of bond strength of luting cements