Original Article

An *In vitro* Study to Evaluate the Effect of Eugenol-free and Eugenol-containing Temporary Cements on the Bond Strength of Resin Cement and Considering Time as a Factor

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Abstract

Aims and Objectives: The aim of this study was to assess the outcome of eugenol-free and eugenol-containing cements on the bond strength of resin cement.
Materials and Methods: Dentin was exposed in five groups of extracted teeth (20 specimens each). In Group 1, specimens were not given temporary cementation. In Groups 2 and 3, specimens were given temporary restoration fixed with eugenol-free temporary cement for 7 and 14 days, respectively. In Groups 4 and 5, specimens were given temporary restoration fixed with eugenol-containing temporary cement for 7 and 14 days, respectively. Permanent cementation was done for all groups after specified period of time. Shear bond strength testing of specimens was carried under universal testing machine. The data were analyzed by SPSS for Windows (version 14) statistical package (SPSS Inc., Chicago, IL, USA).
Results: One-way analysis of variance test revealed that Group 1 specimens produced higher shear bond strength than Groups 2, 3, 4, 5 and the difference was statistically significant ($P < 0.001$). In Groups 2, 3, 4, and 5, no significant difference in shear bond strength was observed between provisional restoration with eugenol-containing zinc oxide cement and provisional restoration with eugenol-free zinc oxide cement ($P = 0.095$).
Conclusion: The findings of this *in vitro* experiment lend no support to the common opinion that eugenol-containing cements should be avoided as temporary cement.

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Introduction

There have been many recent advances in the field of fixed prosthodontics, both in materials such as luting agents as well as technique wise. Luting agents such as resin cements are used to fix restorations to prepared teeth. Soon after tooth preparation, a temporary restoration is given to protect pulp and also for esthetic purpose. These interim restorations are normally fixed using a zinc oxide-eugenol (ZOE)-luting material.[1]

The advantages of ZOE cement are that it gives excellent seal, has a sedative effect on prepared sensitive teeth, cost-effectiveness, and ease of removal of cemented temporary restorations. However, these materials have the disadvantage that eugenol hinders the polymerization of resin cements that are used to fix final restorations. For this reason, eugenol-free cements with essential oils in place of eugenol were introduced, which were found to have acceptable dentin binding strength.[2]

Tooth preparation usually exposes dentin, and hence, luting agents should possess property of being able

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to bond with the dentin. Eugenol used in cements for fixation of temporary restoration can penetrate into dentin and might affect adhesion of resin cements that are used for fixation of permanent restorations at a later stage. Hence, few authors suggested to use noneugenol cements for fixing interim restorations.[1,3]

We conducted this study to evaluate the shear bond strength of self-adhesive resin cement to dentin surface after the treatment with two types of temporary cements one containing eugenol and other without eugenol. Ours is first study which compares effect of eugenol on resin bond strength taking time into consideration.

Materials and Methods

Hundred extracted intact human teeth were collected and study sample size was selected after carrying out a pilot study. The *in vitro* study was carried out from January 2015 to June 2015 after obtaining Institutional Ethical Committee approval (reference number: 269/SSCDS/IRB-E/2012). The residual soft tissue was mechanically removed and teeth were cleaned and stored in normal saline solution until use.

Preparation of specimens

The teeth were mounted in self-cure acrylic resin blocks [Figure 1], such that their incisal or occlusal surface faced upward. For this, a rectangular block of size, 8 mm × 8 mm × 10 mm, was prepared with wax and duplicated with silicon-duplicating material. Autopolymerizing acrylic resin monomer and polymer were mixed in a porcelain jar in 3:1 ratio, so that a pourable consistency of resin was formed. It was poured in the silicon mold and teeth were placed in the center of the mold until the root part was immersed in the acrylic resin and the tooth was perpendicular to the floor.

Figure 1: Teeth mounted in self-cure acrylic resin blocks

Fabrication of provisional restorations

Provisional restorations were made with self-cure tooth-colored acrylic resin. A metal model of size 4 mm × 4 mm × 2 mm was fabricated, which was then duplicated using a silicon-duplicating material, silicon mold of size 4 mm × 4 mm × 2 mm was obtained. Polymer was mixed with monomer so that a pourable consistency of self-cure tooth-colored acrylic resin was formed. Sufficient amount of mixed material was placed in silicon mold and then placed in pressure pot for curing under pressure of 30 psi. Provisional restorations of size 4 mm × 4 mm × 2 mm were formed.

Fabrication of final restorations

Final restorations were prepared with nickel-chromium alloy. The prepared silicon mold was used to make hundred inlay wax blocks of size 4 mm × 4 mm × 2 mm. Sprues of 5 mm length were attached to the wax blocks and invested with deguvest investment material, keeping the powder liquid ratio of 150 g: 30 ml, 50% of distilled water and 50% of deguvest investment liquid was used. The furnace was preheated to 8000°C and the muffle was placed inside the furnace. Following which temperature of the furnace was raised to 9000°C and holding time was set to 40 min. The casting was carried out in ceramic crucible in centrifugal casting machine when the metal was liquefied with the flame. The muffle was cooled to room temperature before divesting. To avoid the dust while divesting, the muffle was placed in the water bath.

Following which fabricated metal blocks were sandblasted (110 μ) to remove the residual investment material at 6 bars pressure. Then, sprue cutting was done using a thin carborundum disc in alloy grinder. The obtained metal blocks were finished and polished using universal polishing paste.

The enamel layer of any one axial surface of tooth specimen was removed using a diamond bur to form a flat superficial dentin surface in the middle-third of the tooth of size >5 mm × 5 mm. These dentin surfaces were air dried and carefully checked for the absence of enamel. These teeth were randomly divided in to five groups as follows:

- Group 1: 20 teeth-control group, without temporary restoration
- Group 2: 20 teeth-temporary restoration done with noneugenol cement and stored in artificial saliva for 1 week
- Group 3: 20 teeth-temporary restoration done with noneugenol cement and stored in artificial saliva for 2 weeks
- Group 4: 20 teeth-temporary restoration done with eugenol cement and stored in artificial saliva for 1 week
- Group 5: 20 teeth-temporary restoration done with

eugenol cement and stored in artificial saliva for 2 weeks.

After that provisional restoration was fixed with any one of the following provisional cements on prepared teeth specimens as per the group specifications [Figure 2] (a) ZOE temporary cement, (b) Zinc oxide-noneugenol temporary cement.

The provisional cements were mixed according to the manufacturer's instructions and applied on the restoration base, which was seated over a delimited dentinal area under finger pressure and allowed to set. Excess cement was removed and the specimens were stored at room temperature in artificial saliva for 7 or 14 days as per the group specification [Figure 3]. After the period of storage, the provisional restorations were removed using an explorer and teeth were cleaned devoid of any temporary cement remnants using a hand scaler and air dried. They were visually inspected for the absence of any remnant of temporary cement.

The permanent restoration blocks were cemented on teeth specimens of all the groups. For this self-etching, dual cure resin cement was mixed according to the manufacturer's instructions and placed on the base of permanent restoration blocks, which were then seated under finger pressure over the delimited dentinal area which was previously occupied by provisional restoration in Groups 2, 3, 4, and 5 and without any provisional restoration in Group 1. After the initial setting, excess cement was removed with explorer tip. Permanent cemented specimens were allowed to dry for 30 min before they were stored in 100% humidity for 24 h at room temperature. The bond strengths of the respective groups were then tested, 24 h after definitive cementation, using the universal testing machine with a crosshead speed of 0.5 mm/min until failure [Figure 4].

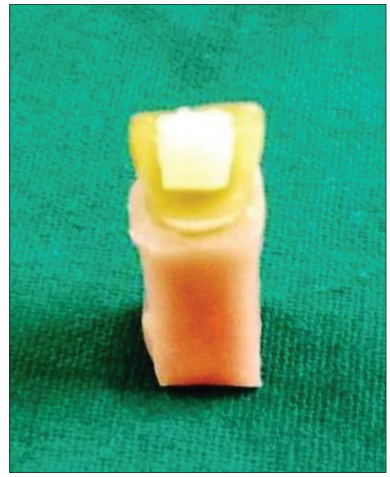

Figure 2: Tooth specimen with acrylic block cemented

Figure 3: Specimens were stored at room temperature in artificial saliva

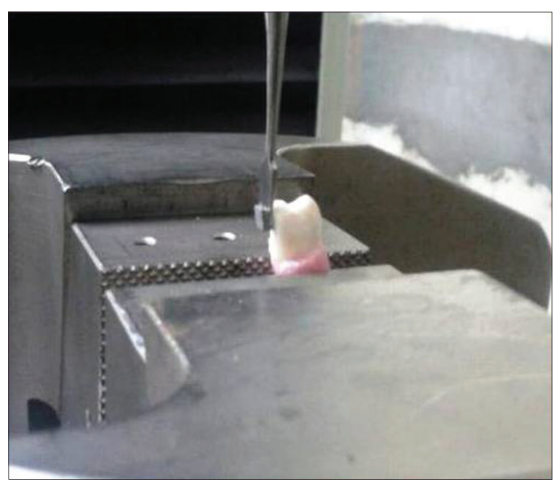

Figure 4: Testing of shear bond strength

Results

Peak failure load was converted to shear bond strength by dividing failure load with bonding area and values were expressed in MPa. Data were analyzed using Student's *t*-test, one-way analysis of variance (ANOVA), and *post hoc* test.

In Group 1, the maximum shear bond strength observed was 28.0965 Mpa and the minimum shear bond strength was 21.0915 Mpa. The average shear bond strength of the specimens tested was 23.6153 Mpa [Table 1].

In Group 2, the maximum shear bond strength observed was 27.1921 Mpa and the minimum shear bond strength was 15.4507 Mpa. The average shear bond strength of the specimens was 20.3236 Mpa [Table 2].

In Group 3, the maximum shear bond strength observed was 27.2227 Mpa and the minimum shear bond strength was 15.6960 Mpa. The average shear bond strength of the specimens was 19.5740 Mpa [Table 3].

In Group 4, the maximum shear bond strength observed was 26.8549 Mpa and the minimum shear bond strength

Table 1: Universal testing load and shear bond strengths of Group 1 test specimens

Specimen	Load	Shear bond strength (Mpa)
1	175.5990	21.9499
2	187.3710	23.4214
3	168.7320	21.0915
4	182.4660	22.808
5	201.1050	25.1381
6	206.0100	25.7512
7	175.5990	21.9499
8	169.7130	21.2141
9	192.2760	24.0345
10	195.9548	24.4943
11	201.1050	25.1381
12	224.7716	28.0965
13	173.6370	21.7046
14	178.5420	22.3177
15	175.5990	21.9499
16	176.5800	22.0725
17	202.0860	25.2607
18	180.5040	22.5630
19	203.8027	25.4753
20	206.9910	25.8739

Table 2: The universal testing load and shear bond strengths of Group 2 test specimens in which provisional restoration was done with zinc oxide‑noneugenol temporary cement for 7 days before permanent cementation with resin cement

Specimen	Load	Shear bond strength (Mpa)
1	204.0480	25.5060
2	144.2070	18.0259
3	150.0930	18.7616
4	142.2450	17.7806
5	137.3400	17.1675
6	143.2260	17.9032
7	123.6060	15.4507
8	141.2640	17.6580
9	170.6940	21.3367
10	156.9600	19.6200
11	152.0550	19.0069
12	173.6370	21.7046
13	173.6370	21.7046
14	154.9980	19.3747
15	168.7320	21.0915
16	173.6370	21.7046
17	170.6940	21.3367
18	170.6940	21.3367
19	217.5368	27.1921
20	182.4660	22.8082

Table 3: The universal testing load and shear bond strengths of Group 3 test specimens

Specimen	Load (*n*)	Shear bond strength (Mpa)
1	211.6508	26.4563
2	163.8270	20.4784
3	217.7820	27.2227
4	132.5576	16.5697
5	147.1500	18.3937
6	150.8288	18.8536
7	132.4350	16.5544
8	132.5576	16.5697
9	131.4540	16.4317
10	125.5680	15.6960
11	158.9220	19.8652
12	163.8270	20.4784
13	144.2070	18.0259
14	136.3590	17.0449
15	180.5040	22.5630
16	143.9618	17.9952
17	127.5300	15.9412
18	157.9410	19.7426
19	176.5800	22.0725
20	196.2000	24.5250

Table 4: The universal testing load and shear bond strengths of Group 4 test specimens in which provisional restoration was done with zinc oxide‑eugenol temporary cement for 7 days before permanent cementation with resin cement

Specimen	Load (*n*)	Shear bond strength (Mpa)
1	151.0740	18.8843
2	168.7320	21.0915
3	145.9238	18.2405
4	134.3970	16.7996
5	198.1620	24.7702
6	146.1690	18.2711
7	152.0550	19.0069
8	133.4160	16.6770
9	154.0170	19.2521
10	154.9980	19.3747
11	153.0360	19.1295
12	142.2450	17.7806
13	142.2450	17.7806
14	142.2450	17.7806
15	121.6440	15.2055
16	131.4540	16.4317
17	214.8390	26.8549
18	162.8460	20.3557
19	153.0360	19.1295
20	154.0170	19.2521

was 15.2055 MPa. The average shear bond strength was 19.0667 Mpa [Table 4].

In Group 5, the maximum shear bond strength observed was 27.5906 Mpa and the minimum shear bond strength was 14.5924 Mpa. The average shear bond strength was 19.1207 Mpa [Table 5].

Analysis was done using SPSS version 14, (SPSS Inc., Chicago, IL, USA). A $P < 0.05$ was

Table 5: The universal testing load and shear bond strengths of Group 5 test specimens in which provisional restoration was done with zinc oxide-eugenol temporary cement for 14 days before permanent cementation with resin cement

Specimen	Load (*n*)	Shear bond strength (Mpa)
1	168.7320	21.0915
2	153.0360	19.1295
3	149.1120	18.6390
4	141.2640	18.2711
5	138.3210	17.2901
6	131.2088	19.1295
7	138.3210	17.2901
8	131.4540	16.4317
9	220.7250	27.5906
10	151.0740	18.8843
11	143.2260	18.2405
12	133.4160	16.6770
13	116.7390	19.2521
14	123.6060	15.4507
15	125.5680	19.3747
16	129.4920	16.1865
17	150.0930	18.7616
18	127.2848	20.3557
19	155.9790	19.4974
20	127.5300	24.7702

considered statistically significant. Comparison of mean load and bond strength was done using ANOVA with *post hoc* Tukey's test.

One-way ANOVA test revealed that Group 1 produced higher shear bond strength than Groups 2, 3, 4, 5 and the difference was statistically significant ($P < 0.001$).

In Groups 2, 3, 4, and 5, no difference in shear bond strength was observed between provisional restorations with eugenol-containing zinc oxide cement and provisional restorations with eugenol-free zinc oxide cement ($P = 0.095$).

Discussion

In our study, ZOE was used as temporary cement for fixing interim restorations. Nasreen, *et al*. and Watanabe *et al*. suggested that ZOE affects the adhesive properties of resins either by changing the wettability and reactivity of the dentin or by interaction of the remnants of the ZOE material with the setting mechanism of resin composites.[4,5]

Our main objective was to evaluate the effect of eugenol-free and eugenol-containing cements on bond strength of resin cement to dentin. We did not find any significant difference in the resin-dentin bond strength between eugenol-containing and eugenol-free temporary cements. Our findings were similar to that of al-Wazzan *et al*., who supported the view that eugenol-free cements did not reduce the resin-dentin bonding strength.[6] Sabouhi *et al*. was of view that eugenol-free cements appear to have a similar or even superior retentive strength than those containing eugenol.[7] Ajaj *et al*. in their systematic review concluded that eugenol-containing temporary cement affected bond strength, which was statistically insignificant. Peixoto *et al*. suggested that eugenol has a determining role in bond strength of temporary cements. We followed the method used by Fonseca *et al*. for specimen preparation to test resin-dentin shear bond strength. They fabricated restorations of 3 mm × 3 mm × 5 mm dimensions with acrylic resin.[8]

André *et al*. fabricated temporary and permanent restorations in the form of discs of 10 mm diameter and 2 mm thickness,[9] whereas Nasreen *et al*. also fabricated restorations in the form of discs with 2 mm diameter and 3 mm height.[4] Saraç *et al*. used 4 mm × 4 mm × 1 mm acrylic resin plates as temporary restoration.[10] We used specimen dimensions of 4 mm × 4 mm × 2 mm to simulate overlying laboratory processed temporary and permanent restorations.

We used two different time intervals (7^{th} day and 14^{th} day) in our study, keeping in view the fact that residual eugenol may vary at different times thus influencing the bond strength values of resin. Peutzfeldt and Asmussen stored specimens for 7 days before testing the shear bond strength.[11] Whereas Watanabe *et al*. stored specimens for 48 h.[5,12] We stored specimens in artificial saliva for 7 and 14 days. Artificial saliva was selected as storage medium in this study for better evaluation of bond strength as it closely mimics the oral environment.

In Groups 2 and 3, bond strength was found to be inferior to that of control group. The average shear bond strength obtained was 22 Mpa. Our values were similar to those found by Carvalho *et al*.[13] and Bagis *et al*.[14] Whereas Schwartzer *et al*. found higher values of 26 Mpa.[15] We did not find any significant difference in shear bond strength in Group 2 and 3 even though they were stored in artificial saliva for different time periods. Ajaj, *et al*. believed that the reduced resin-dentin bond strength after application of temporary restorations might be due to the presence of temporary cement residues that may interfere with resin-dentin adhesiveness.[2]

In Groups 4 and 5, bond strengths were less when compared to that of control group. The average bond strength obtained was 19 Mpa. Our values were similar to those of Leirskar and Nordbø.[12] Whereas Peutzfeldt and Asmussen found higher shear bond strength values ranging between 24 and 28 Mpa.[11] They stated that eugenol-containing temporary restorative cements did not influence the bond strength of resin-dentin interface.

We did not find any significant difference in shear bond strength in Groups 2 and 3 even though they were stored in artificial saliva for different time periods. Nasreen *et al*. did not found any difference between bond strength after using temporary restorations containing eugenol. According to them, the diffusion rate of eugenol present in ZOE cement increased to a peak up to 24 h and later declined slowly afterward.[4] The possible cause for the decreased bond strengths in this group of specimens might be due to the presence of temporary cement remnants [Figure 5].

There was no significant difference of bond strengths between provisional restorations with eugenol containing and free provisional restorations. This is in accordance with the findings of Peutzfeldt and Asmussen and Sabouhi *et al*. Hence, our findings provide no support to the general belief that eugenol-containing cements must be avoided as provisional cements if resin cements are to be used later for permanent restoration fixation.[7,11,16] Further research should be carried out to assess the influence of eugenol or the cement residue on the bond strength during shorter period.

Limitations of the study and future suggestions

1. Time period after temporary restorations is 7–14 days. However, it will be prudent to evaluate from 24 h to 1 or 2 weeks
2. We used only one type of resin as permanent restoration. Future research should focus on using more types of resin cements
3. Ours is an *in vitro* study. Future studies should be *in vivo* studies, so as to exactly predict the bond strength of resin cement to dentin.

Conclusion

Within the limitations of our study, we found significant difference in the bond strengths of control group without provisional cementation and bond strengths of other groups with provisional cementation. Clinical implications from our study are that provisional restorations are necessary and presence or absence of eugenol does not significantly affect the shear bond strength of subsequent permanent resin cements to dentin.

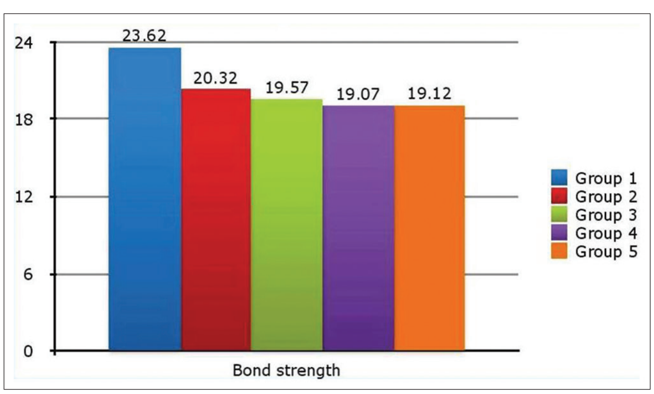

Figure 5: Bar diagram comparing the shear bond strengths of all groups

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Nil.

Conflicts of interest

There are no conflicts of interest.

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