

Effect of surface sealant coating on flexural strength of provisional resin materials

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Objective: To investigate the effect of surface sealant coating on flexural strength of four provisional resin materials used for fixed partial prosthesis.

Materials and methods: The total of one hundred and twenty-eight bar-shaped specimens (25 mm ×2 mm× 2 mm) were fabricated from four provisional restorative materials according to manufacturer's instruction: methacrylate resin (Unifast Trad) and bis-acryl resins (Prottemp 4, Luxatemp Fluorescence and Integrity). The prepared specimens were wet polished with 320-grit silicon carbide abrasive paper. The specimens of each material were then randomly assigned into 2 groups; group 1: non-sealant group (n=16) as a control group and group 2: sealant group (n=16). For group 1, the specimens were immersed in 37°C distilled water for 24 hours. For group 2, the specimens were sandblasted with 50 micron-aluminium oxide, rinsed with water and dried. Then, the surface sealant agent (Optiglaze color) was applied on the specimens' surface and the specimens were immersed in 37°C distilled water for 24 hours. After both groups were stored in distilled water for 24 hours, the three-point flexural strength test by a universal testing machine (EZ-S, SHIMADZU, Japan) with a cross-head speed of 1±0.3 mm/min was performed and the data were analyzed by using a two-way analysis of variance.

Results: In non-sealant group, the mean flexural strength of Unifast Trad, Prottemp 4, Luxatemp Fluorescence and Integrity were 63.45, 66.94, 71.64 and 76.18 MPa, respectively. Flexural strength of all bis-acryl resins was higher than methacrylate resins except Prottemp 4, which was not statistically different from GC Unifast Trad (p>0.05). In sealant group, the mean flexural strength of Unifast Trad, Prottemp 4, Luxatemp Fluorescence and Integrity with surface sealant agent were 57.87, 72.51, 71.86 and 62.19 MPa, respectively. The mean flexural strength of Integrity and Luxatemp Fluorescence in non-sealant group were statistically significant higher than Prottemp 4 and GC Unifast Trad (p<0.05). The mean flexural strength of Integrity and GC Unifast Trad in sealant group were statistically lower than non-sealant group (p<0.05). The mean flexural strength of Prottemp 4 in sealant group were statistically higher than non-sealant group (p<0.05). The mean flexural strength of Luxatemp Fluorescence in sealant group were not statistically different from non-sealant group (p>0.05).

Conclusion: The application of surface sealant did not increase the flexural strength of GC Unifast Trad, Integrity and Luxatemp Fluorescence but it could improve the flexural strength of Prottemp 4.

Key words: Bis-acryl resin, fixed prosthesis, flexural strength, glazing, methacrylate resin, provisional restoration materials, PMMA, self-curing restorations, sealant, surface sealant, temporary crown and bridge

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Introduction

In fixed prosthodontics treatment, the fabrication of definitive prosthesis generally takes approximately one week after preparing

abutment teeth; hence, the provisional restoration is essential during that period in order to protect the prepared teeth. The optimum requirements of provisional restorations are composed of three features; biological, mechanical and esthetic

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requirements. Provisional restorations help protect the pulp of abutment teeth, maintain periodontal health, provide occlusal compatibility and maintain tooth position. In addition, they prevent abutment fracture, resist functional load, resist removal force, and maintain interabutment alignment. They should also be easy to handle, color compatible, translucent and color stable. [1]

In 1936, heat-processed thermosetting poly (methyl methacrylate) (PMMA) was introduced. In the mid 1940s, self-curing prosthetic and restorative resins (also known as cold- and chemical curing resins) were available in the market. In 1950, the low-temperature curing tooth-colored resin for anterior teeth was introduced. Methyl methacrylate/PMMA resins were instantly substituted by the more durable difunctional methacrylate monomers based on either bis-GMA (bisphenol-A glycidylmethacrylate) or urethane dimethacrylate (UDMA). [2]

Although provisional resin materials are temporarily used, the restorations should also have acceptable strength. Strength is a significant mechanical property to withstand fracture or plastic deformation. One of various methods to measure this ability for resin materials is to perform the flexural strength test, which is the strength test of materials under static load. [2]

After finishing and polishing, the surface of the provisional restorations may present irregularity, microcavities and pores. These defects not only influence the color stability and esthetic appearance of the materials but also induce plaque accumulation, gingival inflammation, recurrent dental caries, and wear resistance. Surface sealant agents have been recommended after polishing in order to improve the surface of materials by filling irregularities or defects resulting in better marginal seal, increased wear resistance and stain resistance. [3, 4]

The objective of this study was to investigate the effect of surface sealant coating on flexural

strength, as measured by the resistance to transverse fracture, of four provisional resin materials used for fixed partial prosthesis.

Materials and methods

The total of one hundred and twenty-eight of bar-shaped specimens were fabricated from four provisional restorative materials (Table 1) according to the manufacturer's instructions and ISO 10477. [5] The split stainless steel mold (size 25 ± 0.1 mm x 2 ± 0.1 mm x 2 ± 0.1 mm) was used in this study. The glass slab was covered with the polyester film and the mold was positioned upon it. The materials were prepared according to manufacturer's instructions and immediately placed as evenly as possible without bubbles or voids in the mold. A second piece of polyester film was placed on the material and covered with a glass slab. The pressure was applied to displace the excess material by the clamp. Fifteen minutes after the polymerized time, the specimens were carefully removed from the mold and visually inspected for any voids or defects. The polymerized time according to manufacturer's instructions of GC Unifast Trad, Protemp 4, Luxatemp Fluorescence and Integrity are 2, 5, 7 and 7 minutes, respectively. If there were any irregularities, the specimens were discarded and the new specimens were created. The specimens were gently abraded with 320-grit abrasive papers (TOA, Samut Prakan, Thailand) for removing any flash. The dimensions of the specimens were measured at its center by using the digital vernier calipers with an accuracy of 0.01 mm. The specimens of each material were then randomly assigned into 2 groups; group 1: non-sealant group (n=16) as a control group and group 2: sealant group (n=16). For group 1, the specimens were immersed in 37°C distilled water for 24 hours. For group 2, the specimens were sandblasted with 50 micron-aluminium oxide, rinsed with water and

dried. Then, the filled surface sealant agent (Optiglaze color, GC corporation) (Table 2) was applied on the specimens' surface by a soft brush in a thin layer in one direction. The coated specimens were polymerized with the LED-polymerizing unit (Bluephase, Ivoclar Vivadent) for 40 seconds by overlapping method. The specimens were immersed in 37°C distilled water for 24 hours.

After both groups were stored in distilled water for 24 hours, the specimens were subjected to three-point flexural strength test by using universal testing machine (SHIMADZU, EZ-S, Japan). The apparatus consists of two rods (2 mm in diameter), which were mounted parallel. The distance between centers of the rods was 20 mm. The third rod (2 mm in diameter) was centered between and paralleled to the other two (Figure 1). The load was applied to the specimen

at a cross-head speed of 1±0.3 mm/min until the specimens reach yield point or fracture. The maximum applied load on the specimens was recorded in newtons (N) and the flexural strength (σ), in megapascals, was calculated according to the following equation: [5]

$$\sigma = \frac{3Fl}{2bh^2}$$

F is the maximum applied load, in newtons;
 l is the distance, in millimeters, between the supports;

b is the width of the test specimen, in millimeters;

h is the height of the test specimen, in millimeters.

Table 1 Provisional restoration materials used in this study.

Materials	Types	Manufacturers	Compositions	Shade
GC Unifast Trad TM	Methacrylate	GC America, Illinois, USA	Powder: Methyl methacrylate and Ethyl methacrylate copolymer Liquid: Methyl methacrylate, butylated hydroxytoluene, hydroquinone	Ivory
Protemp™ 4	Bis-acryl	3M ESPE, Seefeld, Germany	Base paste: Dimethacrylate(BisEMA6), Silane treated amorphous silica, Reaction production products of 1,6-diisocyanatohexane with 2-((2-methacryloyl)ethyl]6-hydroxyhexanoate and 2-hydroxyethylmethacrylate (DESMA), Silane treated silica Catalyst paste: Ethanol, 2,2'-[(1-methylethylidene) bis(4,1-phenyleneoxy)] bis-, diacetate, Benzyl-phenyl-barbituric acid, Silane treated silica, Tert-butyl peroxy-3,5,5-trimethylhexanoate	A3
Luxatemp® Fluorescence	Bis-acryl	DMG, Hamburg, Germany	Base paste: Acrylic resin glass power silica Catalyst paste: Urethane dimethacrylate, Aromatic dimethacrylate, Glycol methacrylate	A3
Integrity™	Bis-acryl	Dentsply Caulk, Delaware, USA	Barium boron alumino sillicate glass, Hydrophobic amorphous fumed silica, methacrylate monomers, Polymerizable dimethacrylate resin, Catalyst, Stabilizers	A3

Table 2 Surface sealant agent used in this study.

Sealant agent	Manufacturers	Compositions	Shade
OPTIGLAZE color	GC corporation, Tokyo, Japan	Methyl methacrylate, multifunctional acrylate, silica fiber, photo inhibitor	Clear

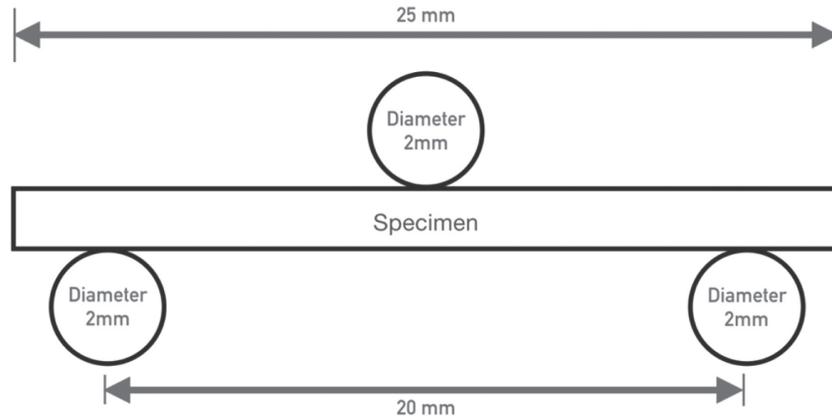


Figure 1 The diagram showing the mounted apparatus

Results

The mean values and standard deviations of the flexural strength are shown in Table 3 and Figure 2. The mean flexural strengths were analyzed by using Shapiro-Wilk test that showed normality distribution of the data in each group and Levene’s test showed the homogeneity variances among the groups.

A two-way analysis of variances (ANOVA) was used for analyzing data (Table 4). In non-sealant group, Integrity exhibited the greatest mean

flexural strength (76.18 MPa ± 10.31) followed by Luxatemp Fluorescence (71.64 MPa ± 5.29), Protemp 4 (66.94 MPa ± 4.98) and GC Unifast Trad (63.45 MPa ± 7.36), respectively. The mean flexural strength of Integrity and Luxatemp fluorescence were not statistically significant different (p>0.05) but, the mean flexural strength of both materials were statistically significant higher than that of Protemp 4 and GC Unifast Trad (p<0.05). The mean flexural strength of Protemp 4 was not significantly different from GC Unifast Trad (p>0.05) (Table 3).

Table 3 The mean flexural strength and standard deviation

Materials	Type	Mean flexural strength (MPa)* ± SD	
		Non-Sealant	Sealant
GC Unifast Trad™	Methacrylate	63.45 ^{B,a} ± 7.36	57.87 ^{B,b} ± 5.28
Protemp™ 4	Bis-acryl	66.94 ^{B,b} ± 4.98	72.51 ^{A,a} ± 5.98
Luxatemp® Fluorescence	Bis-acryl	71.64 ^{A,a} ± 5.29	71.86 ^{A,a} ± 6.09
Integrity™	Bis-acryl	76.18 ^{A,a} ± 10.31	62.19 ^{B,b} ± 8.81

*The different capital letters in the same column compare different provisional materials and lower-case letters in the same row compare same provisional materials with different conditions (sealant & non-sealant) which represent significant differences in the mean flexural strength of provisional restoration materials at 5% level of significant (p<0.05) by Bonferroni multiple comparisons.

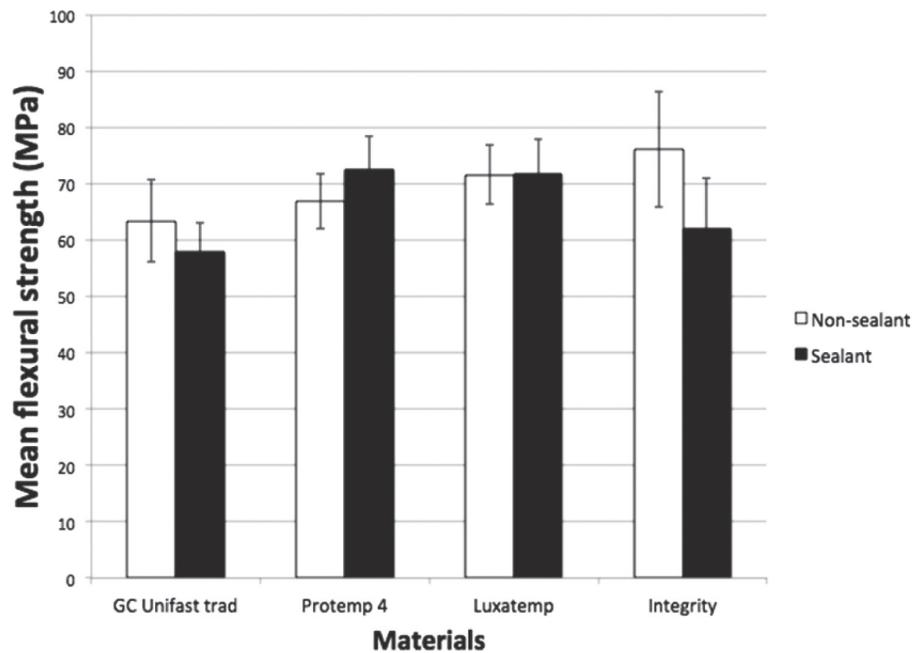


Figure 2 The bar graph showing mean flexural strength of tested provisional resin materials

Table 4 Test of between-subjects effects

Source	Type of III Sum of Squares	df	Mean square	F	Sig.	Partial Eta Squared
Corrected Model	4380.37	7	625.77	12.46	0.00	0.43
Intercept	568065.15	1	568065.15	11307.58	0.00	0.99
Group	2245.71	3	748.57	14.90	0.00	0.28
Surface	365.28	1	365.28	7.27	0.01	0.06
Group*surface	1673.63	3	557.88	11.11	0.00	0.22
Error	5827.56	116	50.238			
Total	579840.71	124				
Corrected Total	10207.92	123				

In sealant group, Protemp 4 presented the greatest mean flexural strength (72.51 MPa \pm 5.98), followed by Luxatemp Fluorescence (71.86 MPa \pm 6.09), Integrity (62.19 MPa \pm 8.81) and GC Unifast Trad (57.87 MPa \pm 5.28), respectively. The mean flexural strength of Protemp 4 and Luxatemp fluorescence were not statistically significant different ($p > 0.05$) but, the mean flexural strength of both materials were statistically

significant higher than that of Integrity and GC Unifast Trad ($p < 0.05$). The mean flexural strength of Integrity was not statistically significantly different from GC Unifast Trad ($p > 0.05$).

The result after comparing the flexural strength of each material between non-sealant and sealant groups showed that the mean flexural strength of GC Unifast Trad and Integrity in non-sealant group was significantly higher than in

sealant group ($p < 0.05$). The mean flexural strength of Luxatemp Fluorescence in non-sealant group was not significantly different from sealant group ($p > 0.05$). But, the mean flexural strength of Protemp 4 in non-sealant group was significantly lower than in sealant group ($p < 0.05$).

Discussion

Nowadays, methacrylate resins and bis-acryl resins have been widely used as provisional resin materials for fabrication of temporary crowns and bridges. The studies of flexural strength of provisional resin materials, especially products available in Thailand, were limited. Therefore, this study aimed to investigate the effect of surface sealant coating on flexural strength of four provisional resin materials used for fixed partial prosthesis.

Because the methacrylate resins and bis-acryl resins are brittle materials, the flexural strength test is ideal for testing the resistance from static load. The three-point flexural strength test was performed according to ISO 10477. [5] The specimens were placed horizontally upon parallel mounted two rods and then the third rod was applied to the top and center of the specimens to create the force until the specimens were fractured.

In the present study, the mean flexural strength of bis-acryl resins was higher than methacrylate resins in both non-sealant and sealant groups. This can be explained by the different composition of bis-acryl resins and methacrylate resins. Moreover, methacrylate resins have low molecular weight and present linear molecules after polymerization resulting in low flexural strength. On the contrary, bis-acryl resins are difunctional monomers and present cross-linking between monomer chains. Furthermore, some of them have the fillers added that bring the highest value of flexural strength. [6] The previous

study of Haselton et al. [7], Nejatidanesh et al. [8] and Young HM et al. [9] reported the same result that methacrylate resins have lower flexural strength than bis-acryl resins. The similar result was found in the study of Lang et al. [6] that fracture resistance of methacrylate resins was lower than bis-acryl resins. In this study, the flexural strength of one of bis-acryl resins in non-sealant group (Protemp 4) was slightly higher than that of GC Unifast Trad but not significantly different. This was also found in the study of Mei ML et al. [10], which exhibited no significant difference of flexural strength among Duralay (PMMA), Trim II (PEMA) and Luxatemp (bis-acrylic composite) specimens at the three curing temperatures (23°C, 37°C and 60°C).

In this study, the effect of surface sealant on flexural strength of provisional resin materials was examined that the smoother surface may affect the flexural strength of the materials. The beginning of the crack was derived from the flaw on the surface or edge of the specimen. The finishing or polishing procedure may form microcracks on the surface of the materials. [11, 12, 13] Microcracks allowed continuous propagation in the subsurface area, causing a debonding of the filler particles as well as a weakening of the matrix itself. [14, 15]

The microdefects that formed after finishing and polishing procedures would be filled by the sealant. So, the flexural strength of material with sealant surface might be enhanced. In this study, additional observation was achieved. The specimens were inspected under a scanning electron microscope (JSM 6610, JEOL, Japan) under $\times 5000$ magnification. The scanning electron microscopic examination showed that Protemp 4 has distinctively smoother surface after applying the surface sealant (Figure 3, 4). This may cause the increased flexural strength of this material after glazing. Whereas GC Unifast Trad, Luxatemp fluorescence, and Integrity still have some pores or microroughness after sealant. The surface sealant agent may not penetrate into deep microconcavities of these materials. Thus, the

flexural strength of GC Unifast Trad, Luxatemp Fluorescence, and Integrity in sealant group were not improved. Remarkably, the flexural strength of

GC Unifast Trad and Integrity were decreased, even though the filled surface sealants were applied.

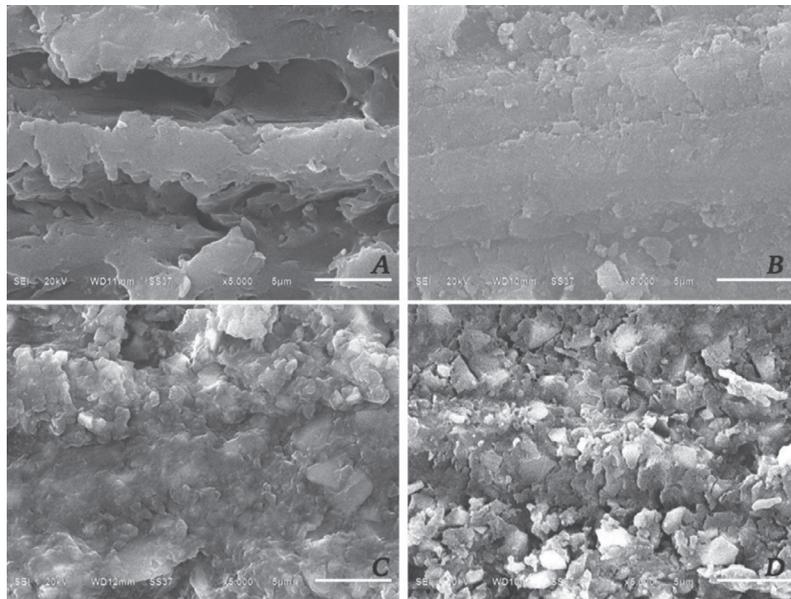


Figure 3 SEM image of the non-sealant group ($\times 5000$), scale bar 5 μm : (A) GC Unifast Trad; (B) Protep 4; (C) Luxatemp Fluorescence; (D) Integrity

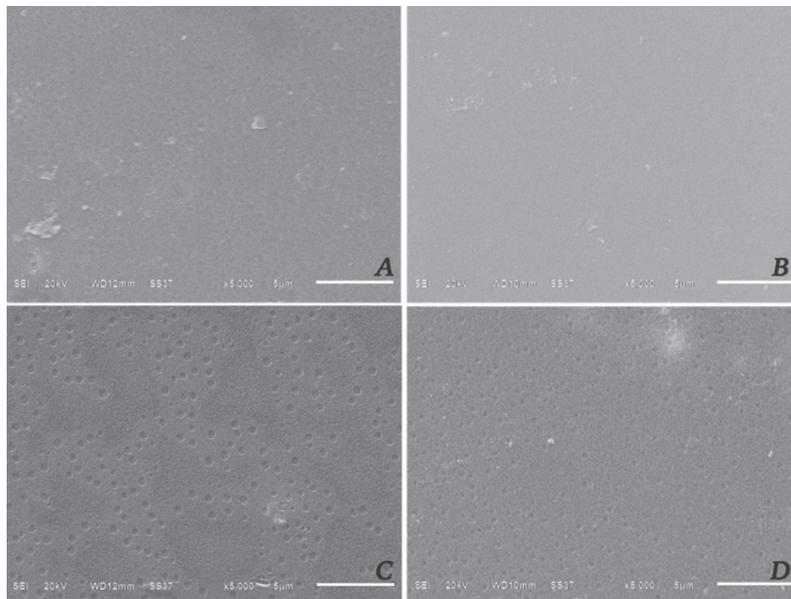


Figure 4 SEM image of the sealant group ($\times 5000$), scale bar 5 μm : (A) GC Unifast Trad; (B) Protep 4; (C) Luxatemp Fluorescence; (D) Integrity

In the oral cavity, the flexural strength of restorations can be observed in a three-unit fixed dental prosthesis. This stress was produced by bending force in prosthesis. [2] Although the specimens were prepared and tested in the laboratory environment which was different from the oral environment such as humidity, the masticatory load, and the temperature [6], the results could be advantageous when choosing the provisional resin materials. [6] However, the flexural strength of provisional resin materials is only one factor to consider for material selection. Under the study conditions, bis-acryl resins presented greater flexural strength. [11]

Conclusion

In this study, the effect of surface sealant coating on flexural strength of provisional resin materials was examined. The application of surface sealant did not increase the flexural strength of GC Unifast Trad, Integrity and Luxatemp Fluorescence but it could improve the flexural strength of Protemp 4.

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