The Effect of Mouthwashes on the Flexural Strength of Interim Restorative Materials

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Abstract

Aim: This study aimed to evaluate the effects of different mouthwashes on the flexural strength of five interim restorative materials.
Materials and Methods: Based on ADA specification #27, 50 identical 25×2×2 mm samples were fabricated from five interim materials (TempSpan, Protemp 4, Unifast III, Trim and Revotek LC) and stored for 14 days at 37°C in three different mouthwashes (Listerine, Oral B and Chlorhexidine) and distilled water (control group). After conditioning, the flexural strength values were assessed by a universal testing machine. The standard three-point bending test was conducted on the specimens at a crosshead speed of 0.75 mm/min. Data were statically analyzed by the two-way ANOVA and Tukey HSD tests.
Results: The mean ranks of flexural strength of the examined materials were as follows: TempSpan= 121.10, Protemp 4= 111.93, Unifast III= 63.44, Trim= 62.83 and Revotek LC= 46.55.There was no significant difference between Unifast III and Trim, however; the other materials showed significant differences. Both bis-acryl resin composite materials showed higher flexural strength than the methacrylate and light-cured resins after 14 days storage in mouthwashes. One of the bis-acryl resins (TempSpan) showed the highest flexural strength. The light polymerized resin (Revotek LC) presented the least flexural strength.
Conclusions: The mouthwashes employed in this study did not show any statistically significant effect on the flexural strength of the five tested interim materials.

Key Words: Interim restorative material, Flexural strength, Mouthwash

Introduction

One of the crucial parts of prosthodontic treatment is fabrication of the temporary fixed prosthesis which should be provided for the patients from primary tooth preparation until the final prosthesis is placed [1]. The significance of such restorations is their feasibility as a guide for final restorations. Furthermore, they have a critical role in preservation of esthetic, biological conditions such as pulp and periodontal protection, and mechanical conditions such as function [2]. Consequently, a problematic interim restoration cannot protect the prepared teeth and supporting tissues properly [3,4].

The interim restorative materials were greatly modified from their first generation, made of acryl , to the more recent bis-acryl materials and computer-aided design/computer-aided manufacturing (CAD/CAM) restorations[2,5]. However, still there is no interim material that can fulfill all requirements for every situation [6,7,8]. Thus, clinicians always choose their restorations concerning some influential factors such as cost, effectiveness, esthetic, strength, marginal adaptability, and ease of manipulation [9].

Sometimes mouth reconstruction needs longer application of these restorations due to unpredictable reasons and in several situations; the final prosthesis insertion is postponed intentionally. For instance, temporomandibular problems or periodontal diseases should be treated before the application of final restoration [2]. Moreover; interim prosthesis should be worn for a long period of time to assess the result of the occlusal plane correction, changes in vertical dimension and during the restorative phase of implant treatments [10].

The interim restorations can be affected by salvia, food components, beverages, and their interactions in the oral cavity [10-13]. Interim restorations may also be influenced by using mouthwashes with different ingredients especially when the patients must use these restorations for a long time.

Hygiene is a crucial factor while the patient is using interim restorations, since the gingival inflammation and bleeding could happen when these restorations are used in a mouth with poor oral hygiene. The longer the application of these restorations, the more important the hygiene is [2]. Usually, bacterial plaque is removed from the dental surfaces by mechanical procedures in order to prevent and control the level of plaque, however; due to the occasional difficulty in obtaining an adequate level of plaque control mechanically, mouthrinses have become more practical and useful for both patients and clinicians [14]. Improper contacts or connector designs typically make some difficulties in the application of flossing and interdental brushes to control the interdental plaque [2]. Mouthrinses can be used for different purposes such as in-office and at home irrigation, reduction of aerosol microorganisms, implant maintenance, and treatment of oral mucositis and candidiasis [15]. Professionals believe that another reason for using these solutions is their propensity to provide cooling sensation and reducing the malodor [16].

One of the important properties of interim restorations which should be considered, especially in long-span interim prostheses with short height pontics and connectors, is their flexural strength. The flexural strength of interim restorations also plays a critical role in patients with parafunctional habits, bruxism or clenching and also in the instances when long-term use of these restorations is requisite [9].

Almedia et al. [17] evaluated the effect of mouthrinses on salivary sorption, solubility and surface degradation of a nanofilled and hybrid resin composites. Their analysis revealed that mouthrinses produced more severe surface degradation in the nanofilled composite. Mohamed Abdollah R. [18] assessed some physico-mechanical properties such as flexural strength of two types of flowable composite resins (Filtek Flow and Tetric Flow) after immersing them in mouthwashes (Betadine or Hexitol).The results showed that

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Betadine mouthwash caused a significant increase in flexural strength of Filtek Flow. J.A Von Fraunhofer et al.[19] evaluated the effect of mouthrinses containing essential oils on dental restorative materials and reported that the application of these solutions had no adverse effect on mechanical properties of restorative materials. Akova et al. [10] evaluated the effect of food simulators such as water, 0.02N citric acid, heptane and 75% ethanol on four interim restorative materials. After immersing the materials in solutions for seven days, they experienced that the flexural strength and the surface roughness of interim restorative materials were highly affected by food simulator solutions.

Since the authors did not identify any study regarding the effect of mouthrinses on the flexural strength of interim restorations, this study aimed to evaluate this possible effect. The null hypothesis was that Chlorhexidine, Listerine and Oral-B mouthrinses does not influence the flexural strength of five interim restorative materials including Trim, Protemp 4, Unifast III, and TempSpan & Revotek LC.

Materials and Methods

In the present study, the flexural strength of five interim restorative materials including Unifast III, Trim, Protemp 4, Temp Span and Revotek LC was examined after 14 days of storage at 37°C [9,20] in 3 types of mouthrinses including Chlorhexidine 0.2%, Listerine and Oral B. Distilled water was considered as the control solution. Interim materials and mouthwashes used in this study were listed in *Table 1 and 2*.

Table 1*. Temporary materials used in this study.*

Product name	Manufacturer	Lot number	Composition	Polymerization
Revote LC	GC corporation,Tokyo,Japan	1110121	Urethane dimethacrylate	Light-cured
Unifast III	GC corporation,Tokyo,Japan	1104081	Methyl methacrylate	Self-cured
Protemp 4	3M ESPE. AG,Seefeld,Germany	452445	Bis-acryl	Self-cured
Trim	Bosworth company,Skokie ,USA	1007-323	Vinylethyl methacrylate	Self-cured
Temp Span	Pentron clinical,orange CA,USA	4605909	Bis-acryl	Dual-cured

Table 2*. Mouthwashes used in this study.*

Product name	Manufacturer	Lot number	Ingredients
Listerine	Johnson & Johnson healthcare products, Skillman, USA	3400LZ	Water, alcohol (21.6%), sorbitul solution, flavoring, ploxamer407, benzoic acid, zinc chloride, sodium benzoate, sucralose, sodium saccharin, FD&C blue no.1
Oral-B	Procter & Gamble, Weybridge, UK	3045028813	Aqua, glycerin, polysorbate 20, aroma, methyl paraben, cetyl pyridinium chloride, sodium fluoride, sodium saccharin, sodium benzoate, propyl paraben
Chlorhexidine 0.2%	Behsa corporation, Arak , Iran	473	Water, glycerin, ethanol, polysorbate20, chlorhexidine-digluconate 0.2%, aromatic composition with predominant flavor of mint, sodium saccharine, FD & C blue dye#1

By the application of Plexiglas split mold, the specimens were made with the dimension of 25×2×2 mm according to the ADA specification# 27 [21]. 50 samples were fabricated for each of the materials.30 samples were considered as experimental groups which were immersed in mouthrinses, 10 samples for baseline measurement and 10 samples were stored in distilled water as the control group .The interim restorative materials were mixed according to the manufacturer's instructions and injected to the mold. Trim and Unifast III were mixed manually but TempSpan and Protemp 4 were mixed automatically using dispenser tip. Revotek LC was put into the mold by hand and spatula.

A weight of 1.5 kg was inserted on the glass slab over the mold, in order to apply adequate pressure needed for complete polymerization, minimal air bubble entrapment and also in order to remove excess material from the mold [21,22]. After polymerization, samples were taken out and evaluated to detect air bubbles. Then defective specimens were excluded from the study. Finally, samples were polished according to the instruction of the manufacturing company.

The materials were stored in solutions at 37°C for 14 days and then they were washed under running water and air-dried. The standard three-point bending test was applied on the specimens with the universal testing machine at a crosshead speed of 0.75mm/min [9].

The force at fracture was recorded in Newton unit and the flexural strength was calculated in MPa according to the following equation:

$S= 3FL/2WH^2$ in which:

s= flexural strength; f= maximum fracture load; L= length of the specimen

W= width of the specimen; H= height of the specimen.

Statistical Analysis

The data were analyzed by two-way ANOVA and Tukey HSD tests at the significance level of $\alpha = 0.05$.

Results

Table 3 summarizes the mean and the standard deviation of the flexural strength of specimens before and after immersing in solutions. The statistical analysis of two-way ANOVA showed that different mouthwashes did not have a statistically significant effect on the flexural strength of the 5 interim materials investigated (p> 0.05).Results of Tukey's test indicated no significant difference between Trim and Unifast III (P= 0.99), however, there were statistically significant differences among the other tested materials (p< 0.05) *(Table 4)*. TempSpan was statistically superior to the other examined resins followed by Protemp 4. Trim and Unifast III showed lower flexural strength than bis-acryl resins and Revotek LC exhibited the lowest. *Figure 1* displays the changes of flexural strength of materials after immersion in solutions.

Table 3*. The mean and standard deviation of flexural strength (MPa) of temporary materials before and after immersion in mouthwashes.*

Mouthwashes	TempSpan	Protemp 4	Unifast III	Trim	Revotek LC
Distilled water	120.3 + 2.94	111.6 + 3.4	64.99 + 3.76	63.8 + 1.9	45.69 + 3.37
Oral B	121 + 2.7	112.5 + 5.42	63.65 + 1.5	64.07 + 4.02	45.67 + 3.03
Chlorhexidine	122.4 + 6.8	108.48 + 7.94	61.56 + 1.8	62.17 + 3.9	47.77 + 3.23
Listerin	121.6 + 3.62	114.1 + 4.06	62.84 + 1.7	60.38 + 2.07	46.04 + 3.19
Baseline	120.2 + 3.01	113 + 5.29	64.2 + 1.9	63.73 + 1.72	47.16 + 2.7
Total	121.1 + 4.06	111.93 + 5.568	63.44 + 2.51	62.83 + 3.14	46.55 + 3.10

Table 4*. Results of Tukey HSD multiple comparison test. *Materials in the same subset had no significant difference in their flexural strength.*

Interim Materials	Number	Subset			
		1	2	3	4
TempSpan	50	121.1			
Protemp 4	50		111.936		
Unifast III	50			63.448	
Trim	50			62.83	
Revotek LC	50				46.554

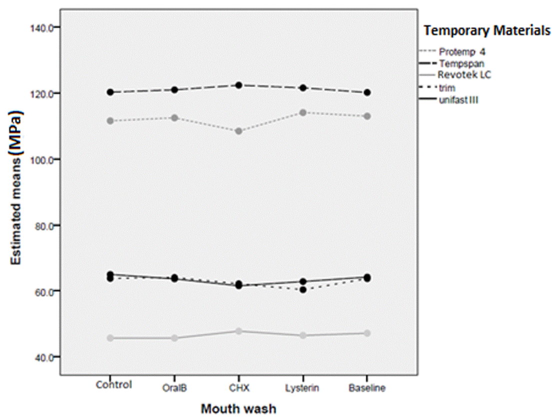

Figure 1*. The changes of flexural strength of materials (MPa) after immersion in solutions.*

Discussion

The current study assessed the flexural strengths of 5 interim restorative materials including Trim, Unifast III, Protemp 4, TempSpan and Revotek LC after 14 days of storage in 3 different mouthrinses including Chlorhexidine, Oral B and Listerine. Distilled water closely imitates the wet environment of saliva and water in mouth and considered as the control group media. According to the results, different mouthwashes did not have a statistically significant effect on the flexural strength; therefore, the null hypothesis was accepted.

The present study recruited three popular and commonly-used mouthwashes due to the importance of hygiene during the provisional treatment phase. Clinical studies reported that Chlorhexidine mouthwash, as diguanidohexane with certain antiseptic properties, could reduce the dental plaque up to 45-61%, and gingivitis to 27-67% which is of great importance for clinicians. The reversible and localized side effect of this material is the brown discoloration of teeth, tongue, and also silicate or resin restorations. Another complaint reported by Chlorhexidine consumers is its unpleasant taste, though temporary [23-25]. Essential oil mouthrinses contain thymol, ocalypthol, menthol, and methyl salicylate as their ingredients [24]. They also contain alcohol up to 24%, depending on its mode of preparation [23]. Studies indicated 20-35% reduction in dental plaque and 25-35% reduction in gingivitis by the application of these products. Essential oil mouthrinses such as Listerine have fewer side effects than Chlorhexidine. These include mouth irritation, bitter taste and dryness of oral mucosa. Cetylpyridinum chloride mouth rinses (quadric ammonium compounds) such as Oral B also showed the evidence of reducing plaque and gingivitis, even if the amount of this reduction was less than Chlorhexidine and essential oil mouthwashes [25].

Interim restorative materials are divided into 4 groups according to their composition ; polymethyl methacrylate, polyethyl or butyl methacrylate, microfilled bisphenol A-glycidyl dimethacrylate (Bis-GMA) composite resin, and urethane dimethacrylate (light-polymerizing resins) [2,6] . These materials can also be classified into 2 groups according to their chemical components; Methacrylate resins (including methyl acrylate and ethyl acrylate and etc.) and composite resins of Bis-GMA, bis-acryl/UDMA (Polyurethane D-methylacrylate) [26].The materials used in this study were evocative for both groups *(Table 2)*.

PMMA resins have some advantages such as color stability, good marginal accuracy and excellent polishability and they are relatively inexpensive. However, the main drawbacks of this type of resins are their high polymerization shrinkage, exothermic polymerization, low strength, low wear resistance, and pulpal irritation which would occur in the presence of excessive free monomers. Comparing to PMMA resins, Poly R′ methacrylates exhibit low polymerization shrinkage and low exothermic reaction. However, they may also show low strength, low wear resistance, and low color stability which limits their clinical usage. Bis-acryl composite resins have great properties such as low polymerization shrinkage, low exothermic reaction, good wear resistance and strength; therefore, they have more superiority over methacrylate-base resins in clinical use. Their high cost, brittleness and difficulty in polishing and repairing accounts as some disadvantages of this type of resins [27].

It can be assumed that in the oral cavity, saliva, food components, beverages and also the interactions that occur among them can deteriorate and age the dental restorations [10-12,28,29]. Many previous studies confirmed the potential effects of food simulators and mouth rinses on the methacrylate base composites [10,30-36] . Based on the results yielded by some studies, when the resin-bonded materials were immersed in water, the resin matrices swelled and consequently, radial tensile forces have been produced at the filler interface, thereby strained the filler's bonds. Thus, the reduction in flexural strength and other physical properties can be due to the degradation of the filler matrix interface [12,37].

Some rudiments can cause water absorption and solubility of dental resin-based materials such as monomer resin chemistry, the extend of matrix polymerization [38], the size, shape and distribution of filler particles [39,40], and finally the interfacial properties between the filler and resin matrix [41,42].

On the other hand, the shrinkage of matrix during polymerization can make hoop stresses around the filler particles [43]. The frictional forces between the filler and resin matrix can be increased by hoop stresses. Therefore the tendency of filler pull-out while testing flexural strength will be decreased [44]. It can be assumed that hoop stresses can maintain the resistance-to-degradation of restorations in oral environment.

J.A Von Fraunhofer et al. [19] evaluated the effect of mouthrinse containing essential oils on dental restorative materials. They experienced a marked difference in fluid sorption of specimens when they were immersed in distilled water with the ones in Listerine. The result of their study showed that even though the alcohol/essential oil mixture affected the fluid sorption, they had no adverse effects on either the strength or the surface characteristics of the restorative materials.

Some studies [19,20,45] claimed that water sorption, food simulators , and mouthwashes did not affect the mechanical properties of dental restorations. The results of these researches are consistent with our study outcomes.

In the present study, the specimens were made and immersed in the solutions for 2 weeks at 37°C.The result of this study indicated that different mouthwashes did not have a statistically significant effect on the flexural strength of interim materials, although bis -acryl composite resins including TempSpan and Protemp 4 had the higher flexural strength than Trim and Unifast III which are methacrylate base resins .The light polymerized Revotek LC exhibited the lowest flexural strength.

The flexural strength of methacrylate base and bis-acrylic based resins is different because they have different monomer compositions. Multifunction monomers that are in bis-acryl resins can increase the strength as a result of cross-linking with other monomers [46]. The physical properties of composites and poly acid modified composites may also be enhanced by a protective layer formed over the surface of composite [44].

The strength and rigidity of conventional methacrylate resins is lower than bis-acryls because of their low-molecular weight, linear molecules and also their mono-functional feature. If these resins do not polymerize under pressure, weakness and air bubble trapping will occur [47-49].

Many studies [9,20,37,50] indicated that the flexural strength of bis-acryl resins were higher than methacrylate based resins. Nejatidanesh et al. [9] evaluated the flexural strength of 7 interim materials and concluded that TempSpan had the highest flexural strength as it is composite based, whereas the Trim material, being resin-based, exhibited the lowest flexural strength. Balkenhol et al. [50] believed that having greater mechanical properties makes the composite resin-based materials superior to methacrylate resins. They suggested the application of dual-curing interim materials when a high mechanical strength is desired. A dual polymerizing material with the highest flexural strength such as TempSpan can increase the degree of polymerization as it has both auto polymerizing and light polymerizing components. Protemp 4 is an auto polymerizing resin, thereby; having lower strength than dual polymerized TempSpan [9].

Sharma et al. [49] reported poly methyl methacrylate resin (PMMA) had higher flexural strength than urethane dimethacrylate (UDMA). They proposed that, in order to remove the excess material during primary polymerization, the UDMA samples should be taken out and placed in the mold again for a complete polymerization. This issue would result in distortion of samples and changes in their flexural strength.

Although laboratory values of the flexural strength under static loading may not reflect the intraoral conditions, these values can be helpful in comparing materials under controlled situations. They can also be considered as a predictor of clinical performance. The results of this study can be improved by simulating the complicated oral environment in future studies.

It should be considered that flexural strength is only one, out of many important properties of the interim restorations that should be evaluated. Further studies are necessary to identify the best mechanical properties which can help the clinicians predict the behavior of interim restorative materials *in vivo*. The clinician should consider all the characteristics of different materials to select the appropriate interim material for their patients.

Conclusions

Within the limitation of this study, it can be concluded that the mouthrinse consumption during the provisional treatment phase might have no significant effect on the flexural strength of interim restorative materials. Bis-acryl resins have the higher flexural strength than the methacrylate based and light-cured resins .This difference should be deliberated particularly in the long term application of interim restorations and in patients suffering from parafunctional habits.

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