

# Flexural Strength of Provisional Crown and Fixed Partial Denture Resins both with and without Reinforced Fiber

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## Abstract

**Aim:** The aim of this study was to evaluate the fracture strength of various provisional crown and fixed partial denture resins using an invitro test system.

**Materials and Methods:** Provisional crown-bridge materials (autopolymerising Poly Methyl Metacrylate (PMMA), autopolymerising Poly Ethyl Metacrylate (PEMA), bis-acryl composite resin and light cured composite resin), reinforcement materials; polyethylene fiber and glass fiber are compared. A total of 150 specimens are prepared for the flexural strength test. The specimens are divided into 5 groups according to the type of resin used (Tetric Ceram, Charisma, Dentalon Plus, TAB 2000, Prottemp 3) and then each group was divided into 3 subgroups according to the type of fiber reinforcement (Construct, Fiber-splint ML). Unreinforcement specimens served as the control. Specimens are loaded in a universal testing machine until the point of fracture. The mean flexural strength (MPa) was compared using one-way analysis of variance, followed by Duncan's multiple range tests.

**Results:** The highest average flexural strength value was found in the Charisma with Construct fiber reinforcement (442.00 MPa). The lowest average flexural strength value was found in the Dentalon Plus without fiber reinforcement (70.50 MPa). There was significant difference between Fiber-splint ML, Construct and control group.

**Conclusion:** Dentalon Plus without fiber reinforcement. There was significant difference between Fiber-splint ML, Construct and control group.

**Keywords:** Flexural strength; Provisional crown; Reinforced fiber

## Introduction

Fabrication of provisional restorations is an important procedure in fixed prosthodontics. Provisional restorations must satisfy the requirements of pulpal protection, positional stability, occlusal function, ability to be cleansed; margin accuracy, wear resistance, strength, and esthetics [1]. The strength of a material can be a determinant of how well these requirements are met. Flexural strength, also known as transverse strength, is a measurement of the strength of a bar (supported at each end) under a static load [2]. The flexural strength test is a combination of tensile and compressive strength tests and includes elements of proportional limit and elastic modulus measurements [3]. The flexural strength of provisional materials is important, particularly when the patient must use the provisional restoration for an extended period, when the patient exhibits parafunctional habits, or when a long-span prosthesis is planned [4].

Materials commonly used to fabricate interim restorations are heat polymerising Poly Methyl Metacrylate (PMMA), autopolymerising Poly Ethyl Metacrylate (PEMA), autopolymerising Poly Methyl Metacrylate (PMMA), Bis-acryl composite resin and light cured composite resin [5-8]. They were chosen for esthetics, micro hardness, fabricating methods, economics and the other reason is fracture strengths. In patients with bruxism or patients whose treatment plan requires long-term use of provisional restorations, provisional restorations with improved physical properties are required. Several attempts have been made to reinforce provisional Fixed Partial Dentures (FPDs). These included the use of metal wire [9] a lingual cast metal reinforcement, a processed acrylic resin interim restoration, [10] and different types of fibers, e.g., carbon, polyethylene, and glass [10-14].

The concept of using fibers to reinforce an interim restoration appears to have an acceptable rate of success [14-16]. With the recent introduction of improved fiber reinforcing materials, this has become increasingly beneficial. But light cured composite resins with fiber reinforcement are not commonly used in provisional crown and bridges.

Investigations have shown that carbon fibers produced a significant increase in the flexural strength of polymers [11,17,18]; however, the black colour limits their use. Transverse strength was not improved by polyethylene fibers in the absence of surface treatment because of poor adhesion between the fibers and the polymer matrix [12]. When plasma-treated polyethylene fibers were used, a significant increase in strength was shown [19]. Silanized glass fibers are promising new materials due to their good

sion to the polymer matrix, high aesthetic quality, and increased strength of the resulting composite [13,15,20-22]. Others have found that the position, quantity, direction of fibers, degree of adhesion between the fibers and polymer affect the degree of reinforcement.

The purpose of this study was to compare the effects of with and without two different types of fibers on the flexural strength of heat polymerising Poly Methyl Methacrylate (PMMA), auto polymerising Poly Ethyl Methacrylate (PEMA), auto polymerising Poly Methyl Methacrylate (PMMA), bis-acryl resins and light cured composite resin

## Materials and Methods

Ten bar-shaped specimens with dimensions of 25×2×2mm (American National Standards Institute/American Dental Association specification no. 27) [23] were fabricated for each material with the use of a split machined aluminium mould sandwiched between two glass slabs. The fiber-reinforced specimens were made from pre-cut 23-mm-long fibers which were wetted using the polymer-monomer mix (PMMA, PEMA) and bonding agent (bis-acryl), and then these were placed in the bottom side of the mould cavity with resin applied on top of fibers. A weight of 2.5kg was applied. All materials were mixed and polymerised according to the manufacturers' instructions. The specimens were stored in distilled water at 37 °C for 10 days. After this period, specimens were positioned on a flexural strength testing apparatus with 10mm support separation. A 3-point bend test was carried out in a universal testing machine (Instron; M12-13667-EN) with a 10kN load cell at a crosshead speed of 1mm/minute. The force was applied on specimens to the resin side. The force at fracture was recorded in MPa using testing machine software. The statistical analysis was performed using the SPSS 10.01 programme. The data was statistically analysed for differences using one-way Analysis Of Variance (ANOVA) and multiple comparisons were made using Duncan's multiple range test

Product name	Material type	Manufacturer
Fiber-splint ML	Glass fiber	Polydentia.,CH6805;Mezzovico,Switzerland
Construct	Polyethylene fiber	Kerr Lab, Belle de st.Claire Orange, CA 92867,USA
Gluma Comfort Bond	Bonding agent	Heraus Kulzer Gmbh, Hanau, Germany
Tetric ceram	Visible light curing composite	Ivoclar Vivadent AG, FL-9494, Schaan; Liechtenstein
Charisma	Visible light curing composite	Heraus Kulzer Gmbh, Hanau, Germany
Dentalon plus	PEMA	Heraus Kulzer Gmbh, Hanau, Germany
TAB 2000	PMMA	Kerr, 1717 W.Collins Ave. Orange, CA 92867 Italy
Protemp 3 Garant	Bisacryl resin	3M ESPE AG D-82229 Seefeld, Germany

Table 1: Materials used

## Results

The mean flexural strengths and standard deviations are presented in Table 2. The highest average flexural strength value was found in the Charisma with Construct fiber reinforcement. The lowest average flexural strength value was found in the Dentalon Plus without fiber reinforcement. A significant difference between the Fiber-splint ML, Construct and the control group (Table 3) was observed. There was a significant increase in the specimens with reinforced fiber. Statistically, by using Duncan multiple range tests, the results revealed the flexural strength of Tetric Ceram and Charisma was significantly higher than Dentalon Plus and TAB 2000. However, there was no significant difference between the Protemp 3 and Tetric Ceram (Table 4).

Materials	Fiber type	Means	SD
Tetric ceram	Control	127.66	10.84
	Construct	426.30	37.77
	Fiber-splint ML	155.16	13.72
Charisma	Control	156.98	14.90
	Construct	442.00	60.98
	Fiber-splint ML	182.74	12.33
Dentalon Plus	Control	70.50	3.97
	Construct	191.00	20.12
	Fiber-splint ML	88.14	13.36
TAB 2000	Control	98.28	8.14
	Construct	160.52	22.08
	Fiber-splint ML	124.00	18.06
Protemp 3	Control	126.74	19.47
	Construct	351.65	29.30
	Fiber-splint ML	229.24	28.05

Table 2: Mean flexural strengths and standard deviations

Fiber	1	2	3
Control	116.03 <sup>c</sup>		
Fiber-splint ML		155.86 <sup>b</sup>	
Construct			307.12 <sup>a</sup>

Table 3: Mean flexural strengths for fiber-reinforcement groups

Material	1	2	3
Dentalon Plus	116.55 <sup>a</sup>		
TAB 2000	127.60 <sup>a</sup>		
Protemp 3		227.61 <sup>b</sup>	
Tetric ceram		236.37 <sup>bc</sup>	236.37 <sup>bc</sup>
Charisma			247.61 <sup>c</sup>

Table 4: Mean flexural strengths and standard deviations for resins

In this study, five provisional crown materials and two fibers were evaluated for flexural strength. While flexural strength values obtained in laboratory under static load may not reflect the conditions found in the oral environment, it is useful to compare provisional materials tested in a controlled situation. Strength values may be a useful predictor of clinical performance.

The use of fibers to reinforce a provisional restoration seems to have an acceptable success rate [16]; because of the recent advances in the production of improved fiber-reinforcing materials [24].

Numerous investigators have confirmed the reinforcing effect of fibers on different polymer types [11-22,24,25]. This is in agreement with the results of this study, which revealed that the majority of tested fibers increased the flexural strength of provisional restoration resins. The explanation for this increase was the transfer of stress from the weak polymer matrix to the fibers that have a high tensile strength [16]. The stronger adhesion between the fiber and the matrix, the greater the strengthening effect [21]. In fact, the presence of poorly bonded fibers, to which little load is transferred, can be almost equivalent to voids [26].

## Discussion

One approach to increase the adhesion of fibers to a polymer matrix is resin impregnation of fibers before application. An effective impregnation process allows the resin to come into contact with surface of every fiber. Wetting the fibers with a monomer has been a commonly used method. However, although the monomer increases the adhesion of fibers to the matrix, it may impair other properties because of the residual monomer. The pre-impregnated fiber-construct used in the present study was developed to overcome this problem and compare with the non pre-impregnated e-glass fiber.

The degree of fiber adhesion to the polymer matrix also differs according to the type of fiber used. Several surface treatments of polyethylene fibers have attempted to solve this problem, including plasma spraying, chemical, flame, and radiation treatments. Construct consists of pre-impregnated silanized plasma treated polyethylene fibers. The present study showed that there was a significant difference between the reinforcing effect of Construct polyethylene fibers and Fiber-splint ML glass fiber. The improved performance of the Construct product may be due to the use of silane, as well as plasma treatment to increase the degree of adhesion of the polyethylene fibers to the resin.

The results revealed better strengthening effects for all resins tested with Construct rather than with Fiber-splint ML. The present study showed that there was a difference in the results of the flexural strength test. This difference may be caused by Fiber-splint ML glass fiber that is not pre-impregnated.

When using reinforced provisional resin materials clinically, it may be beneficial to choose a combination that, although prone to fracturing, is held together by intact fibers. This might prevent catastrophic failure and may decrease patient discomfort and unscheduled appointments. Both unreinforced and Fiber-splint ML reinforced specimens showed undesirable complete separation. With the remaining groups, the fibers were intact, and the fracture stopped at the fiber location, suggesting that use of these fibers may be beneficial in reinforcing fixed provisional restorations, which may be used for extended periods.

## Conclusion

The Within limitations of this invitro study, the following points were discovered:

1. Visible light curing composites display higher flexural strength than other provisional restorations.
2. The use of fibers is an effective method of increasing flexural strength of provisional restoration resin.

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