"A COMPLETE EVALUATION OF THE FLEXURAL STRENGTH OF PROVISIONAL CROWN AND FIXED PARTIAL DENTURE RESINS WITH AND WITHOUT GLASS FIBER REINFORCEMENT"

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Abstract:

Aim: To evaluate the flexural strength of various provisional crown and fixed partial denture resins with and without glass fiber reinforcement using in-vitro testing system.

Settings and Design: Total of 60 sample specimens were made of 35mm X 2mm X 2mm dimensions. Two groups were made- Group 1 ‗without glass fibres' and Group 2 ‗with glass fibres'. Each group included three subgroups- Subgroup A ‗PMMA', Subgroup B ‗Protemp' Subgroup C ‗Cooltemp'. All subgroups included ten specimens each.

Methods and Material: The fiber-reinforced specimens were made, resin applied on top of fibers. these were placed in the bottom side of the mould cavity; mould placed between two glass slabs and weight was applied over. The specimens were stored in distilled water for 10 days. A 3-point bend test was carried out in universal testing machine. The force was applied on specimens at resin side until Breaking Point. Data obtained of force at fracture was recorded in MPa and tabulated.

Statistical analysis used: . Data were summarised as Mean ± SE. Groups were compared by two factor (fibers and resins) analysis of variance (ANOVA). and the significance of mean difference within (intra) and between (inter) the groups was done accordingly. Analysis on SPSS software

Results: ¬ Protemp with glass fiber reinforcement is best suitable provisional crown and fixed partial denture resin followed by cooltemp with glass fiber reinforcement followed by PMMA with glass fiber reinforcement.

Conclusions: Flexural strength is an important factor while choosing provisional crown and bridge materials.

Key-words: provisional crown, fixed partial denture resins, glass fiber reinforcement

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INTRODUCTION

The use of provisional prosthesis in fixed partial dentures (FPD) in the cases of full mouth or partial oral rehabilitation has been an indispensable protocol for restoring function, esthetics, occlusion, and providing pulpal protection until a permanent prosthesis can be given which may take from a week to few months.[1]

Provisional restorations must satisfy the requirements of pulpal protection, positional stability, occlusal function, ability to be cleansed, margin accuracy, wear resistance, strength and esthetics.[2]

Materials commonly used to fabricate interim restorations are autopolymerising Poly Methyl Methacrylate (PMMA), Bis-acryl composite resins[3,4,5] .

The strength of material can be determinant of how well these requirements are met. [9,10] Flexural strength, also known as transverse strength ; is a measurement of the strength of a bar (supported at each end) under a static load The concept of using fibers to reinforce an interim restoration appears to have an acceptable rate of success. [6,7] With the recent introduction of improved fiber reinforcing materials, this has become increasingly beneficial.[8]

The purpose of this study was to compare the effects of E-glass fiber reinforcement on the flexural strength of auto polymerising Poly Methyl Methacrylate (PMMA), and two different commercially available bis-acryl resins used for fabrication of provisional crown and bridge restorations.

MATERIALS AND METHODS

The present in vitro study to evaluate the flexural strength of provisional crown and fixed partial denture resins with and without glass fiber reinforcement was carried out at Sadar Patel Post Graduate Institute of Dental Sciences, Lucknow and Central Institute of Plastics Engineering and Technology, Lucknow.

SAMPLE SIZE

A total of 60 sample specimens were made of 35mm X 2mm X 2mm dimensions(American National Standards Institute/American Dental Association specification no. 27)[9]. Two groups were made- Group 1 _without glass fibres‘ and Group 2 _with glass fibres‘. Each group included three subgroups- Subgroup A _PMMA‘, Subgroup B _Protemp‘ Subgroup C _Cooltemp‘. All the subgroups included ten specimens each. The specimens were of 35mm X 2mm X 2mm dimensions(in accordance with the American National Standards Institute/American Dental Association specification no. 27)[1,9].

METHODOLOGY

The fiber-reinforced specimens were made from pre-cut 30mm–long fibers which were wetted using the polymer-monomer mix (PMMA,) 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. The mould was placed between two glass slabs and a weight of 2.5 kg will be applied over it[1,9]. All materials were mixed and polymerised according to the manufacturers‘ instructions. The specimens were stored in distilled water at 37 o C for 10 days. After this period, the 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 until Breaking Point. Data was obtained on the digital screen connected to the universal testing machine. The force at fracture was recorded in MPa and tabulated.

Statistical Analysis –

Data was obtained on the digital screen connected to the Universal Testing Machine. The force at fracture was recorded in Megapascal (MPa) using testing machine software. Data were summarised as Mean ± SE (standard error of the mean). Groups were compared by compared by two factor (fibers and resins) analysis of variance (ANOVA) and the significance of mean difference within (intra) and between (inter) the groups was done by Tukey HSD (honestly significant difference) post hoc test after ascertaining normality by Shapiro-Wilk‘s test and homogeneity of variance between groups by Levene‘s test. A two-tailed (α=2) p) $p<0.05$ was considered statistically significant. Analysis was performed on SPSS software (Windows version 17.0).

RESULTS AND OBSERVATIONS

Table 1: Distribution of samples and allocation of groups-

Resins/ Materials	**Without glass fiber (Group 1) (n=30)**		**With glass fiber (Group 2) (n=30)**	
	Subgroup	**n**	**Subgroup**	**n**
PMMA	Subgroup A1	10	Subgroup A2	10
Protemp	Subgroup B1	10	Subgroup B2	10
Cooltemp	Subgroup C1	10	Subgroup C2	10

Table No. 2: Flexural strength (N) of two groups and three subgroups -

Subgroups	**Group 1**		**Subgroups**	**Group 2**	
	N	**Mean ± SE**		**n**	**Mean ± SE**
Subgroup A1	10	44.08 ± 1.89	Subgroup A1	10	52.95 ± 2.11
Subgroup B1	10	58.82 ± 1.25	Subgroup B1	10	67.19 ± 2.47
Subgroup C1	10	57.45 ± 0.86	Subgroup C1	10	64.71 ± 1.82

The flexural strength of two groups/fibers (Group 1 and Group 2) and three subgroups/resins is shown in table 2. Overall, it was highest in Group 2/Subgroup B2 and least in Group 1/Subgroup A1

Table No. 3: Effect of groups and subgroups on flexural strength (N) using ANOVA

Source of variation (SV)	**Sum of squares (SS)**	**Degree of freedom (DF)**	**Mean square (MS)**	**Fvalue**	**p value**
Group	1000.09	1	1000.09	30.36	<0.001
Subgroup	2476.78	2	1238.39	37.59	<0.001
Group x Subgroup	6.86	2	3.43	0.10	0.901
Error	1778.79	54	32.94	-	-
Total	5262.51	59	-	-	-

In table 3 the effect of groups and subgroups together on flexural strength, ANOVA showed significant effect of both group (F=30.36, p<0.001) and subgroups (F=37.59, p<0.001) on flexural strength (Table 6). However, the interaction effect of both (group x subgroup) on flexural strength was found insignificant (F=0.10, p=0.901).

Table No. 4: Comparisons of difference in mean flexural strength (N) between subgroups of Group 1 by Tukey test

Comparisons- Group 1	**Mean difference (%)**	**p value**
Subgroup A1 vs. Subgroup B1	14.74 (25.1)	<0.001
Subgroup A1 vs. Subgroup C1	13.37 (23.3)	<0.001
Subgroup B1 vs. Subgroup C1	1.36 (2.3)	0.995

In table 4 for each group, comparing the difference in mean flexural strength between subgroups (i.e. intra group), Tukey test showed significantly (p<0.001) different and higher flexural strength of both Subgroup B1 and C1 as compared to A1 in Group 1 but not differed (p>0.05) between Subgroup B1 and C1 i.e. found to be statistically the same

Table No. 5: Comparisons of difference in mean flexural strength (N) between subgroups of Group 2 by Tukey test

Comparisons- Group 2	**Mean difference (%)**	**p value**
Subgroup A2 vs. Subgroup B2	14.24 (21.2)	<0.001
Subgroup A2 vs. Subgroup C2	11.76 (18.2)	0.001
Subgroup B2 vs. Subgroup C2	2.48 (3.7)	0.926

In table 5, in Group 2, flexural strength was also found significantly (p<0.01 or p<0.001) different and higher in both Subgroup B2 and C2 as compared to A2 in but not differed (p>0.05) between Subgroup B2 and C2 i.e. found to be statistically the same

Table No. 6: For each subgroup, comparisons of difference in mean flexural strength (N) between groups by Tukey test

Comparisons- Subgroups	**Mean difference (%)**	**p value**
Subgroup A1 vs. Subgroup A2	8.87 (16.8)	0.013
Subgroup B1 vs. Subgroup B2	8.37 (12.5)	0.022
Subgroup C1 vs. Subgroup C2	7.25 (11.2)	0.069

In table 6,for each subgroup, comparing the difference in mean flexural strength between groups (inter group), Tukey test showed significantly (p<0.05) different and higher (16.8%) flexural strength of Subgroup A2 as compared to Subgroup A1

DISCUSSION:

The purpose of this study was to compare the effects of using E-glass fibers on the flexural strength of auto polymerising Poly methyl Methacrylate (PMMA) and bis-acryl resins of two different commercially available provisional crown and bridge products.

A study conducted by Solnit[10] (1991) However, the increase in strength was not found to be significant to those without reinforcement which was not coinciding with our results. Assimilation of loose glass fibers treated with silane coupling agent and autopolymerizing PMMA resin monomer did increase strength but not like other reinforcements.

Studies conducted by Stipho[11] and Karacaer et al[12] .(1998) on effect of concentration of loose glass fiber on reinforcement autopolymerizing PMMA resin showed that there was a definite increase in the transverse strength. Their study found that only in specific low concentration of glass fiber, there was enrichment in the strength of resin. They concluded that just 1% of glass fibers were able to increase the strength.

Garoushi SK et al[13] (2008) evaluated the flexural strength of composite using different length and volume fraction of fibres.

Duymus ZY, Karaalioglu FO and Suleyman F[9] (2014) also conducted a study on flexural strength of provisional crown and bridge material using glass fibers. In their study 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 were prepared for the flexural strength test. The specimens were divided into 5 groups according to the type of resin used (Tetric Ceram, Charisma, Dentalon Plus, TAB 2000, Protemp 3) and then each group was divided into 3 subgroups according to the type of fiber reinforcement (Construct, Fiber-splint ML). Unreinforced specimens served as the control. Specimens were loaded in a universal testing machine until thepoint of fracture. The mean flexural strength (MPa) was compared using one-way analysis of variance, followed by Duncan's multiple range tests.

K.S. Naveenet al.[14] (2015)studied the flexural strength of provisional crown and bridge material using silane treated and untreated glass fibres.

Gupta Parikshit et al.[1] (2017)also did a study to compare the fracture strength of provisional crown and bridge material using stainless steel wires and glass fibres in different groups and found same result. In their study fifty samples were made (10 samples for each group) with autopolymerizing PMMA resin using reinforcement materials (stainless steel wire: looped and unlooped and glass fiber: loose and unidirectional) as 3- unit posterior bridge. The test specimens were divided into five groups depending on the reinforcing material as Group I, II, III, IV, and V; Group I: PMMA unreinforced (control group), Group II: PMMA reinforced with stainless steel wire (straight ends), Group III: PMMA reinforced with stainless steel wire (looped ends), Group IV: PMMA reinforced with unidirectional glass fibers, and Group V: PMMA reinforced with randomly distributed glass fibers. Universal testing machine was used to evaluate and compare the fracture strength of samples. Comparison of mean ultimate force and ultimate stress was done employing one- way analysis of variance and Tukey'spost hoc tests.

In the present study it was found that the mean flexural strength of Group 2 (with glass fibres) was comparatively higher than Group 1 (without glass fibres) in all the subgroups.As depicted in the above given tables 1 to 6. It was also seen that amongst these three provisional crown and bridge materials subgroup B(Protemp 4) with glass fibre reinforcement had the maximum flexural strength. The mean of unreinforced PMMA group was 44.08 MPa. The mean of unreinforced Protemp group was58.82 MPa. The mean of unreinforced Cooltemp group was 57.45 MPa.The mean of fiber-reinforced PMMA group was52.95 MPa. The mean of fiber-reinforced Protemp group was 67.19 MPa. The mean of fiber-reinforced Cooltemp group was 64.71 MPa.

The results of the present study have also been achieved in agreement with the studies done by Viswambaran et al. [15], Gupta and Reddy, Naveen et al. [14],and Kapri[16] .

Duymus ZY (2014)[9]found the highest average flexural strength value 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. Polymerization shrinkage of acrylic resin and poor wetting of fibers within the dough can lead to voids formation, which can hamper the strength of acrylic. This can be prevented by proper wetting of glass fiber with monomer. However, excess use of monomer would increase the polymerization shrinkage[17].

Gupta Parikshit et al. [1] (2017) also found that among the various reinforcements used to the upsurge fracture strength of autopolymerizing

PMMA resin, sample reinforced with unidirectional glass fiber showed determined increase in mean ultimate force and stress. The mean ultimate stress of unreinforced group was 49.72 MPa, for those reinforced with stainless steel wire (straight ends) was 67.12 MPa, reinforced with stainless steel wire (looped ends) was 62.73 MPa, reinforced with unidirectional glass fibers wa 70.09 MPa, and reinforced with randomly distributed glass fibers was 52.38 MPa

Clinical inference

The site of placement of fibres is crucial for strength of the restoration. As per literature the various sites of reinforcement include occlusal, middle and cervical third,[18,19]. It has been established that by engaging the fibres at middle third, there is significant improvement in flexural strength. The E-glass fibers used do not compromise the esthetic qualities of provisional restoration and strength achieved exceeded the normal strength of PMMA and Bis acrylic resin. Fiber reinforcement is a potential technique for strengthening provisional fixed partial dentures at the connector sites to avoid fractures which may be used for extended periods[20].

Limitations of the present study

In the present study the acylic resin samples were soaked in distilled water for 10 days. However, the intraoral conditions could not be simulated while testing of samples such as repeated rhythmic loading of the prosthesis under masticatory loads, which leads to fatigue of the prosthesis and causes fracture, and also, the lateral forces were not taken into deliberation, which if considered would have given more pertinent results. The effect of the luting agent on flexural strength of interim FDP was not explored in this study. It is likely that cementing the FDP to the abutments increases the fracture resistance of the FDP by transferring stresses more evenly to the FDP abutment system. One more limitation of the present study was the trouble in securing the fibre in the exact location; though, the results may provide a balanced clinical protocol for the fabrication of E-glass fibre-reinforced interim FDP[14]. The specimen surfaces were flat, whereas clinically, provisional restorations will have an irregular shape with convex and concave surfaces[21]. The test specimens were dipped in the test solutions which were static unlike the oral cavity where the solutions are in a dynamic state (temperature, pH and microbial load). Complete precautions were taken following a standard protocol for fabrication of the test specimens. The factors such as the climate temperature, presence of internal porosity, and the releases of stresses during finishing and polishing procedures could not be controlled. Polymerization shrinkage and voids in glass fiber reinforcements could have also altered the results although the standard prescribed procedures were followed[1].

Future leads

The present was an in-vitro study, but the provisional restorations are meant to function in the oral cavity. Hence, clinical trials along with other properties like color stability, micro-hardness, polymerisation shrinkage, marginal adaptability and absorption need to be further investigated to help the clinician in selecting the most optimum interim crown and bridge material for clinical use.[22] Compressive and shear strengths need to be investigated in clinical conditions for choosing most optimum interim crown and bridge material for clinical use.

CONCLUSION

Flexural strength is an important factor while choosing provisional crown and bridge materials. Within limitations of this in-vitro study, the following points were discovered:- ¬ Protemp with glass fiber reinforcement is best suitable provisional crown and fixed partial denture resin followed by cooltemp with glass fiber reinforcement followed by PMMA with glass fiber reinforcement. The mean flexural strength of Protemp without E-glass fibres is comparatively higher than PMMA and slightly higher than cooltemp without E-glass fibres. The mean flexural strength of Protemp with E-glass fibres is comparatively higher than PMMA and slightly higher than Coolemp with E-glass fibres. The mean flexural strength of PMMA with E-glass fibres is comparatively higher than PMMA without E-glass fibres. The mean difference is 8.86%. The mean flexural strength of Protemp with E-glass fibres is comparatively higher than Protemp without E-glass fibres. The mean difference is 8.37%. The mean flexural strength of Cooltemp with E-glass fibres is comparatively higher than Cooltemp without E-glass fibres. The mean difference is 7.25%. The site of placement of fibres is crucial for strength of the restoration. As per literature the various sites of reinforcement include occlusal, middle and cervical third[18,19]. It has been proven that by placing the fibres at middle third, there is considerable improvement in flexural strength. The intraoral conditions could not be simulated while testing of samples such as repeated rhythmic loading of the prosthesis under masticatory loads, which leads to fatigue of the prosthesis and causes fracture, and also, the lateral forces were not taken into consideration. The effect of the luting agent on flexural strength of interim FDP was not explored in this study. Clinical trials along with Also, other properties like colour stability, microhardness, polymerisation shrinkage, marginal adaptability and absorption need to be further investigated to help the clinician in selecting the most optimum interim crown and bridge material for clinical use. [22]

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FIGURES:

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