



COMPARATIVE IN VITRO EVALUATION OF FLEXURAL STRENGTH AND HARDNESS OF THREE FIXED PROSTHODONTICS PROVISIONAL CROWN MATERIALS

Dental Science

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ABSTRACT

Objectives: To evaluate and compare the flexural strength and hardness of three provisional crown after storing in artificial saliva and testing at intervals of 10 days.

Study design: A metal master mould was fabricated to obtain samples of standard dimensions. The three provisional crown materials that will be tested in this study are Protemp™ IV (group PSC), Combo- Lign™ (group CDC), and Tempron™ (TSC). The specimens were tested for flexural tests were using universal testing and the micro hardness using microhardness tester. Statistically analysed by ANOVA test.

Results: Flexural test results showed that Group PSc (105.78 MPa) has the highest flexural strength followed by Group CDC (80.90 MPa), Group TSC (69.67 MPa). The hardness tests showed that Group CDC (95.40 KHN) has the highest hardness value followed by Group PSC (69.10 RHN), Group TSC (47.80 KHN).

Conclusion: Group PSC showed the highest flexural strength compared to others, and Group PSC.

KEYWORDS

Flexural Strength, microhardness, provisional Crowns.

INTRODUCTION:

The provisional crowns play a major role within the time interval between the tooth preparation stage to fixation of the definitive restoration¹. Overall success of definitive prosthesis in its biologic, mechanical, and esthetic aspects depend on a well made provisional crown². In addition, Provisional restorations act as a diagnostic tool in reviewing patients' response to altered vertical dimension occlusal plane corrections and aid in assessing the success of periodontal, endodontic, and implant treatment³.

Physical and mechanical properties of the materials play a vital role in selection of a material for provisional restoration. Resins are commonly used as interim restorative materials^{4,5}. Presently there is no single material that meets the optimal requirements for all the situations¹. Resins used for interim restoration are classified as Poly Methyl Methacrylate Resins (PMMA), Poly Ethyl Methacrylate Resins (PEMA), vinyl ethyl methacrylate resins, butyl methacrylate, bis-acryl composites, bis-GMA composites, Urethane Di Methacrylate Resins (UDMA)^{4,5}. Flexural strength for a provisional material is determined when the fixed partial dentures are subjected to various functional loads. The fixed partial dentures should be strong enough to withstand such forces, this is assessed by flexural strength tests^{6,7}. The other mechanical requirement is wear resistance or hardness of a material. Structural integrity of these restorations is increased by increasing the hardness as it reduces the incidence of perforation of the given provisional restorative material^{7,8}. The aim of this study is to evaluate and compare the flexural strength and hardness of three commercially available provisional crown and fixed partial denture resins and also to evaluate and compare the flexural strength and hardness of three provisional crown after storing in artificial saliva and testing at intervals of 10 days.

MATERIALS AND METHODS:

Three groups of forty specimens each were prepared from the following materials:

(a)Temporan™ self curing resin. (A2 shade) GC America (Group TSC), (b)Protentp™ IV self curing resin. (A3 shade) 3M-ESPE, Germany (Group PSC), (c)Combo lign™ dual curing resin (A2 shade). Bredent company (Group CDC).

A customized 3 piece brass flask of dimensions 85x 30 x 10 mm, was machined, which contained 5 single mold space corresponding to the dimensions of the specimen required (65x10x2.5mm-ANSI/ADA specification No.12). Four screws were present at the corners of the flask, which helped in assembling the 3 pieces. This customized flask was used for the fabrication of the autopolymerizing resin specimens.

Fabrication of Samples:

For group PSC, The material was dispensed using a Garant dispenser attached to the cartridge. The material was dispensed with the mixing tips on to the lubricated brass flask mold. The flask was closed using intermittent pressure in a bench press (Siria, India). Trial closure was

done. The specimen was retrieved from the flask after 5 min.

For group CDC, the material was dispensed into the mold lubricated with petroleum jelly and the flask was closed using intermittent pressure in a bench press (Siria, India). Trial closure was done. The specimen was retrieved from the flask after 10 min. Then the brass lid of the flask was removed and an identical glass lid was placed over the body of the brass flask. An LED powered visible light curing unit was used for 180 seconds in fast cure mode (440-480 nm) for curing of the material. This was carried out for every 4 mm along the entire length and width of the specimen. The depth of curing for each of the specimen was 2.5mm, which is well within the acceptable limits.

For group TSC, The material is supplied in powder and liquid form as polymer and monomer respectively. In a glass mixing jar, regular monomer was taken and powder was added to it in the ratio of 1.0g/0.5mL (upto the first graduation on the powder measure and the first graduation of the liquid pipette) and mixed for 20 to 30 seconds. The material was packed into the lubricated mold space of the customized flask. The flask was then closed using intermittent pressure in a bench press. Trial closure was done until all the excess material was removed. The flask with resin was allowed to set for 3 minutes.

Conditioning of the specimens:

During the fabrication of the 120 specimens, the completed ones were stored in distilled water. About 60 specimens were stored in artificial saliva for 10 days since it simulates the oral environment. At the end of the conditioning period, they were washed under running water and air-dried. All 120 specimens were then tested for flexural strength and hardness.

Testing of the specimens:

Flexural strength determination with a Universal testing machine:

A total of 120 specimens which includes 60 dry samples and 60 stored in artificial saliva for 10 days was initiated for testing process. Each specimen was subjected to the 3-point bending test, at a cross head speed of 2 mm/min, at a 40mm distance, with a universal testing apparatus (model 4206, Instron Corp., Canton, Mass.). The load was applied to the centre of the specimen. The loading was continued till fracture occurred and the breaking load was noted in Kilograms. The procedure was repeated accordingly for all the specimens.

Figure 1: Testing The Sample For Flexural Strength



Testing hardness with a Microhardness tester:

The fractured specimens were used to determine the surface hardness using a microhardness tester [Clemex microhardness dual indenter, Clemex, Canada]. Surface hardness was determined by loading each specimen for 15 sec with a force of 50 gms, after mounting it on the microindenter.

Figure 2: Testing The Sample For Hardness



Statistical analysis:

The mean between 3 groups and effect of flexural strength and hardness in dry and wet conditions were compared using Two Way Analysis of Variance (ANOVA) test.

RESULTS

The comparison flexural strength and hardness values are shown in Tables 1 and 2. The comparison of flexural strength and hardness between the study groups in two different conditions are shown in table 3 and 4.

Table (1) : Comparison Of Main Effects Of The Group On The Flexural Strength

Condition	Group	N	Mean	Std. Deviation
Dry	PSC	10	105.78	4.80
	TSC	10	69.67	1.77
	CDC	10	80.90	3.41
Wet	PSC	10	63.32	1.35
	TSC	10	52.98	1.82
	CDC	10	49.78	1.66

Table (2) : Comparison Of Main Effects Of The Group On The Hardness

Condition	Group	Mean	Std. Deviation	N
Dry	PSC	69.10	1.29	10
	TSC	47.80	2.57	10
	CDC	95.40	2.01	10
Wet	PSC	55.40	2.50	10
	TSC	25.20	3.08	10
	CDC	55.20	2.62	10

Table(3): Comparison Of Flexural Strength Between The Study Groups In Two Different Conditions.

Condition	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Dry	PSC	105.78	0.87	104.03	107.53
	TSC	69.67	0.87	67.92	71.42
	CDC	80.90	0.87	79.14	82.65
Wet	PSC	63.32	0.87	61.56	65.07
	TSC	52.98	0.87	51.23	54.74
	CDC	49.78	0.87	48.03	51.54

Table(4): Comparison Of Hardness Between The Study Groups In Two Different Conditions.

Condition	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Dry	PSC	69.10	0.76	67.57	70.63
	TSC	47.80	0.76	46.27	49.33
	CDC	95.40	0.76	93.87	96.93
Wet	PSC	55.40	0.76	53.87	56.93
	TSC	25.20	0.76	23.67	26.73
	CDC	55.20	0.76	53.67	56.73

Graphical representation of distribution of values of flexural strength and hardness, are shown in Figures 3 and 4.

Figure 3 : Comparison Of Mean Flexural Strength Between The Different Groups

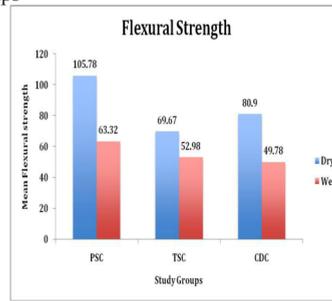
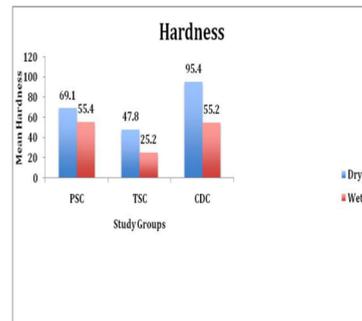


FIGURE 4: Comparison Of Mean Hardness Between The Different Groups



DISCUSSION

Provisional restorations play a critical role in the success of fixed prosthodontic treatment. They are fabricated for use during the time period between the tooth preparation and fitting of a definitive restoration. A provisional restoration should provide both function and comfort, and it should also be an esthetic replacement for the prepared tooth structure⁹⁻¹². Presently, there are many provisional restorative materials commercially available which has the same base resin group, having varying physical properties depending on the type, amount, geometry and size of the filler particles and the properties of the polymer matrix^{13,14,15}. The material selection for fabricating provisional restorations should be based on the merits and demerits of a given material relative to the clinical mandates for specific treatments^{14,16}. Hence, it is imperative that clinicians should be familiar with the mechanical properties of the commercially available provisional materials.

The aim of this study was to evaluate which of the commercially available provisional materials studied is better suited for fabricating provisional restorations associated with long term use, for long span bridges or in areas of heavy occlusal contacts. In the present study, the flexural strength and hardness of three different commercially available provisional crown and fixed partial denture resins were tested using ADA specification Number 12 as guideline¹³ for fabricating the specimens. A fixed partial denture is subjected to a variety of forces under load⁸. The flexural strength test used in this study was an attempt to simulate the stress distribution in clinical situations, such as multiple unit fixed partial dentures^{7,8}.

Surface hardness is used as an indicator of density and it can be hypothesized that a denser material would be more resistant to wear and surface deterioration¹⁶. When a provisional restoration is fabricated with a material having good wear resistance, the risk of perforation is greatly decreased, maintaining its structural integrity for a longer period of time. There are several types of hardness tests like Barcol, Brinell, Rockwell, Shore, Vicker and Knoop^{7,8,16,17}. The selection of the test is dependant on the material being studied. In this study, Knoop Hardness Number (microhardness test) was determined since it was more reliable, as relatively thin specimens of soft acrylic resins and microfilled composites were to be analyzed.

Flexural test under dry condition results showed that Group PSC (105.78 MPa) has the highest flexural strength followed by Group CDC (80.90 MPa), Group TSC (69.67 MPa). Where as under wet

condition the flexural test results showed as follows Group PSC (63.32 MPa) has the highest flexural strength followed by Group TSC (52.98MPa), Group CDC (49.78MPa), in the descending order. When statistically analyzed, the 'P' value was found to very highly significant. This shows that the flexural strength between the groups have a comparable difference and this is highly significant for all practical purposes.

The hardness tests showed that Group CDC (95.40 KHN) has the highest hardness value followed by Group PSC (69.10 RHN), Group TSC (47.80 KHN) for samples tested under dry condition. The wet samples showed following results Group PSC (55.40 KHN) has the highest hardness value followed by Group CDC (55.20 KHN), Group TSC (25.20 KHN), in descending order. When statistically analyzed, the 'P' value was found to very highly significant between all the groups. This indicates that the hardness between the groups have a very highly significant difference in the values obtained and this has to be taken into consideration.

The standard deviation of flexural strength of PSC, TSC and CDC were found to be 4.80, 1.77, 3.41 (under dry condition) 1.35, 1.82, 1.66 (under dry condition) of their mean values respectively. The standard deviation of hardness values of PSC, TSC and CDC were found to be 0.76 for all the groups in dry and wet condition of their mean values respectively. This clearly indicates that the standard and uniform protocol for preparing, curing and finishing of all test specimens and the homogeneity of the mix were well maintained during the study.

The data indicated that the heat cure polymerizing provisional material, Prottemp IV with bisacryl resin, had the highest flexural strength and the combolign provisional material had highest hardness when tested under dry condition. Prottemp IV is a bis-acryl resin containing bifunctional methacrylate (70%), silicone dioxide as filler (25%), vinyl copolymers (4%), inorganic fillers (56%) and bifunctional esters (40%). They attain a flexible cross-linked polymer structure imparting strength and hardness to the material^{18,19}. They are hydrophobic, ensuring minimal water uptake, and thus reducing the plasticizer action. In addition, vinyl copolymers are included to increase the flexural strength. The high percentage of silicone dioxide fillers improves the wear resistance of the material^{18,19}. Bis-acryls have a rigid central structure that reduces the dissolution of its resin-filler particles during its immersion in saliva²⁰. These features impart high flexural strength and hardness compared to other autopolymerizing and light cure resins used in this study.

The dual curable resin, CombolignTM has the second highest flexural strength followed by autopolymerized resin TempronTM provisional crown material when tested under dry conditions. But the results varied when the samples were tested under wet condition between the CombolignTM and TempronTM provisional materials. Under wet condition the Prottemp IV again showed highest flexural strength, second being the TempronTM followed by CombolignTM. The samples when tested for hardness in dry condition the combolign was the hardest of all followed by prottemp and tempron. But in wet condition CombolignTM and Prottemp IV showed similar range of values but the TempronTM had least hardness values as compared to the rest.

These results are similar to that obtained in a study^{8,21} conducted to compare the quality of provisional restorations fabricated from bis-acryl composite resins and poly (methyl methacrylate) resins. It was proved that bis-acryl composite resin is a predictable material for effective fabrication of provisional restorations. Another study²⁰ was done by Haselton et al to compare the transverse strength of 5 methacrylate based resins and 8 bis-acryl resins. Most bis-acryl resins demonstrated significant superior flexural strength over traditional methacrylate resins evaluated in this study.

On the basis of the results obtained, Prottemp IV with bisacryl resin, (self cure resin) maybe considered as the material of choice as it showed highest flexural strength and CombolignTM showed highest hardness. The samples when tested under wet condition that is when immersed in artificial saliva for 10 days the flexural strength of Prottemp IVTM was the highest again but in the hardness factor both Prottemp IVTM and CombolignTM showed equal values under wet condition. Hence CombolignTM could be considered as the material

choice based on the hardness factor.

Limitations of the study

In this study, the sample groups included should have more extensive study. Similar products of the same group should be done, instead of single commercial product.

Also the following study is an invitro study hence simulation of oral cavity in relation to force can not be made accurately resulting in restricting the scope of the study. Therefore further investigations are required under more closely imulated clinical conditions. Technical errors in fabrication and finishing of the samples can effect the final outcome of the results. In spite of following a standard protocol while fabrication of the samples..

CONCLUSION

Within the limits of the present study and on the basis of results obtained, it may be concluded that -

- **Prottemp IVTM with bisacryl resin** (auto cure resin) showed the highest flexural strength followed by **CombolignTM** (dual cure resin), **TempronTM with self cure monomer** (self cure resin), in descending order when tested under dry and wet conditions.
- **CombolignTM** showed the highest hardness when tested under dry condition followed by, **ProttempTM IV** (self cure resin), **TempronTM** (self cure resin), in descending order. But when tested under wet conditions **ProttempTM IV** showed highest hardness followed by **CombolignTM** and **TempronTM**.
- **ProttempTM IV**, which is an autopolymerizing resin, is a better material for the fabrication of provisional restorations because of its ease of use, less time consumption and superior mechanical properties.

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