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Invitro Comparative Analysis of the Flexural Strength of 4 Different Commercially Available Provisional Materials Used in Fixed Partial Dentures – An Original Research

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Abstract

Background: Provisional Prosthesis in fixed partial dentures are subjected to Flexure under stress. Selection of appropriate material for fabrication of Provisional is of utmost importance as the Provisional prosthesis has to remain in function till definitive prosthesis is delivered. **Material & Methods:** Bar type specimens of four different commercially available brands for provisional restorations fabricated according to ADA specification No. 27 and immersed in artificial saliva. The specimens were fractured under 3-point loading test. **Results:** The flexural strength ranged between 60 to 110 Mpa. BisGMA Auto polymerizing composite resin from Dentsply Caulk shows the highest flexural strength. **Conclusion:** Within the limitations of this study, the flexural strengths were material specific rather than category one. The BisGMA composite based resin shows significantly higher flexural strength over other materials.

Keywords:- Provisional restoration, Fixed Partial Denture, PMMA, Bis-GMA composite, Urethane Di Methacrylate.

INTRODUCTION

Provisional restorations play an important role in fixed prosthodontics and is used in between before the delivery of the final prosthesis. The fabrication of a good provisional restoration is essential for a successful outcome of the final restoration.[1] A properly constructed and accurate fitting provisional restoration provide protective coverage for Vital prepared tooth. Most frequent problem associated with fixed partial denture is the fracture of the material. Undue forces, parafunctional habits lead unnecessarily wear off provisional restoration which ultimately leads to need of multiple time for fabrication of provisional restoration before delivery of definitive prosthesis.[2] Some physical and mechanical properties of these provisional restorations are of extreme importance, like flexural strength, hardness, wear resistance. These materials are temporary

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but they should last enough time in the oral cavity to fulfil their requirements. The importance is to withstand the environment of the oral cavity. The clinician should be aware of provisional materials commercially available and their mechanical properties. In this study, we will compare and evaluate 4 different commercially available provisional materials hardness.

MATERIAL AND METHODS

Mold Description: According to ADA specifications no.13, the master die was machined (64 mm × 3.5 mm × 12.3 mm × 65 mm × 13.5 mm) to determine hardness. Then, the mold was prepared. 100 g powder: 30 ml water ratio was used to fill the lower portion of the brass flask in which stainless steel dies were then placed. The second half of the flask was filled with dental stone after applying cold mold seal on the previous set mixture and flasking was done. The flask was then placed on the bench press and allowed to set. After the set was achieved, the flasks were opened and the dies were removed from the lower flasks.

Specimen Fabrication

Fabrication of Group A Specimens (PMMA Resin): The material is supplied in powder and liquid form as polymer and monomer respectively and the main component of the material is PMMA. The manipulation of the material was carried out according to the manufacturer's instructions. The standard polymer/monomer ratio is 1.0g/0.5ml. Spatulation was done for approximately 20–30 seconds to evenly wet the polymer particles. This material was placed in to the lubricated mould space and the flask compartments were approximated under constant pressure until the flash comes out. After five minutes, the samples were retrieved and polished. Similarly, all the 10 samples were fabricated.

Fabrication of Group B Specimens (Polymethyl Methacrylate Resin): Wax patterns were made by pouring molten modelling wax into the customized mould space of dimensions 64 mm × 3.5 mm
× 12.3 mm × 65 mm × 13.5 mm and conventional flasking was done using two pour technique. Dewaxing was done. Short curing cycle was followed by placing the flasks at 74°C for 2 hours and then the temperature was raised to 100°C and processed for 1 hour. After completion of the polymerization cycle, the flasks were allowed to cool in the water bath to room temperature before deflasking and samples were retrieved.

Fabrication of Group C Specimens (Bis-Gma Composite Resin): The material is supplied in cartridge form as base and catalyst pastes and the main component of the material is BisGMA. The cartridge was placed in the mixing gun and the material was loaded into the mould spaces of the lubricated brass flask. The flask compartments are approximated and after five minutes, the samples were retrieved and polished. All the samples were prepared in the same way.

Fabrication of Group D Specimens (UDMA Resin): The material is supplied in the form of a putty stick and the main component of the material is UDMA. Required amount of material was dispensed using a spatula and the material was kneaded with fingers to soften it. Initial light curing was done using a Light Emitting Diode (LED) powered visible light curing unit for 10 seconds in fast cure mode (440−480nm) for each specimen according to the manufacturer's instructions. The specimens

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were then retrieved and final curing was done for 10 minutes with Delta Polymat Light Curing Unit. After obtaining the 40 specimens, they were assessed for internal or external flaws. Later finishing procedures were carried out.

Resin Type	Polymerization Method	Manufacturer	LOT Number
Group A: Poly methyl methacrylate	Auto polymerizing	Dental Products of India Ltd.	Mumbai, India 3452
Group B: Poly methyl methacrylate	Heat cure	Dental Products of India Ltd.	Mumbai, India 4133
Group C: Bis-GMA composite	Auto polymerizing Integrity	Dentsply Caulk,	USA 1502031
Group D: Urethane Di Methacrylate	Light Cure	Revotek	GC Corporation, Japan 150326

These specimens were subjected to three-point bend test by Universal Testing Machine.
The load was applied to the centre of the specimen until the specimen fractures. The breaking load was noted in Newton. The procedure was repeated accordingly for all the specimens. These breaking load values were converted to flexural strength using the formula, $S=3FL/2bd2$ Where, S = Flexural strength/modulus of rupture in Mega Pascals, F = Load at the fracture point in Newton's at which specimens failed between load bearing edges, L= Length of the support span (15mm), b = Width of specimen (2mm), d = Thickness of the specimen (2mm).

Statistical Analysis

Substituting the above formula for each load value obtained, the corresponding flexural strength was calculated for all 40 specimens. The flexural strength values obtained were in Mega Pascal (Mpa). The data were analysed and computed with statistical software package SPSS 16 version (Chicago.inc).

RESULTS

This study evaluated the flexural strength of four provisional crown materials of 4 different brands. When the mean flexural strength of four provisional crown materials was considered the methyl methacrylate-based auto-polymerized resin showed the highest flexural strength followed by the light polymerized resin and bis-acrylic composite-based auto-polymerized resin showed least flexural strength. Methyl methacrylate-based resin reduced in flexural strength significantly after 24 hours storage in artificial saliva and remained constant to the 7 days storage time. However, bis-acrylic composite resin observed an increase in its flexural strength after 24 hours storage in artificial saliva and did not show significant change after 7 days, whereas light polymerized resin decreased in flexural strength after 24 hours storage in artificial saliva and thereafter an increase in the flexural strength values after 7 days.

Table 1: Comparison of flexural strengths between any two groups was evaluated.

Group	**Mean**	**S.D**	**p-value**
Group A	78.13	0.65	<0.001 Significant
Group B	92.86	1.24	
Group A	78.13	0.65	<0.001 Significant
Group C	103.98	2.52	

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Group A	78.13	0.65	<0.001 Significant
Group D	61.01	0.71	
Group A	92.86	1.24	<0.001 Significant
Group C	103.98	2.52	
Group B	92.86	1.24	<0.001 Significant
Group D	61.01	0.71	
Group C	103.98	2.52	<0.001 Significant
Group D	61.01	0.71	

DISCUSSION

Provisional restoration is an important component of fixed prosthodontics, designed to improve aesthetics, stability, and function during the transition period before a definitive prosthesis is placed. Repair procedures can be time consuming and breakage of these restorations can lead to tooth movement, functional and aesthetic problems. Hence, provisional restorations made of appropriate material are considered to be critical components of fixed prosthodontic treatment. Many commercially available provisional restorative materials have evolved but no single material was proved to be ideal for all clinical situations. Therefore, careful understanding of the composition and mechanical properties of the materials available is required to select a material that best suits the clinical situation.[3] In this study the flexural strength of four types of provisional restorative resin materials were compared after thermal cycling i.e. auto polymerizing PMMA (Group A); heat activated PMMA (Group B); auto polymerizing Bis-GMA composite resin (Group C) and light activated UDMA (Group D). A universal testing machine and a 3-point bend test was used to determine flexural strength. Furthermore, when a material is subjected to different temperature regulations, the changes that occur were evaluated when the material is used overtime. Specimens were stored in artificial saliva for a few days to simulate the oral environment before being thermos cycled for 2,500 cycles (5°C to 55°C) to assess various thermal regulations. Following that, the specimens were subjected to a standard three-point bending test. Flexural strength was tested on 40 of the 40 specimens, 10 from each group, and the mean, standard deviation, and test of significance were calculated for all groups.

[Table 1] shows the flexural strength comparisons between Groups A, B,and C are statistically significant (P = 0.045) because the values differ. Bis-acryl composite resin (Group B) had the highest flexural strength, followed by PMMA (Group A). Analyzing the data, within the limitations of the study the flexural strength of the materials compared were in the following descending order: Auto polymerizing Bis-GMA (Group C) > heat activated PMMA (Group B) > light activated UDMA (Group D) > auto polymerizing PMMA (Group A).

According to the International Organization for Standardization (ISO 4049) and the American National Standards Institute (ANSI)/ American Dental Association (ADA) Specifications no. 27, an interim fixed prosthesis material must have a minimum strength of 50 Mpa when a bar of the material undergoes a 3-point bend test.[4] All the specimens tested in this study had flexural

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strength values more than 50 Mpa, which infers that all the materials, can comfortably be used for the fabrication of provisional restorations.

Bis-GMA composite resin material exhibited greater flexural strength than the other materials because of multifunctional monomers, which increase the strength due to cross-linking with other monomers. Additionally, they contain inorganic nano fillers which further improve the strength of the material. It is hydrophobic in nature, ensuring minimal water uptake and thus reducing the plasticizer action when stored in artificial saliva. Hasselton et al compared flexural strength of methacrylate base resins and bis-acryl resins after immersing in artificial saliva for 10 days.[5] They concluded that due to chemical composition i.e., difunctional and capable of crossing linking with other monomer chain bis-acryl resins demonstrated significantly superior flexural strength over traditional methacrylate resins which were mono functional in their chemical composition.

Heat cured PMMA resins were ranked next to Bis-GMA resins because heat polymerization eliminates excess residual monomer (0.2%-0.5%), leading to a higher degree of polymerization and therefore makes the material stronger. However, the presence of even small amount of residual monomer and its evaporation makes the material to absorb water when placed in artificial saliva. These water molecules interfere with the polymer chains and act as plasticizer when stored in artificial saliva. The main disadvantages with heat cure acrylic are time consuming and exhaustive laboratory procedures.[6]

Auto polymerizing PMMA resins are mono functional, low molecular weight linear molecules that exhibit decreased strength and rigidity. However, the reasons for decreased flexural strength could be lack of time available for the monomer in self cure resin to wet the polymer beads. So, a less homogenous polymer is produced. The material deforms under stresses subjected by thermal cycling unlike other materials.[7]

The flexural strength of the light polymerized urethane Di methacrylate composite resin material was comparatively low among all the materials compared. The reason for this result was mainly because of less crystalline silica filler particles (15%- 35%) when compared to normal composites (85% by weight).These glass filler particles are slowly leached out in the presence of artificial saliva and thus, reducing the flexural strength of the material.[8]

Nejatidanesh et al., conducted a study to compare the flexural strength of seven provisional restorative materials. In their study, composite resins exhibited better flexural strength values when compared to acrylic resins.9 Within the acrylic resin groups, polyethyl methacrylate exhibited higher flexural strength values when compared to polymethyl methacrylate and vinyl ethyl methacrylate resins.[10] However, the difference in flexural strength performance is material specific and hence, direct comparison with other studies was not possible.

CONCLUSIONS

The results obtained in this study are consistent with those of previous studies in which flexural strength of bis-acryl resins was higher than

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conventional provisional restorative materials. However, the direct comparison among various studies cannot be done as this property is material specific and continuous development to improve the properties of material are taking place. At last, it should be mentioned that flexural strength is not only one factor that influence the success of an interim prosthesis. Other properties should also be taken into consideration for the success of a material.

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