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Comparative Evaluation of Fracture Resistance of Three Commercially Available Resins for Provisional Restorations: An *In vitro* Study

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RD and RPN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and managed literature searches. Authors RPN, RD and RP managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Aims: To evaluate and compare the fracture resistance of three commercially available resins for provisional restorations.
Study Design: The fracture resistance of three commercially available resins for provisional restorations (DPI Dental Products India, SNAP, PROTEMP4) have been tested for three point bend test using Universal Testing Machine and the mean fracture resistance of each specimens were tabulated and subjected to statistical analysis.
Place and Duration of Study: Department of Prosthodontics and Crown and Bridge, V.K Institute of Dental Sciences, KLE University, Belgaum, Karnataka, India and Gogte Institute of Technology, Belgaum, Karnataka, India between March 2013 and December 2013.
Methodology: A Ni-Cr alloy master model with a 3-unit FPD, (Fixed Partial Denture) (abutment teeth 45 and 47) was fabricated. Provisional 3-unit FPD's (5 samples each of DPI, SNAP, PROTEMP4) were produced by direct fabrication using the master model. Maximum force at

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fracture was determined using a universal testing machine.
Results: Comparison of the mean fracture resistance between the three groups was done using one way ANOVA. Statistically significant difference was present between the groups ($p<0.05$). Bonferroni test was applied and statistically significant difference was seen between DPI and Protemp4 but not between DPI and SNAP or between SNAP and Protemp4.Hence this suggested that Protemp4 significantly has higher fracture resistance when compared to DPI.
Conclusion: Bis-acryl composite resin (Protemp 4) was significantly superior in fracture resistance to ethyl methacrylate (SNAP) and methyl methacrylate (DPI) as a provisional restorative material for provisional restorations in fixed partial dentures.

Keywords: Methyl methacrylate resin; ethyl methacrylate resin; bis-acryl composite resin; resins for provisional restorations; fracture resistance.

1. INTRODUCTION

Fixed prosthodontic treatment involves the restoration of compromised natural teeth with crowns or partially edentulous arches with fixed dental prosthesis or implant supported prosthesis. Fixed prosthesis used to replace missing teeth, improve patient comfort and masticatory ability, maintains the health and integrity of the dental arches and in many instances elevates the patient's self-image [1].

During the tooth preparation procedure, much of the tooth structure is removed and it becomes comparatively smaller in size, thus compromising the esthetics, masticatory efficiency and occlusal harmony. This is when the role of provisional restoration is to be considered. The need for provisional restorations arises due to the considerable time that is required for the fabrication of the definitive prosthesis. Provisional restoration has its function only for a limited period of time, after which it is to be replaced by a definitive prosthesis. The purpose of providing a provisional restoration would include immediate replacement of missing teeth, protection of pulp and maintenance of periodontal health, to provide occlusal stability and hence to improve masticatory efficiency [2,3,4,5,6].

Currently available provisional materials can be divided into four resin groups, namely, poly (methyl methacrylates), poly (R′ methacrylates), bis-acryl composite resins and visible light cured urethane dimethacrylates [7].

Clinicians should be familiar with the range of mechanical properties of commercially available provisional restorative materials to determine a suitable material for a specific treatment plan. In clinical situations, fixed partial dentures are subjected to various functional loads which cause the prosthesis to flex in different directions. In order to assess if a provisional restorative material is strong enough to withstand such forces, fracture resistance should be determined.

This in vitro study determined fracture resistance of three different commercially available provisional crown and bridge material which were subjected to maximum load.

2. MATERIALS AND METHODS

The mechanical properties of the three different materials and manufacturing techniques were tested using a semi clinical setup on a metal master model with a 3-unit FPD. The three resins tested were DPI tooth moulding powder and liquid (methyl methacrylate resin), SNAP (ethyl methacrylate resin), Protemp4 (bis-acryl composite resin).Table 1 briefs an overview of the materials tested including their composition. All materials were used according to the manufacturer's recommendations.

2.1 Preparation of the Master Model

An addition polysilicone putty (Dentsply Inc, Germany) index of 45, 46 and 47 with 46 as a pontic was fabricated on the mandibular typhodont teeth (Frasco, Germany). The pontic 46 was a hygienic pontic and was made in inlay wax (Figs. 1 and 2).

The occlusal surface of the pontic was shaped to allow unequivocal positioning of a stainless steel spheric in the centre of the FPD. The space between the cervical surface of the pontic and the crest of the ridge was shaped with putty in order to standardize the space (Fig. 3).

Table 1. The materials used in the study

Serial no	Name of the material	Manufacturer	Composition	Lot number
1.	Self cure tooth moulding powder and liquid	DPI ,Bombay, India	Methyl-methacrylate resin	SB13
2.	Self cure SNAP polymer and monomer	PARKELL *inc* Edgewood, USA	Ethyl-methacrylate resin	S441
3.	Protemp ™ 4	3M ESPE NorthRyde, USA	Bis-acryl composite resin	503990

Fig. 1. Typhodont teeth set with 46 as pontic made in inlay wax

Fig. 2. Addition polysilicone putty index of 45, 46 and 47

Tooth preparation was done on 45 and 47 to receive cast metal restoration. The finish line of choice was chamfer finish line (Fig. 4).

Two stage putty light body (Dentsply Inc, Germany) sectional impression of the model (prepared 45, 47 and missing 46 region) was made (Fig. 5).

Inlay wax (Bego, Germany) was poured into this impression and retrieved to obtain the final model in wax (Fig. 6).

Fig. 3. Standardization of space between the cervical surface of the pontic and the crest of the ridge

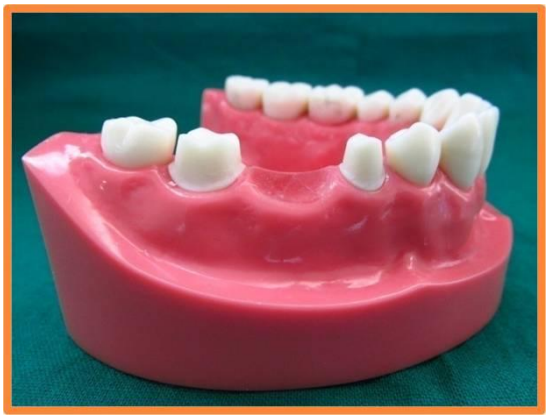

Fig. 4. Tooth preparation showing chamfer finish line

Spruing and casting was done using Ni-Cr alloy (Wiron99, Bego, Germany), then trimming, finishing and polishing was done to obtain the master model (Fig. 7).

Fig. 5. Two stage putty light body sectional impression of the model

Fig. 6. Final model In inlay wax

2.2 Direct Fabrication of Provisionals

Direct fabrication of provisional FPD's (5 samples each) was performed using the putty index made earlier. The provisional materials DPI and SNAP were mixed in a small mixing jar using stainless steel spatula and PROTEMP4 was injected in to mould using cartridge supplied by the manufacturer. All the materials were dispensed into the putty index from bottom to top to prevent incorporation of voids (Figs. 8, 9 and 10).

The filled impression was then placed in the correct position onto the master model by a single operator (Fig. 11).

The provisional's were carefully removed from the putty index after the manufacturers recommended setting time. Excess material was trimmed to precisely fit them on to the abutment teeth in the desired position (Fig. 12).

Fig. 7. Final model in metal

Fig. 8. Manipulation of DPI and snap

Fig. 9. Material dispensed into the putty index

2.3 Testing the Fracture Resistance

The Ni-Cr alloy alveolar ridge master model along with the fabricated provisional's were kept in the Universal Testing Machine (Instron, Italy) for fracture testing. A stainless steel spherical

ball (diameter 6mm) was placed on the central fossa of the occlusal surface of the pontic (Fig. 13).

Fig. 10. Manipulation of protemp4 using dispensing gun

Fig. 11. Positioning of the putty index on the master model

Fig. 12. Trimmed temporary bridge

Fig. 13. Setup with temporary bridge and sphere prior to fracture testing

Fracture test was started at a crosshead speed of 1.2 mm/min until fracture occurred (Fig. 14) Maximum force at which the fracture occurred was recorded.

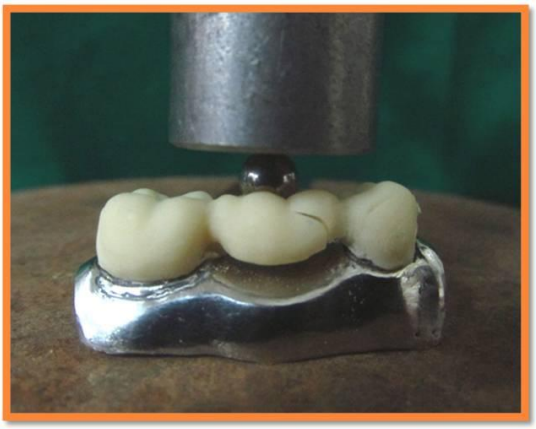

Fig. 14. Fracture of the bridge after load application

3. RESULTS AND DISCUSSION

The maximum forces at fracture is listed in Table 2 and summarized in Fig. 15.

Protemp4 showed the highest fracture resistance values followed by SNAP and then DPI. Table 3 shows the comparison of the mean fracture resistance between the three groups using one way ANOVA.

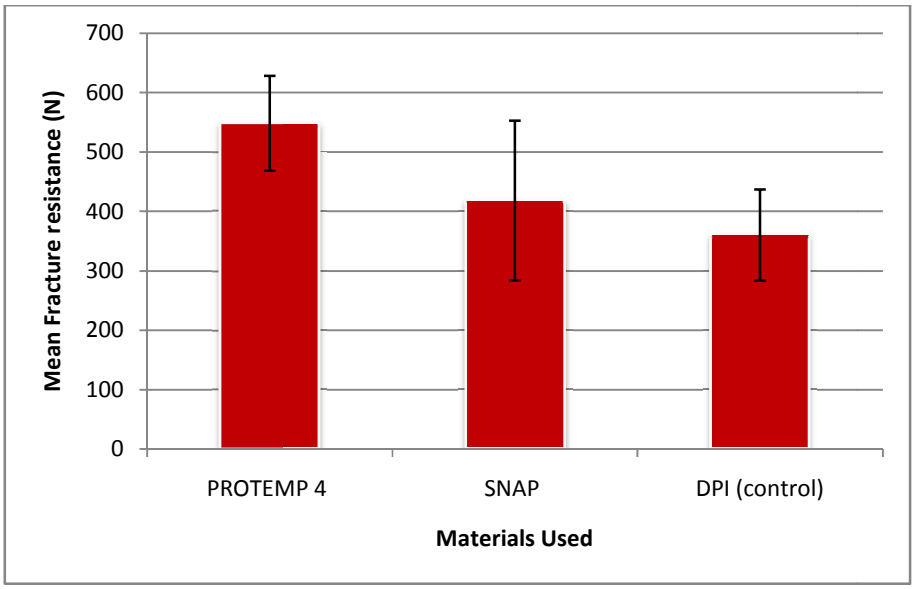

Fig. 15. Graph comparing the mean fracture resistance and the materials used

Table 2. Maximum force at fracture in Newtons (N)

	DPI self cure	Snap	Protemp 4
Sample 1	321.5986	289.43712	586.7424
Sample 2	289.43712	353.75648	450.23552
Sample 3	385.91616	546.71456	482.3952
Sample 4	482.3952	578.87424	578.87424
Sample 5	321.5986	321.5968	643.1936
Mean±S.D.	548.29±79.65	418.08±134.53	360.19±76.78

Table 3. Statistical evaluation- one way ANOVA

	Fracture resistance (N)	Degree of freedom	*P* value
DPI (control)	360.190000		
Snap	418.076000	14	0.03
Protemp4	548.288000		

Statistically significant difference was present between the groups ($P<0.05$). Bonferroni test was then applied for pair wise comparison, in which the statistically significant difference was seen between DPI and Protemp4 but not between DPI and SNAP or between SNAP and Protemp4 (Table 4). Hence this suggested that Protemp4 significantly has higher fracture resistance when compared to DPI.

This study aimed at investigating the influence of fabrication technique and material on the fracture resistance of provisional 3-unit FPD's. When fabricating provisional crowns and FPD's, the quality of the final restoration is strongly dependent on the technique used as well as the accuracy used during manufacturing [8]. Therefore, a semi-clinical setup with a master model was selected to simulate the clinical situations [9,10].

While fracture resistance values obtained in a laboratory under static load may not reflect the conditions found in the oral environment, it is helpful to compare provisional materials tested in a controlled situation. Strength values may be a useful predictor of clinical performance.

Statistically significant results between methyl methacrylate- type resins and bis-acryls could be partly attributed to the difference in their chemical composition. Traditional methyl (DPI) and ethyl methacrylate (SNAP) type resins are monofunctional. They are low molecular-weight,

linear molecules that exhibit decreased strength and rigidity. Bis-acryl composite resins (PROTEMP 4) are difunctional and capable of cross-linking with another monomer chain. This crosslinking imparts strength and toughness to the material [11]. Bis-acryls are also gaining popularity, in part because of their ease of fabrication and finishing. This may be contributed to superior results credited to Protemp4 [12].

Table 4. Post Hoc comparison – Bonferroni test

	DPI	Snap	Protemp 4
DPI	--	1.00	0.036
Snap	1.00	--	0.189
Protemp 4	0.036	0.189	--

BAC (Bis Acryl Composite) resins are supplied in automixing cartridge, presumably providing more homogeneous mix than hand mixing the PMMA(Poly Methyl Methacrylate) resin [13]. However this is not supported by Haselton et al. [11] who found no lower standard deviations for the BAC resins compared to hand mixed PMMA resin.

BAC resin has been marketed as Protemp 4 Garant. This includes a newly modified monomer system, not with the rigid intermediate chain characteristic of BAC resin, but with flexible chain in comparison to other synthetic resins. This modification allows a balance between high mechanical strength and limited elasticity of the BAC resin resulting in a material that can withstand higher stresses until fracture and that can tolerate brief deformation [6]. On the contrary, a study conducted by Poonacha et al. [14] and Sharma SP et al. [15] stated that Methacrylate based autopolymerizing resins showed the highest flexural strength and elastic moduli after fabrication and after storing in artificial saliva and for 24 hours and 7 days and Bis-acrylic composite resin showed the least flexural strength and elastic moduli [14,16].

Moreover, a temporary luting agent was omitted for the purpose to exclude it as additional influencing variable. It might be speculated that luting agent would have increased the fracture resistance. However, these issues can be addressed in further studies [8].

4. CONCLUSION

Fracture resistance of a provisional resin is only one of a number of factors to be taken into account in selecting suitable materials for clinical use. This study has shown that, among the three different provisional materials used, bis-acryl resin would be expected to provide a greater fracture resistance when used for provisional fixed partial dentures.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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