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Original Research

Comparative evaluation of flexural strength and hardness of four different commercially available provisional restorative materials in fixed prosthodontics: An in vitro study

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***ABSTRACT*:**
Aim: To evaluate and compare the flexural strength and hardness of four different commercially available provisional restorative resins for the fabrication of interim fixed partial restoration used in dental clinics. **Objectives:** This in vitro study will be carried out with the following objectives: 1) To measure and compare the flexural strength of four different commercially available provisional restorative materials that will help to provide strength to the restoration. 2) To measure and compare the hardness of four different commercially available provisional restorative materials which will give adequate strength to the interim restoration. **Materials and method:** Four provisional crown and bridge resins, DPI self-cure tooth molding powder (PMMA) (Group A), SNAP (EMA) (Group B), Protemp 4 Temporization Material (bis-acrylic composite) (Group C) and Revotek LC (urethane dimethacrylate) (Group D) were used. Rectangular shaped specimens for flexural strength testing (n = 10 for each material) and hardness testing (n = 10 for each material) were fabricated using a metal mold. The specimens were immersed in distilled water for 8 days37-42°C. Flexural strength and hardness was evaluated after 8 days of immersion. **Result:** Group C showed significantly higher flexural strength and hardness as compared to Group A, B and D. **Conclusion:** The findings of the study showed that, Protem-4 has more flexural strength and hardness as compared to other resin materials.
Key words: Provisional materials, flexural strength, hardness and distilled water.

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INTRODUCTION:
Provisional fixed restorative materials are an important component in fixed prosthodontic therapy from the time a tooth is prepared until placement of the definitive restoration and in dental implantology[1]. The term ‘‘provisional’’ restoration is often used as a synonym for interim or temporary or transitional restoration[2,3]. Provisional fixed restoration have the same biologic, mechanical and aesthetic requirements as definitive restoration[1,2]. In addition, provisional restorations are

also used for providing diagnostic information, changing the vertical dimension, correcting the occlusal plane and altering the gingival contours especially for implant-supported fixed restorations[4]. It also provides an important tool for the psychological management of patient aesthetic, where the patient should feel as the temporary simulate the final restoration, until the final restorations are cemented. Because of complex environment of oral cavity, the materials should have certain mechanical properties, such as flexural strength and hardness to resist the 6 various functional forces especially in long term use and long span bridges[5,6]. Temporary materials have changed immensely since their early days in the 1930s from acrylics and premade crown forms to newer Bis-acryl materials and Computer- Aided Design/Computer-Aided Manufacturing (CAD/CAM) generated 18 restorations. Composite based includes Bis-GMA resins, Bis-acryl composite resin and Light cured composite resin.[7,8,9] Each material has different physical properties unique to its chemistry and differ with method of polymerization, filler composition and monomer type[10,11,12]. Keeping these factors in mind many different companies with manufacturer's claims that there material is superior. In many previous studies, researchers investigated the physical properties of provisional resin materials and concluded different findings.[6] Among all the physical properties the flexural strength and hardness of provisional crown and bridge material is of particular importance, as these factors influence the integrity and longevity of the provisional restoration during functions over the period of time.[13] Hence, this in vitro study was conducted to evaluate the flexural strength and hardness of old and the new generation of provisional crown and bridge material.

MATERIALS AND METHOD:

In this study four provisional materials were used. The samples were divided into four main groups: Group A: PMMA (DPI), Group B: PEMA (SNAP PARKELL), Group C: Bis-acryl (PROTEMP-4 3M ESPE), Group D: Urethane Dimethacrylate (REVOTEK-LC G C). A standard split rectangular hollow well finished and polished Stainless Steel die was fabricated according to ADA specification No. 27. The hollow die was open, having length of 25mm width of 2mm and thickness of 2mm with vertical stud that will fit on slot of opposite side, so as to assemble all the parts of die.

SPECIMEN DESIGNING:

GROUP A-DPI:

In a glass bowl self-curing liquid was taken and powder was added to it in the ratio 1:2 by volume, respectively. According to the size of die the required quantity is o.5ml of monomer and 1gm of powder was taken to prepare the specimen. The metal die was coated with a layer of petroleum jelly for ease of separation of the specimen after complete polymerization. The mixing was done for 30 s as per manufacturer's instructions until all the polymer particles were thoroughly wetted with the monomer and a homogenous mix was obtained. When the material reached dough-like stage, it was packed into the die and was closed under uniform pressure with the metallic lid of die to ensure complete polymerization and to remove excess material.

GROUP B -SNAP:

In a glass bowl self-curing liquid was taken and powder was added to it in the ratio 1:3 by volume, respectively. According to the size of die the required quantity is 0.5ml of monomer and 1gm of powder was taken to prepare the specimen. The metal die was coated with a layer of petroleum jelly for ease of separation of the specimen after complete polymerization. The mixing was done for 1.5-2minutes as per manufacturer's instructions, until a thick, creamy, sluggish consistency was obtained. When the material reached the dough-like stage, it was packed into the die and was closed under uniform pressure with the metallic lid of die to ensure complete polymerization and to remove excess material.

GROUP C- PROTEMP 4:

It is available in cartridge form. The ratio of catalyst and base paste is 1:10. The cartridge of the same ratio was used to manipulate the material. The die was lubricated with petroleum jelly. Material was directly dispensed into the die, through a dispensing gun. The die along with the material was closed under uniform pressure using metallic lid of die to extrude the excess material. The specimen was allowed to polymerize for 8 min as per manufacturer's instructions, and was retrieved from the die.

GROUP D - REVOTEK LC:

This material comes in light protected sealed pack. It comes in putty like consistency which can be knead and moldable. The metal die was coated with a layer of petroleum jelly for ease of separation of the specimen after complete polymerization. For group RLC, the material was knead and packed in metal die with the help of spatula provided by the manufacturer and covered by glass lid with uniform load applied and all excess material was removed. For the light-polymerization LED-powered visible light-curing unit (LEDITION curing unit; Ivoclar Vivadent USA) was used for 10s in fast-cure mode (430–490 nm) for initial polymerization of the material. This was carried out for every increment along the entire length and width of the specimen. The specimen was then retrieved from the die. All the specimens were then evaluated for any

surface irregularities and porosities, and if found, the specimens were excluded from the study. Thereafter, all specimens were finished and polished with only top surface which was exposed to air using sand paper of number 600. Further the dimensions of the specimens were checked with the caliper and if required the necessary corrections were done. After 24 hours the specimens were kept in distilled water for 8 days. There after they were dried on tissue paper. The specimens were then tested for flexural strength and micro-hardness.

EXPERIMENTAL PROCEDURE:

The metallic stainless steel die was placed on to the metallic base properly. (Figure 1) The material was then injected into the metallic die and allowed to set completely as per the manufacturer's instruction. 20 specimen of each material was prepared in lengths (25x2x2 mm) so a total of 80 samples were made. The samples were made and tested at the relative humidity of 65% and average temperature of ◦ 37-42 C. The samples of each material were placed in distilled water for eight days and then tested. (Figure 2) The flexural strength was tested by using a universal testing machine system (computerized, software based) Company: Star Testing System Model No. STS 248, Accuracy of the machine: ±1% at Cross head speed of 3 mm/minute. Distance between supports is 20mm. The load applied to the center of the specimen and continued till fracture occurred. The load at fracture was recorded (in kilograms) the results obtained were statistically analyzed. The breaking load values were converted to flexural strength using the formula: $\sigma = 3\ FL/2\ bd2$. Where σ=flexural strength; F= load at fracture; L= length of the support span, b= width of specimen; and d= thickness of the specimen. The flexural strength values obtained were in kg/mm2, which were converted into Mega-Pascal (MPa) by multiplying it with 9.8. The hardness of the provisional materials was measured and determined by Micro-hardness Tester, Reichert Austria Make and Sr. No. 363798 and expressed as Vickers Hardness Number (VHN). The applied load is 50g. The lengths of the diagonals of the indentation were measured and VHN corresponding to each indentation for samples was calculated using the formula: $HV = 2F\sin^{136/2} / d^2$ Where HV = Vickers hardness number, F = Load in kgf, d = Arithmetic mean of two diagonals, d1 and d2 in mm.

RESULTS:

Descriptive statistics of each variable was presented in terms of Mean, standard deviation, standard error of mean. Comparison of mean and SD between all groups was done by using one way ANOVA test. Following these comparisons the ANOVA was significant, then Post Hoc Tukeys HSD test was carried out to assess whether the mean difference between a pair of group is significant or not. A p value of <0.05 was considered as statistically significant whereas a p value <0.001 was considered as highly significant. Table 1 and 2 shows descriptive statistics of flexural strength and hardness for all Groups. Table 3,4,5,6 shows the measurement of four different materials are described for the Group A, B, C and D. The individual calculation of mean, standard deviation and standard error was calculated to calculate the confidence interval about a mean, along with upper and lower bound. The total of mean, standard deviation, standard error and 95% confidence for each dependent variable are summarized in Table 7, 8 and 9.

TABLE 1: Descriptive Statistics Of Flexural Strength And Hardness

GROUPS	N	Mean	Std. Deviation.	Std. Error	Range	Minimum	Maximum
A	10	23.70	10.90	3.45	32.34	6.61	38.95
B	10	81.32	8.60	2.72	31.61	63.57	95.18
C	10	89.66	9.34	2.95	24.99	80.11	105.10
D	10	51.56	8.27	2.62	27.20	35.64	62.84

TABLE 2: Descriptive Statistics Of Hardness

GROUPS	N	Mean	Std. Deviation.	Std. Error	Range	Minimum	Maximum
A	10	16.95	.67	16.95	2.21	16.11	18.32
B	10	19.82	.56	19.82	1.83	18.43	20.26
C	10	20.36	.70	20.36	2.28	19.59	21.87
D	10	18.51	1.24	18.51	4.92	16.35	21.17

TABLE 3: Descriptive Statistics Of Maximum Load In All Groups.

	N	Mean	Std. Deviation	Std. Error	Range	Minimum	Maximum
DPI	10	6.32	2.91	.92	8.62	1.76	10.38
SNAP	10	21.68	2.29	.73	8.43	16.95	25.38
PROTEMP	10	23.91	2.49	.79	6.66	21.36	28.02
REVOTEK LC	10	13.75	2.21	.70	7.25	9.50	16.75

TABLE 4: Comparison Of Maximum Load Between All Groups.

		N	Mean	Std. Deviation	F	df	p	Inference
Max load (N)	DPI	10	6.32	2.91	103.86	3	0.0001 (<0.001)	Highly significant
	SNAP	10	21.68	2.29				
	PROTEMP 4	10	23.91	2.49				
	REVOTEK LC	10	13.75	2.21				
	Total	40	16.41	7.43				

TABLE 5: Post Hoc Tukeys HSD Test To See Whether The Mean Difference Between Individual Group Is Significant Or Not

	SNAP	PROTEMP 4	REVOTEK LC
DPI	-15.36*	-17.59*	-7.43*
SNAP		-2.23	7.93*
PROTEMP 4			10.16*

TABLE 6: Comparison Of Flexural Strength Between Groups A, B, C AND D

		N	Mean	Std. Deviation	F	df	p	Inference
Flexural strength (MPa)	GROUP A-DPI	10	23.70	10.90	103.83	3	0.0001 (<0.001)	Highly significant
	GROUP B-SNAP	10	81.32	8.60				
	GROUP C- PROTEMP 4	10	89.66	9.34				
	GROUP D- REVOTEK LC	10	51.56	8.27				
	Total	40	61.56	27.86				

TABLE 7: Post Hoc Tukeys Hsd Test to See Whether The Mean Difference Between Two Groups Is Significant Or Not

	SNAP	PROTEMP 4	REVOTEK LC
DPI	-57.62*	65.96*	-27.85*
SNAP		-8.34	29.76*
PROTEMP 4			3.81

*indicates that the difference is significant at 0.05 level

TABLE 8: Comparison Of Hardness Between Groups a, b, c And d

		N	Mean	Std. Deviation	F	df	p	Inference
Hardness	GROUP A-DPI	10	16.95	.67	33.19	3	0.0001 (<0.001)	Highly significant
	GROUP B-SNAP	10	19.82	.56				
	GROUP C-PROTEMP 4	10	20.36	.70				
	GROUP D-REVOTEK LC	10	18.51	1.24				
	Total	40	18.91	1.56				

TABLE 9: Post Hoc Tukeys Hsd Test To See Whether The Mean Difference Between Two Groups Is Significant Or Not

	SNAP	PROTEMP 4	REVOTEK LC
DPI	-2.86	-3.4*	1.55
SNAP		0.54	1.31*
PROTEMP 4			1.85

*Indicates that the difference in the mean is significant at 0.05 levels.

Figure 1: Top views of metallic die with length of 25 mm height of 2 mm and width of 2 mm.

Figure 2: Samples stored in Distilled Water

DISCUSSION:

Provisional restorations are a decisive component of Fixed Prosthodontics Treatment. In addition to their biologic and biomechanical requirements, provisional restorations also provide the clinician with precious diagnostic information. They act as a functional and esthetic trial which is acceptable to both clinician and technician, and also serve as a blueprint plan for the design of the definitive prosthesis. In selecting a material for the fabrication of a single crown or long bridge interim restoration, the clinician must consider multiple factors, such as physical properties (e.g. flexural strength, surface hardness, wear resistance, dimensional stability, polymerization shrinkage, wettability, color range and stability), handling properties (e.g. mixing time, working time, predictable and consistent setting time, ease of trimming, polish ability and repair ability), patient acceptance (e.g. odor and taste) and material cost[1,2,3]. A plethora of commercially available provisional materials have evolved with the resin based groups having varying physical properties depending upon the type, amount and size of the filler particles and the properties of the polymer matrix. However, no single material was proved to be ideal for all clinical situations. As newer materials enter the clinical arena, a thorough careful understanding of each material is imperative to maximize the benefits in any given prosthetic scenario.[15] Eighty samples for each material were made according to ADA specification no.27.To simulate the oral conditions the samples were stored in distilled water for 8 days. All the samples were subjected to a universal testing machine at a Cross head speed of 3 mm/minute with the Distance between supports of 20 mm, whereas micro- hardness testing was done at load of 50g. Using the universal testing machine, average values for maximum load leading to fracture obtained in this study were 6.32 N for DPI (methyl methacrylate), 21.68 N for SNAP (ethyl methacrylate), 23.91 for PROTEMP 4 (Bis-acryl composite) and 13.75N for REVOTEK-LC (urethane dimethacrylate). The differences between groups were highly significant ($p < 0.05$) and believed that these differences arise from differences in the chemical structures of the materials. The mean flexural strength for group A (DPI) is 23.70 MPa ± 10.90 MPa. The mean flexural strength for group B (SNAP) is 81.32 MPa ± 8.60 MPa. The mean flexural strength for group C (PROTEMP-4) is 89.66MPa ± 9.34 MPa. The mean flexural strength for group D (REVOTEK-LC) is 51.56 MPa ± 8.27 MPa. While mean hardness for group A (DPI) is 16.95 ± .67.For group B (SNAP) is 19.82 ± .56. For group C (PROTEMP-4) is 20.36 ± .70 and for group D (REVOTEK-LC) is 18.51 ± 1.24. The results of the present study revealed that flexural strength and hardness of group C (PROTEMP-4) is significantly higher than other materials after conditioning in distilled water. The higher mechanical strength of acrylic-based temporary crown materials compared to traditional mono-methacrylate is concurrence with the various literatures.[14]

CONCLUSION:

The study evaluated and compared the Flexural Strength and Hardness of four different commercially available provisional restorative material mainly, Self-cure poly methyl methacrylate (DPI), Self-cure poly ethyl methacrylate (SNAP), Bis-acryl composite (PTOTEMP-4) and Urethane dimethacrylate (REVOTEK-LC). Within the scope of this study, the following conclusion can be drawn: 1) Maximum flexural strength was obtained by Bis-acryl followed by poly ethyl methacrylate and urethane dimethacrylate and minimum by self-cure poly methyl methacrylate. The difference amongst all the groups was statistically significant. 2) Maximum hardness was obtained by Bis-acryl followed by poly ethyl methacrylate and urethane dimethacrylate and minimum by self cure poly methyl methacrylate. The difference amongst all the

groups was statistically significant. 3) According to the present study, it can be concluded that Bis-acryl provisional material displayed the higher flexural strength and hardness than methacrylate and light cured based resins. Therefore, the application of Bis-acryl material can be choosen as a provisional restoration among all of these studied four materials in patients with heavy occlusal forces and in long span bridges.

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