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Comparative evaluation of surface hardness of different provisional restorative materials at different time intervals-An *in vitro* study

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Abstract

Background: It is essential to comprehend the mechanical characteristics of temporary restorative materials for their clinical application, aiding clinicians in selecting appropriate materials based on specific patient needs and expected clinical conditions.
Aim: This *in vitro* study aimed to evaluate and compare the hardness of four different provisional restorative materials used in dental practice under dry and wet conditions.
Material and Methods: Materials tested included auto-polymerizing PMMA, heat-cured PMMA, Bis-acryl composite, and Bis-GMA composite. Each material was assessed using Rockwell hardness testing, both initially and after immersion, in artificial saliva for one week. Split mold of dimension 50 mm diameter and 3 mm thickness was used to make specimens of each group. Specimens were prepared according to manufacturer specifications and subjected to hardness testing using 50 g load and a 12.70 mm ball indenter. Because of the data's non-normal distribution, non-parametric tests were used for statistical analysis.
Results: Results showed significant variations in hardness among the materials both in dry and wet conditions. Bis-GMA Composite and Bis-acryl Composite Resin exhibited the highest hardness values in both conditions, followed by Heat activated PMMA, auto-polymerizing PMMA. Wet conditions generally resulted in decreased hardness across all materials compared to dry conditions.
Conclusion: The results of this investigation indicate that, in terms of hardness, composite-based materials are superior to PMMA-based materials. As a result, they ought to be the material of choice for temporary restorations.

Keywords: Provisional restorations, hardness, PMMA, bis-acryl, bis-GMA, Rockwell hardness testing

Introduction

A dentist creates a provisional restoration, a temporary fixed or removable dental or maxillofacial prosthesis, to enhance stability, appearance, and/or function for a specific period before replacing it with a definitive prosthesis. These prostheses are frequently used to assess the therapeutic efficacy of a certain treatment plan or the shape and function of the definitive prosthesis that is planned.

From a processing perspective, provisional restorative materials have been divided into four classes according to how they change from plastic to solid masses: (1) chemically activated acrylic resins, (2) heat activated acrylic resins, (3) light activated composite resins, and (4) dual activated composite resins. In terms of chemistry, there are two main groups: (1) Methacrylate Resin (Methylmethacrylate, Ethylmetacrylate, Vinylmethacrylate, Butylmethacrylate) and (2) Composite Resin (bis-GMA, bisacryl, UDMA) [1].

A product's selection by clinicians is determined by a number of characteristics, such as its strength, ease of manipulation, affordability, and marginal correctness. Understanding a provisional restoration's mechanical characteristics is essential to assessing new goods on the market and confirming the makers' promises are supported because these restorations are subjected to masticatory stresses in an oral environment. The flexural strength, fracture toughness, and hardness of the interim prosthesis are crucial mechanical attributes. This is particularly true for connectors and long-span temporary prostheses with low pontic height, as well as in cases when the patient exhibits parafunctional behaviors like clenching or bruxism [2].

Materials and Methods

The study was done to evaluate and compare the hardness of different resins used for fabrication of interim fixed restorations. Four groups of interim restorative materials were selected.

Group A chemically activated acrylic resin (DPI), group B heat activated acrylic resin (DPI), group C bis-acrylic resin (Oratemp, Prevest), group D bis-GMA composite (Protemp, 3M), (Fig 1). The above mentioned groups had two subgroups as follows: Subgroup 1-Specimens tested in dry condition, Subgroup 2-Specimens conditioned in artificial saliva for 1 week.

A stainless steel die with dimensions of 50 mm diameter and 3mm height was machined with a vent hole so that the excess material can be removed, (Fig 2). Ten samples were created for each group after each specimen was mixed in compliance with the manufacturer's instructions, placed into a mold, and allowed to set, (Fig 3) every sample was created at room temperature. The specimens were taken out of the mold after setting. Defective specimens were disposed of after the specimens were checked for any voids. Every test specimen was polished and ground using silicon carbide paper of1000 grit.

Each specimen were taken under Rockwell hardness testing machine, (Fig 4) measurements were made with a 50g load 12.70 mm ball indenter and 15 second dwell time. Data was collected for all the samples.

Fig 1: The above mentioned groups had two subgroups as follows

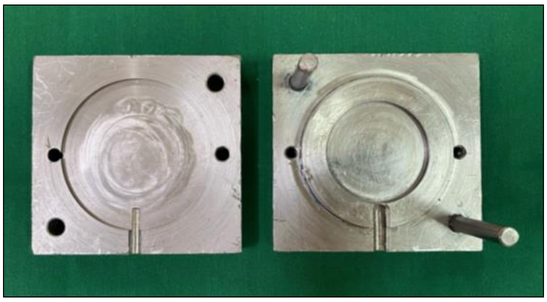


Fig 2: Show ten samples were created for each group after each specimen was mixed in compliance with the manufacturer's instructions, placed into a mold, and allowed to set

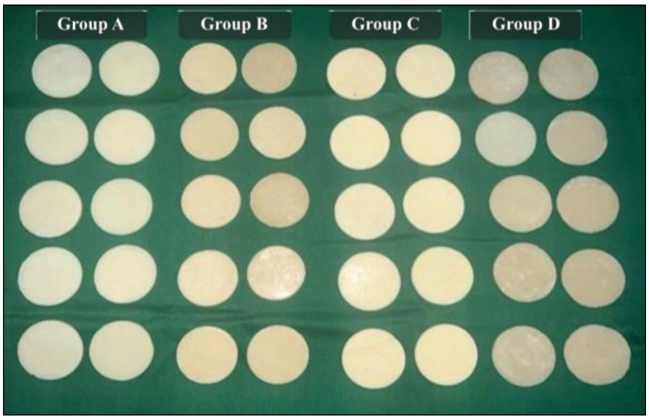


Fig 3: Show every sample was created at room temperature. The specimens were taken out of the mold after setting

Fig 4: Each specimen were taken under Rockwell hardness testing machine

Statistical analysis

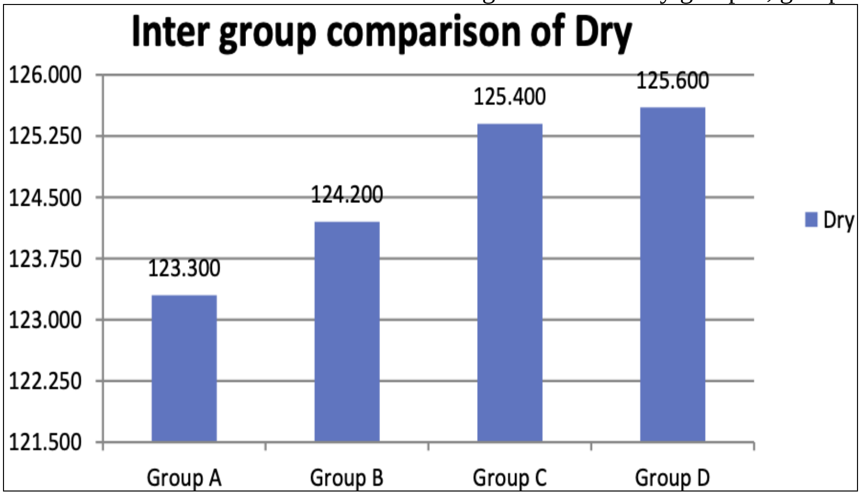
Table 1: The data in the groups showed a statistically significant difference ($p<0.01$), with group 4 having higher values for dry and group 4 having higher values for wet

	Group	N	Mean	Std. deviation	Median	Mean rank	Chi square value	P-value of Kruskal-Wallis Test
Dry	1	10	123.30	0.949	123.500	7.90	27.839	.000**
	2	10	124.20	0.789	124.000 125.000 126.000 118.500 121.500	15.10		
	3	10	125.40	0.516		28.30		
	4	10	125.60	0.516		30.70		
Wet	1	10	118.40	0.966		5.60	30.166	.000**
	2	10	121.30	0.823		19.25		
	3	10	121.90	0.876	122.000	23.80		
	4	10	123.10	0.738	123.000	33.35		

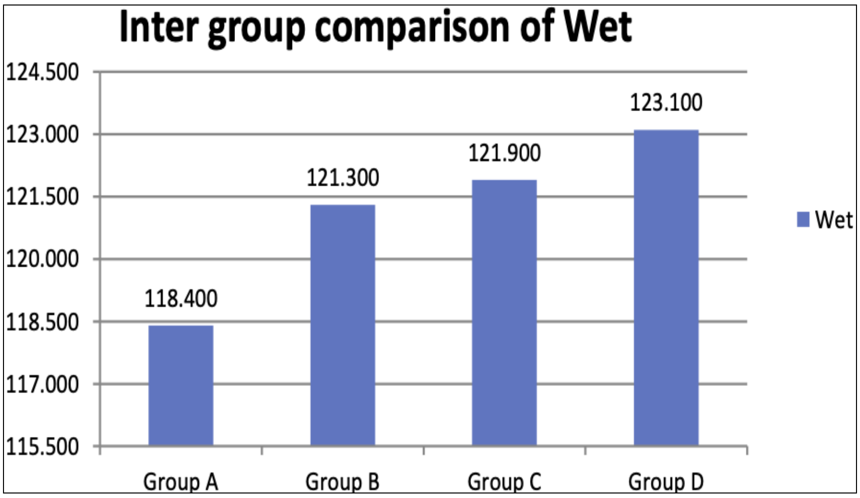
Results

The results showed significant variations in hardness among the materials both in dry and wet conditions. Bis-GMA Composite and Bis Acryl Composite Resin exhibited the highest hardness values in both conditions, followed by Heat activated PMMA, auto-polymerizing PMMA. Wet conditions generally resulted in decreased hardness across all materials compared to dry conditions.

Graph 1 and graph 2 shows that hardness of group D is highest followed by group C, group B and least of group A.



Graph 1: Inter group comparison of dry



Graph 2: Inter group comparison of wer

The selection of provisional materials should be based on the material's advantages and disadvantages in relation to the clinical recommendations for particular therapies. Certain scenarios may need the use of different therapeutic procedures, such as indirect interim fabrication. Last but not least, experience and individual preference play a significant role in the selection of materials among several proprietary material brands that have comparable chemical composition and physical characteristics [13, 14].

Temporary restorations must withstand the functional forces of mastication without breaking or distorting. Good mechanical qualities are necessary for these materials to meet these strict standards. Density can be inferred from surface hardness, and it makes sense to assume that a denser material would be more resilient to wear and surface degradation [15, 16]. A material's surface hardness is a complicated mechanical attribute that depends on a number of other characteristics, including as strength, malleability, ductility, proportional limit, and resistance to cutting and abrasion.

Saliva, food ingredients, drinks, and interactions between these substances in the oral environment can all affect the mechanical qualities of the temporary resin materials. When stored under water as opposed to dry circumstances, a number of intermediate resin groups displayed a decrease in hardness [17]. Prior studies conducted by Balkenhol [18] have demonstrated that the material's strength is at its lowest during this initial phase. Additionally, he mentioned that some chemically and dual-polymerized interim resin materials exhibit a comparatively significant increase in mechanical strength from one hour to twenty-four hours of set time.

According to Knobloch's research, this might be mostly because of ongoing post-gelation polymerization, which raises methacrylate conversion. Although Ferracane [19] came to the conclusion that peroxide initiators in chemical and dual-polymerized bis-acryl resin systems are both heat and amine activated, this meant that after initial vitrification, free-radical polymerization would continue, leading to a higher crosslink density.

Geoffrey A. Thompson *et al.* [20] PMMA interim materials are linear molecules and therefore should exhibit lower strength and elastic modulus. Furthermore, when hand-mixing interim polymer ingredients, air entrapment and intrinsic flaws affect the porosity and strength. This is because ultimate failure occurs when load at any one imperfection causes unstable crack propagation and extension. Auto mixed materials would be expected to have less porosity.

Moshen *et al.* [21] postulated the mechanism by which water is absorbed in composites was and follows closely which was described by Puffer *et al.* [22] in their study of water sorption an polyamides. First, polar carbonyl groups on the polymer chain create strong intramolecular hydrogen bonds with water absorbed into the dry polymer matrix. As water sorption continues to increase, water molecules begin to break up the intermolecular hydrogen bonds between the carbamate nitrogen and carbonyl oxygen atoms of the neighboring polymer chains. This loosely bound water results in chain slippage and plasticization of the polymer matrix.

Limitations of study

1. Effect of thermo cycling and cycling loading effect was not used.
2. Properties other than hardness were not considered in present study.
3. Effect of natural saliva on hardness of interim restorative materials was not studied.

Conclusion

Following conclusions were drawn within the limitations of the study

- Material and time factor influenced hardness of the four interim restorative materials.
- The hardness of all the materials decreases with immersion time.
- At 24 hrs (dry) and at 1-week interval (wet), the hardness of Bis-GMA and Bis-acryl composite was significantly greater than PMMA.
- The hardness of composites are better than PMMA at any time intervals.
- Aging had a significant effect on the hardness, of PMMA and composites.

The results of this investigation indicate that, in terms of hardness, composite-based materials are superior to PMMA-based materials. As a result, they ought to be the material of choice for temporary repairs. Compared to directly produced crowns, PMMA-based CAD/CAM provisional crowns have greater fracture strength. The durability of temporary restorations may be improved via computer-aided design and production. There will be additional interim CAD/CAM materials available to facilitate future research.

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