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COMPARATIVE EVALUATION OF FLEXURAL STRENGTH AND ELASTIC MODULUS OF PROVISIONAL CROWN AND BRIDGE MATERIALS AT DIFFERENT STORAGE INTERVALS.

Prosthodontics

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ABSTRACT

Introduction: Provisional restorations are an integral part of fixed prosthesis and dental implantology. They serve as a key role in functional and esthetic tryin for design of final prosthesis. Fixed prosthesis prognosis depends on the quality of provisional restoration. In long term cases like full mouth rehabilitation and in implant supported prosthesis flexural strength (FS) and elastic modulus (EM) of the interim prosthesis play a vital role.
Aim: To evaluate and compare the flexural strength (FS) and elastic modulus (EM) of provisional crown and bridge materials stored at different time intervals in artificial saliva.
Materials And Methods: Ninety bar-shaped specimens (with dimensions of 25 × 2 × 2 mm) as per American National Standards Institute (ANSI specification no 27) were fabricated with three provisional restorative materials Polymethyl Methacrylate (PMMA), Bis acrylic, Urethane dimethacrylate (UDMA) and are stored in artificial saliva at different time intervals. Further three point bending test were carried out in universal testing machine to calculate FS and EM. Changes were evaluated and data was analysed using one way ANOVA and paired t test.
Results: Results showed significant difference (P<0.05S) in FS values of provisional materials at different storage intervals except PMMA showed non-significant difference (p>0.05) between 10days to 30days storage. There was non-significant difference (p>0.05) of EM of bis-acryl samples between 24hrs to 10days and from10days to 30days of storage.
Conclusion: Within the limitations of the study, it can be concluded that the FS and EM of Bis acrylic is comparatively better than PMMA and UDMA. Bis acrylic could be a better provisional restorative material for an extended period as less change was observed in elastic modulus of bis-acryl during long term storage compared to other materials.

KEYWORDS

Flexural strength, elastic modulus, Provisional restoration, Polymethyl methacrylate (PMMA), Bis-acrylic, Urethane dimethacrylate (UDMA).

INTRODUCTION

In fixed prosthodontic treatment it is important to protect the prepared teeth with provisional restoration so that the patient can be made comfortable during cast restoration fabrication[1]. Materials providing more durability are required in situations like provisional FDPs that are expected to function for extended periods of time or when additional therapy is required before completion of definitive treatment as in case of prosthetic phase of dental implants where tissue contour issues should be solved and longer treatment duration as in full mouth rehabilitation.[2]

For longevity of a provisional restoration understanding its mechanical properties is necessary. Among mechanical properties, the flexural strength and elastic modulus of the interim prosthesis are important, particularly if the patient is expected to wear the restoration for a long period of time (e.g. full mouth rehabilitation) [3]. Flexural strength also known as transverse strength, is a measurement of the strength of a bar (supported at each end) under a static load. Elastic modulus describes the relative stiffness or rigidity of a material[4].

The present study was carried out to evaluate and compare the flexural strength and elastic modulus of three provisional crown and bridge materials at different storage intervals in artificial saliva for 24hrs, 10 days and 30 days after setting.

MATERIALS AND METHODOLOGY

Following provisional crown Materials were used in this study

Table 1: Provisional Crown Materials

Product Name	Manufacturing Company	Lot no.
DPI (self-cure tooth moulding powder)	Dental Products of India, Mumbai, India	3452
REVOTEC LC (light cure resin for temporary crown, bridge, inlay & onlay)	GC Corporation., Tokyo,Japan.	1806061
TRANTEMP (bis-acrylic composite)	Nexobio co.ltd, Chungcheongbuk-do Korea.	80529

Metal mold consists of central metal plate and surrounding metal casing. Central metal plate has 5 slots of dimensions 25 × 2 × 2 mm **(Figure 1)** in to which material was dispensed to get specimens of similar dimensions based on American National Standards Institute (ANSI) specification no 27 and surrounding metal casing which prevents movement of central metal plate that was split in between the slots for easy retrieval of samples.

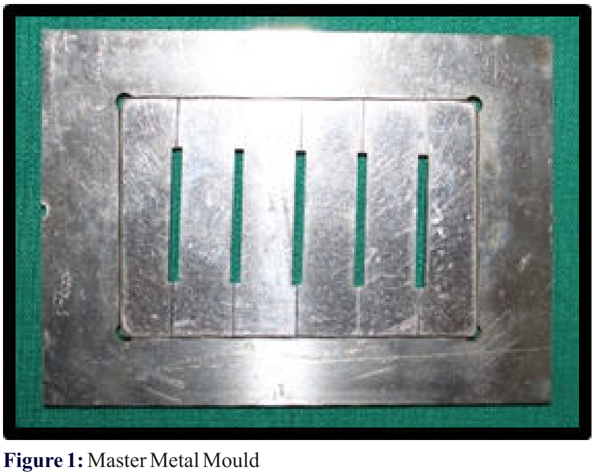

Figure 1: Master Metal Mould

A total of 90 samples are included in this study and they are divided into 3 groups based on material used for fabrication. Each group is further divided in to 3 sub groups based on duration of immersion in artificial saliva i.e., 24hrs, 10days and 30days. **(Figure 2)**

All samples were fabricated using a split machined aluminum mold, sandwiched between two glass slabs. Bis-acrylic composite (Trantemp) was manipulated using automix cartridge loaded by an automix dispensing gun (1:10). The mixing tip of the cartridge was held at one end of the mould and material was expressed into the mould moving the automix dispenser slowly to the other end to avoid incorporation of air bubbles. Light cure composite resin (Revotek LC putty stick) material was kneaded gently with fingers to soften it, dispensed and packed into the mould avoiding air bubbles or defects and glass slab is placed over mould. Care was taken to prevent over kneading of the material. Dispensed material was light cured according to the manufacturer's instructions i.e for 20secs. A required amount of the DPI Self Cure powder and liquid were measured in the ratio of 2:1 by volume, respectively and dispensed in a dapen dish. The polymer-monomer was mixed to a homogenous consistency using a stainless steel mixing spatula. The paste was then filled into a 2 cc disposable syringe and dispensed into the mould avoiding air bubbles. The specimens were subjected for testing under universal testing machine (DAK system Inc Series 9000) which uses 3 point bending test. The specimens were kept on the supports which are 20mm apart from each other. The cross head speed of this machine head is 0.5mm/min. Each specimen was gradually loaded and the point where it flexes and breaks were noted. **(Figure 3)**

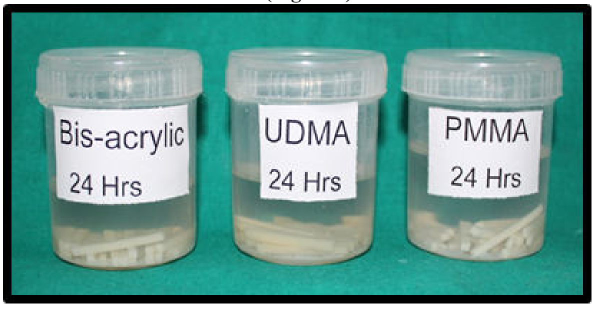

Figure 2: Samples In Artificial Saliva

Figure 3: Testing Of Samples Under Universal Testing Machine

The flexural strength (S) and the elastic modulus (E) were calculated using the following formula for each sample:

Flexural strength (FS)

$S = 3PL/2wt^2$

Elastic modulus (EM)

$E = PL^3/4wt^3\delta$ where

- P-Applied load (N)
- w- width of sample(m)
- t- Thickness of sample(m)
- L – span
- δ- Deflection

The values of each group were tabulated and statistically analyzed using ANOVA one way test and Paired t test.

RESULTS

The mean flexural strength and elastic modulus of all specimens are tabulated. Intra group comparison of Flexural strengths of PMMA, bis-acrylic and UDMA is done. In group-A there was significant difference (P<0.05S) in FS between 24 hr sample to 10days sample and non-significant difference(P>0.05) between 10days to 30days sample. In group-B there was non-significant difference (p>0.05) in FS between 24 hr sample to 10days sample and significant difference (P<0.05 S) between 10days to 30days sample. In group-C there was significant difference (P<0.05 S) in FS between 24 hr sample to 10days sample and between 10days to 30days sample.

Intra group comparison of elastic modulus of PMMA, bis-acrylic and UDMA is done. In group-A there was significant difference (P<0.05 S) in EM between 24 hr sample to 10days sample and non-significant difference (p>0.05) between 10days to 30days sample. In group-B there was non-significant (p>0.05) difference in EM between 24 hr sample to 10days sample and between 10days to 30days sample. In group-C there was significant difference in FS between 24 hr sample to 10days sample (P<0.05 S) and 10days to 30days sample.

Table 2: Mean Comparison Of Flexural Strength In PMMA, BIS-ACRYLIC And UDMA

VARIABLE	TIME	MEAN	SD	F VALUE	P VALUE
PMMA (Group-A)	24HRS	57.19	2.22	19.557	<0.001 Significant
	10DAYS	51.02	2.01		
	30DAYS	50.07	3.74		
BIS-ACRYLIC (Group-B)	24HRS	79.92	2.96	11.612	<0.001 Significant
	10DAYS	82.25	1.78		
	30DAYS	77.48	1.67		
UDMA (Group-C)	2HRS	44.05	1.82	37.900	<0.001 Significant
	10DAYS	38.98	1.71		
	30DAYS	36.30	2.46		

Statistical Analysis: ANOVA one way test. Statistically significant if P<0.05

Table 3: Mean Comparison Of ELASTIC MODULUS In PMMA, BIS-ACRYLIC And UDMA

VARIABLE	TIME	MEAN	SD	F VALUE	P VALUE
PMMA (Group-A)	24HRS	951.32	8.43	470.552	<0.001 Significant
	10DAYS	760.10	7.96		
	30DAYS	760.14	25.35		
BIS-ACRYLIC (Group-B)	24HRS	2779.39	63.55	5.067	0.014 Significant
	10DAYS	2779.62	145.41		
	30DAYS	2615.03	167.93		
UDMA (Group-C)	2HRS	611.67	42.19	76.373	<0.001 Significant
	10DAYS	496.95	23.11		
	30DAYS	397.53	46.87		

Statistical Analysis: ANOVA one way test. Statistically significant if P<0.05

Table 4: Intra Group Comparisons Of Flexural Strengths PMMA, BIS-ACRYLIC And UDMA

TIME	PMMA		BIS-ACRYLIC		UDMA	
	MEAN±SD difference	P value	MEAN±SD difference	P value	MEAN±SD difference	P value
24hrs VS 10 Days	6.17±0.21	<0.001 S	2.33±1.18	0.103 NS	5.07±0.11	<0.001 S
10Days VS 30Days	0.95±1.73	0.408 NS	4.77±0.11	<0.001 S	2.68±0.75	0.011 S

Statistical Analysis: Paired t test. Statistically significant if P<0.05

Table 5: Intra Group Comparisons Of Of ELASTIC MODULUS Of PMMA, BIS-ACRYLIC and UDMA

TIME	PMMA		BIS-ACRYLIC		UDMA	
	MEAN±SD difference	P value	MEAN±SD difference	P value	MEAN±SD difference	P value
24hrs VS 10 Days	191.22±0.47	<0.001 S	0.23±81.86	0.997 NS	114.72±19.08	<0.001 S
10Days VS 30Days	0.04±17.39	0.996 NS	164.59±22.52	0.051 NS	99.42±23.76	<0.001 S

Statistical Analysis: Paired t test. Statistically significant if P<0.05

DISCUSSION

Autopolymerizing polymethyl methacrylate is the most commonly used material for fabrication of interim restorations but its use is on decline because of their disadvantages like polymerization shrinkage, exothermic setting reaction, and the irritation associated with monomer and inaccurate marginal adaptation.[5]

Bis-acrylic composite based provisional restorative materials are gaining popularity because of their cartridge delivery system. This dispensary method is not only convenient but also may allow for a more accurate and consistent mix and thereby improving its physical and mechanical properties. Bis-acryl composite resins have low polymerization shrinkage, low exothermic response but this material has disadvantage of being costly and their repair is troublesome.[6]

The visible Light polymerized (VLC) material containing urethane dimethacrylate, a resin whose polymerization is catalyzed by visible light and initiated by camphoroquinone. UDMA usually incorporate filler such as microfine silica to improve physical properties like reduced polymerization shrinkage. Light-cured urethane dimethacrylates have an advantage of controllable working time, great wear resistance, low temperature changes. Their hindrances are poor peripheral fit, weak nature and high cost.[7]

Results in this study showed that flexural strength and elastic modulus of PMMA decreases from 24 hrs storage (subgroup IA) to 10 days storage (subgroup IB) in artificial saliva. There was no significant change in FS and EM from 10days storage to 30days storage which may be due to saturation.

Results in this study showed that flexural strength of Bis-acryl provisional material increases from 24 hr storage (subgroup IA) to 10 days of storage (subgroup IB) in artificial saliva. The reason may be the increasing conversion of reactive double bonds by radicals and, on the other hand, relaxation phenomena within the polymer network.[8] There was slight decrease of FS from 10 days to 30days storage which can be due to leaching of filler content. There was no significant change in elastic modulus from 24hr storage to 10days storage and 10days storage to 30 days storage. Bis-acryl has a rigid central structure.[9]

Results in this study showed that flexural strength of UDMA decreases from 24 hr storage to 10 days storage and from 10days to 30days storage in artificial saliva. Glass fillers are slowly leached out in the presence of saliva, thus reducing the mechanical properties of the interim composites. Elastic modulus is less for UDMA as there are no phenol rings in its monomer when compared to Bis-acryl hence it has higher flexibility.[10]

Determination of flexural strength was unproblematic for composite based materials as all specimens broke after exceeding a certain stress maximum. In contrast, most specimens made of polymethylmethacrylate (group I) and UDMA (Group III) did not break but were distorted instead. Consequently, the results for group I and group II have to be interpreted with care. The lack of fracture can be related to the chemical nature of resins. The main monomer component of poly methylmethacrylate forming the matrix is methylmethacrylate which forms linear polymer chains without any cross-links. A similar phenomenon was observed by Lang et al who investigated the fracture resistance of provisional crown and bridge materials in artificial oral environment[11].

The results obtained in this study were in correlation with the study conducted by S Dagar et al on direct and indirect provisional materials and found that Protemp 2 has lesser flexural strength as compared to heat cure polymethyl methacrylate but more than self cure poly methyl methacrylate.[12]According to the results of the study among all groups flexural strength and elastic modulus of bis- acryl is highest when compared to other groups after 24hr storage in artificial saliva.

The mean values of flexural strength of Group I and Group II were similar with the results obtained in the study conducted by Haselton et al who compared the flexural strength of five auto-polymerising methacrylate-based resins and eight bis-acryl resins. The authors reported that most of the bis-acryl resins demonstrated significantly superior flexural strength over traditional auto-polymerizing methacrylate resins.[13]

The results obtained in this study were contradictory with the study conducted by Koumjian and Nimmo who tested 3 methyl methacrylate resins and an earlier generation bis-acryl resin. They evaluated the flexural strength immediately following polymerization, seven days of dry storage and 7 days of wet storage. They found that water storage absorption resulted in a slight but insignificant decrease in the transverse strength of methyl methacrylate and bis acryl. Transverse strength varied widely in the repaired group, and all materials showed a statistically significant reduction compared with the seven day wet storage group. Although no data is available to compare the type of resin matrix or filler content of those bis-acryl materials, it is evident that the difference in flexural strength performance was material-specific.[14]

The results obtained in this study for Group I and Group II were in correlation with the study by Balkenhol et al who evaluated the flexural strength and elastic modulus of interim resin materials at different storage times and concluded that the mechanical properties of composite resin-based materials are superior to methacrylate resins and recommended a dual-curing interim resin material if a high mechanical strength is indispensable directly after fabrication. They explained that in dual-curing materials a large amount of polymerization takes place at the beginning because of the light curing initiation of the reaction.[15]

The results obtained in this study for group III were in correlation with the study done by Ireland & Dixon where the elastic moduli and moduli of rupture of Provipont DC resin, Triad(autopolymerising poly methyl methacrylate) and a 50:50 mixture of jet acrylic resin and orthodontic resin was evaluated. Provipont DC resin (dual-polymerizing resin) exhibited significantly higher elastic moduli and moduli of rupture values at the 24 hour test time. However, Provitpont DC resin exhibited the greatest decrease in these values over time. This result was explained by the fact that a large amount of polymerization takes place at the beginning for this provisional crown and bridge material caused by the light curing initiation of the polymerisation reaction.[16]

Limitations Of The Study

This in-vitro study evaluated flexural strength and elastic modulus of three provisional restorative crown and bridge materials.

1. In the oral cavity, the provisional restoration is exposed to forces of varying magnitudes acting in different directions, and there are also temperature variations. The same situation was not simulated in this in vitro study.
2. Provisional restorations are subjected to force immediately after fabrication but in this in vitro study samples are subjected to load after soaking in artificial saliva for 24hrs and 10 days. Therefore further investigations are required under more closely simulated clinical conditions.

CONCLUSION

Bis-acryl interim materials exhibited higher flexural strength than the polymethacrylate resins and urethrane dimethacrylate provisional materials. Polymethylmethacrylate and urethrane dimethacrylate had shown more deflection than bisacrylate. They have undergone more plastic deformation before breakage therefore Elastic modulous of polymethylmethacrylate and urethrane dimethacrylate is less when compared to bis-acryl composite provisional material.

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