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Evaluation of Immediate and Delayed Flexural Strength of Poly Methyl Meth Acrylate and Bis Acryl Composite Based Provisional Restorative Material - An in Vitro Study

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Abstract: ***Introduction: The demand for tooth coloured restorations has increased significantly in recent years due to improved techniques, materials and also patient's demand for aesthetic restorations. Accurate temporary restorations are essential and serve various functions, including protection of the pulpal tissues, preventing bacterial contamination and preservation of the periodontal tissues. Polymethyl methacrylate (PMMA) resins and composite-based resins (CBR) are the most common materials used to fabricate temporary restorations. Aim: The aim of this study was to evaluate and compare the immediate and delayed flexural strength of PMMA (ICERAC- CAD/CAM) and traditional Bis-acryl composite based (ACRYTEMP) provisional restorative material before and after storing in artificial saliva for 7 days followed by thermo cycling and cementation. Materials and Methods: Three unit bridges were fabricated with PMMA using CAD CAM technique and Bis-acryl based composite based (ACRYTEMP) by direct technique on the prepared teeth. Both the groups were subjected to thermocycling for 1500 cycles between 5^0 C and 55 ^{0}C with a dwell time of 30 secfollowed by cementation with the provisional cement. After the thermocycling and cementation of each sample on to the master model, flexural strength was evaluated immediately and after storing in artificial saliva for 7 days using the universal testing machine. Results: Results revealed that the three unit bridge after storing in artificial saliva PMMA using CAD CAM technique shows better strength than that of Bis-acryl based composite based (ACRYTEMP) material. Conclusion: It was concluded that the provisional restoration fabricated using CAD/CAM (polymethyl methacrylate) interim restorations has better flexural strength than traditional Bis–acryl composite (ACRYTEMP) interim restorations in the oral environment.***

Keywords: PMMA,CAD/CAM, ACRYTEMP

1. Introduction

The demand for tooth colored restorations has increased significantly in recent years due to improved techniques, materials and also patient demand for aesthetic restorations. Therefore, using various modern restorative materials which have acceptable mechanical properties, are essential for both temporary and definitive restorations. Fabrication of the final prosthesis takes about 4-6 days. During this time period, the prepared tooth needs to be protected from the oral environment and its relationship with the adjacent and opposing tooth needs to be preserved. It also serves various functions including protection of the pulpal tissues, preventing bacterial contamination and preservation of the periodontal tissues. Hence, in order to protect these prepared abutment teeth, temporary restorations are fabricated. These interim restorations are also beneficial for diagnostic purposes where the functional, stabilizing, occlusal and esthetic parameters are developed to identify an optimum treatment result before the completion of definitive prosthesis.[2]

While selecting a material for a temporary restoration, physical and mechanical properties of the materials should be considered. Clinically significant properties include strength of the material, its rigidity and reparability, exothermic reaction following polymerization and subsequent polymerization shrinkage, marginal integrity and colour stability. There are various materials that have been successfully used for this purpose- Poly Methyl Methacrylate Resins (PMMA), Poly Ethyl Methacrylate Resins (PEMA), vinyl ethyl methacrylate resins, butyl methacrylate, epimine, preformed matrices of plastic and cellulose shells, metals, polycarbonate materials, bis-acryl composites, bis-GMA composites, Urethane Di Methacrylate Resins (UDMA).[1]

Acrylic based resins consist of polymeric materials based on PMMA. These materials are result of a free radical polymerization reaction initiated chemically. PMMA resins are relatively inexpensive with ease of handling, excellent polish and good marginal adaptation. The major drawback of these materials is the exothermic polymerization; high polymerization shrinkage and low wear resistance.CAD/CAM PMMA-based polymers have different mechanical properties depending on monomer and chemical composition and have a highly cross-linked structure, which may offer advantages over conventionally polymerized interim resins. Flexural strength (FS) is an important parameter in approximation of the mechanical strength and rigidity of the material. The FS of interim materials is important in the rehabilitation of long-span

edentulous situations, extended treatment time, or in patients with para-functional habits.[5]

2. Materials and Methodology

The study was conducted in the Department of Prosthodontics, V. S. Dental College and Hospital Bangalore. This study was conducted to Evaluate and Compare the flexural strength of the two materials, i.e., Bis-acrylic composite-based autopolymerizing resin material, i.e., Acrytemp (Zhermac. italy).and CAD/CAM blocks (Ruthinium PMMA Blocks)

2.1 Methodology

1) Teeth preparation of resin teeth 24 and 26
2) Fabrication Of The Metal Dies
3) Fabrication Of the Mold
4) Fabrication of Group A Provisional Restorations (ACRYTEMP)
5) Fabrication of Group B Provisional Restorations (CAD CAM PMMA)
6) Thermocycling
7) Testing of the samples for flexural strength using Universal Testing Machine
8) Statistical methods employed.

1) Resin Teeth Preparation

One maxillary first premolar (no. 24) and one first molar (no. 26), resin teeth were selected for this study. Resin teeth were embedded in the dental typhodont base (NISSAN DENTAL PRODUCTS INC. KYOTO JAPAN). The resin teeth were prepared with a round end tapered diamond bur (Mani burs) with 1mm chamfer and 6^0 taper.The occlusal surfaces were prepared to 2mm with an 811 rotary instrument(Mani burs). Then, the preparations were polished with an 850 rotary instrument (Mani burs).

2) Fabrication of the Metal Dies

The prepared resin teeth were scanned using 3D scanner and copied the same to exocad dental CAD software. The same suprastructure of the prepared resin teeth was copied in an STL file and milled in Cobalt-chromium ingot (Ceramill Sintron) metal using 5 axis dental milling unit.

3) Fabrication of the Mold

The metal dies were then marked 2mm above the cement-enamel junction and the roots were covered with a thin layer of modeling wax to simulate the periodontal ligament. The metal dies were then embedded in the wax block (Hindustan Modelling Wax N0. 2) of dimensions 45*25*15mm, maintaining a 7mm distance between the abutments and thus simulating a 3 unit fixed dental prosthesis. This wax block was then invested, dewaxed for 5 min followed by acrylisation with heat cure acrylic denture base material (cured using short curing cycle). After polymerization, the flask was removed from the water bath and allowed to cool at room temperature. After deflasking, the heat cure acrylic block was trimmed with an acrylic burs and polished with wet polishing wheel and a slurry of pumice.

The master model along with the embedded metal dies were sent to the laboratory (Confident Dental Lab) for the fabrication of the 3 unit porcelain fused to metal FDP, using CAD CAM (Ceramill Sintron)

The samples were divided into 2 main groups and further divide in to subgroups:
Group A: Provisional restorations made by Acrytemp (n=12)
Subgroup 1: 6 samples of 3 Unit Bridge without immersion in artificial saliva.
Subgroup 2: 6 samples of 3 Unit Bridge immersed in artificial saliva for 7 days.
Group B: Provisional restorations made by CAD CAM (n=12)
Subgroup 1: 6 samples of 3 Unit Bridge without immersion in artificial saliva.
Subgroup 2: 6 samples of 3 Unit Bridge immersed in artificial saliva for 7 days.

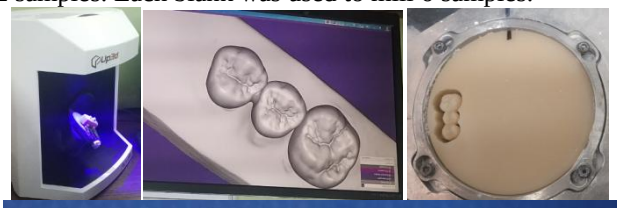
4) Fabrication of Group A Provisional Restorations (ACRYTEMP)

The 3 unit FDP thus obtained, was used in the fabrication of an over impression matrix using putty (Dentsply, Aquasil). In order to maintain the contour stability, only 3 interim FDPs were fabricated with each putty impression matrix. Hence, four such putty impression matrices were fabricated in order to complete the fabrication of 12 interim FDPs. A layer of separating medium (Bioline) was applied onto the metal mold. A new mixing tip was installed and prior to each application a small pea sized amount of paste was extruded. Subsequently, the dried overimpresion matrix was loaded in the relevant spaces with ACRYTEMP (Zhermac).The impression matrix was then positioned over the metal mold. The impression matrix was removed from

the mold within 3 minutes after the onset of mixing. The setting process was checked by observing the excess material on the matrix. The provisional restoration was removed before it hardened completely. The finishing and polishing of the provisional restorations was carried out by using fine carbide burs.

5) Fabrication of Group B Provisional Restorations (CAD-CAM)

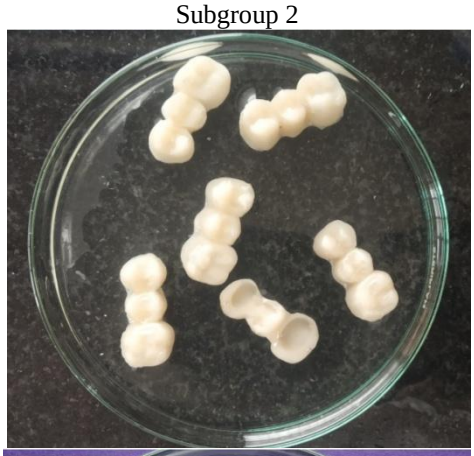
The CAD CAM PMMA resin was supplied in the form of blanks The master metal model with porcelain fused to metal restoration was scanned using 3 shape 2000 3D scanner (imesicore) (Fig-).The Provisional restorations (Group B – 12) were fabricated from CAD/CAM PMMA blank (PMMA disc, Ruthenium; Confident Dental Lab Pvt. Ltd., Bangalore). They were milled using computer aided manufacturing machine (CAM) (imesicore 350i). The restorations were placed on the model and checked for the margins. The scanned image of the metal master model with the dimension 45x25x15mm in the computer was converted into an STL file. The CAD CAM PMMA resin was loaded in the milling machine and any final adjustments required were done and corrected in the computer and then the signals were transferred to the CAD CAM machine for milling. Two CAD CAM PMMA blanks were used to mill 12 samples. Each blank was used to mill 6 samples.

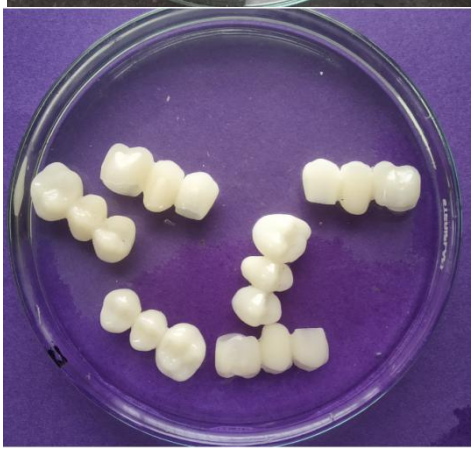


Group A (Acrytemp) Subgroup 2

Samples Immersed in Artificial Saliva Group B Cad/Cam

Subgroup 2





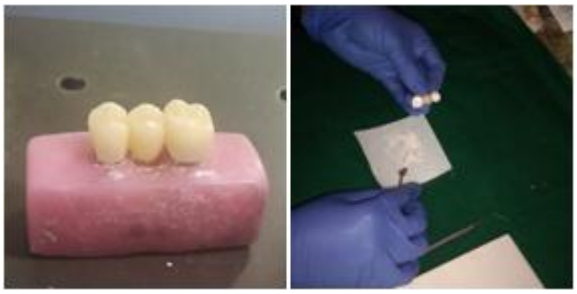
6) Thermocycling

Provisional restorations from each group (i.e, Group A -12 samples and Group B- 12 samples) were then subjected to thermocycling to simulate oral conditions. For thermocycling two time temperature controlled water baths will be used. The temperature of one water bath (hot) was set at 55^0 C and temperature of the other water bath (cold) was set at 5^0 C. The provisional restorations were thermocycled for 1500 cycles between 5^0 C and 55^0C. Dwell time in each water bath was 30 seconds. The transfer time from one water bath at 5^0C to other water bath at 55^0C was 5 seconds.

7) Cementation of the Provisional Restorations

After the provisional restorations were placed on the metal model and checked for the margins and the fit. The provisional restorations were coated with the luting cement and were placed. Temporary cement (Tempbond, Kerr) was used for the cementation. Each interim restoration was

seated on the metal mold with a constant load of 50 N for 5 min using the Universal Testing Machine (Mecmesin Multitest 10i). The excess cement was removed with the help of an explorer.



8) Flexural Strength

All the interim FDPs samples (n=24) were subjected to three point bend test, at a crosshead speed of 0.95mm/min carried out by Universal Testing Machine. The load was applied onto the connector of the samples until the 3 unit FDPs fractures. The breaking load was noted in MPa with the use of testing machine software which was standardized. The procedure was repeated accordingly for all the interim FDPs, immediately and after storing in artificial saliva for 7 days.

3. Statistical Analysis

Data will be entered in the excel spread sheet. Descriptive statistics like mean, standard deviation will be calculated. Inferential statistics like independent sample t test will be computed to find the difference of flexural strength between the groups; paired sample t test will be computed to find the difference of flexural strength before and after immersion using SPSS (statistical Package for Social Sciences) version 20. (IBM SPASS statistics [IBM corp. released 2011]. Any other necessary tests will be dealt at the time of analysis based on data distribution.

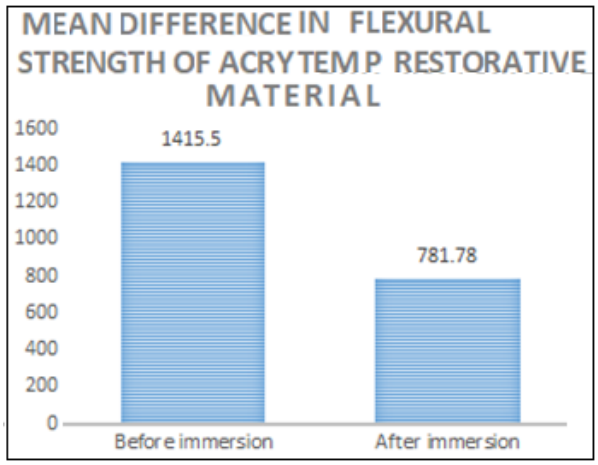
4. Results

1) Comparison of immediate and delayed flexural strength of traditional Bis-acryl composite based (Acrytemp) provisional restorative material- (Table No. 1, Graph No. 1**) :**

In this study, the mean flexural strength of Bis-acryl composite based (Acrytemp) provisional restorative material before storing in saliva was 1415.5±233.49 N/mm^2 and after storing in saliva was 781.78±113.73 N/mm^2. The mean difference in flexural strength was 633.71 N/mm^2, and this was statistically significant (p<0.001).

Table 1

		Minimum	Maximum	Mean	S.D	Mean diff	P value
Acrytemp	Before immersion	1116.7	1697	1415.5	233.49	633.71	0.001*
	After immersion	561.7	864.9	781.78	113.73		



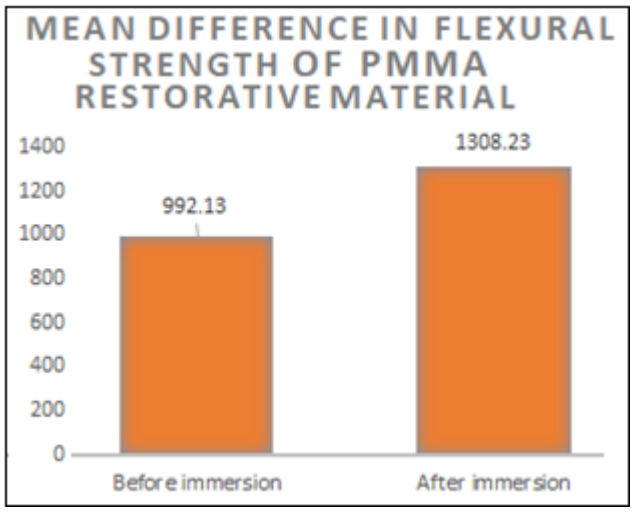
Graph 1

2) Comparison of immediate and delayed flexural strength of PMMA (RUTHINIUM-CAD/CAM) provisional restorative material- (Table No. 2, Graph No. 2)

It was observed that the mean flexural strength of **PMMA (RUTHINIUM-CAD/CAM)** provisional restorative material before storing in saliva and after storing in saliva was 992.13±150.47 N/mm^2 and 1308.23±123.36 N/mm^2 respectively. The mean difference in flexural strength was -316.10 N/mm^2, and this was statistically significant (p=0.01).

Table 2

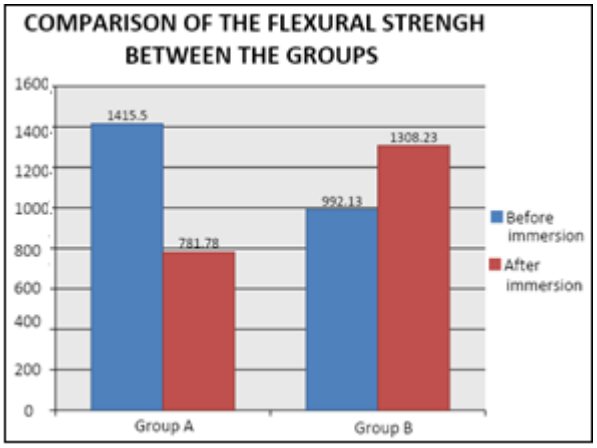
		Minimum	Maximum	Mean	S.D	Mean diff	P value
RUTHINIM CAD/CAM	Before immersion	689.8	1083.9	992.13	150.47	-316.1	0.01*
	After immersion	1131.6	1483.9	1308.23	123.36		



Graph 2

3) Comparison of mean difference in immediate and delayed flexural strength between the groups before and after storing in saliva-(Table No. 3, Graph No.3)

In this study, the mean difference in immediate flexural strength between Bis-acryl composite based **(Acrytemp**) provisional restorative material (Group A) and **PMMA** (RUTHINIUM-CAD/CAM) provisional restorative material (Group B) before storing in saliva was 423.36N/mm^2 and this difference was statistically significant (p<0.001). The mean difference in delayed flexural strength between the two groups after storing in saliva was -526.45 N/mm^2 and this difference was statistically significant (p=0.004).



Graph 3

Table 3

		Minimum	Maximum	Mean	S.D	Mean diff	P value
Before immersion	Group A	1116.7	1697	1415.5	233.49	423.36	0.004*
	Group B	689.8	1083.9	992.13	150.47		
After immersion	Group A	561.7	864.9	781.78	113.73	-526.45	0.001*
	Group B	1131.6	1483.9	1308.23	123.36		

5. Discussion

Provisional restorations are a crucial diagnostic aid for the success of fixed prosthodontic treatment. Long term dimensional stability of provisional restorations in the oral environment is an important criteria for complex integrated treatment plan where the final prosthesis is delayed until the completion of orthodontic, periodontal and endodontic therapy.CAD/CAM technologies have started a new age in dentistry. The quality of dental prostheses has improved significantly by means of standardized production processes. This offers numerous new treatment options such as an extended preliminary treatment phase. Currently, many manufacturers offer high-density polymers based on highly cross-linked PMMA acrylic resins or composites for CAD/CAM manufacturing methods. Since they are manufactured in an industrial process, provisional restorations made of high-density polymer exhibit qualities superior to those of direct restorations.

The result shows that Group A (ACRYTEMP) has more immediate flexural strength than that of group B (PMMA).

Group A (ACRYTEMP) has less delayed flexural strength i.e (after immersion in artificial saliva for 7 days) than that of group B (PMMA). Polymerisation shrinkage occurs which leads to decrease in flexural strength and also there will be release of free monomer content. The water absorption of PMMA and bis-acryl composite materials might be a possible explanation for the decrease in strength after conditioning in water. Excessive water uptake can promote breakdown causing a filler matrix de bonding. Absorbed molecules (e.g., water, saliva) spread polymer chains apart and facilitate slippage between chains. This lubricating effect is called plasticization. Group B (PMMA) has less immediate flexural strength then that of group A (ACRYTEMP).Rawls HR et al., have stated, when water penetrates into the space between the polymer chains and pushes them further apart, the van der Waals forces between the polymer chains reduces. This adds weight and causes volume to increase. The greater the absorption of water by the material, lower the strength.[2]

Group B (PMMA) has more delayed flexural strength i.e (after immersion in artificial saliva for 7 days) than that of group A (ACRYTEMP).- Because During the milling process, the blocks are not affected as they are completely pre-polymerized during fabrication process prior to machining, Which maintains the strength in oral environment.

6. Conclusion

Within the limitations of this in vitro study, it was concluded that the provisional restoration fabricated using CAD/CAM (polymethyl methacrylate) interim restorations has better flexural strength than traditional Bis–acryl composite (ACRYTEMP) interim restorations in the oral environment.

Results suggests that provisional CAD/CAM (PMMA) fabricated interim restorations present a stable, long term clinical outcome compared with those which are fabricated using ACRYTEMP (PMMA) interim restorations.

7. Summary

Interim prostheses are an important part of fixed prosthodontic treatment and generally fabricated from conventional interim resin materials such as poly (methyl), poly (ethylene), and bis-acrylate composite resins. With advancements in computer-aided design/computer aided manufacturing (CAD/CAM) materials, manufacturers recently presented CAD/CAM poly (methyl methacrylate) (PMMA)-based polymers as an alternative material for interim prostheses which gives better strength and longetivity than traditional bis acryl composite resin materials.

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