



# A COMPARATIVE ANALYSIS OF WEAR RESISTANCE, SURFACE HARDNESS AND FRACTURE RESISTANCE OF INTERIM RESTORATION FABRICATED BY CAD/CAM AND CONVENTIONAL METHOD

**Bodhisatta Mukherjee<sup>a</sup>, Upasana Panda<sup>b</sup>, Gautam Naskar<sup>c</sup>, Monika Samal<sup>d</sup>, Gopal Krishna Choudhury<sup>e</sup>.**

- a. Assistant Professor, Department of Prosthodontics and Crown & Bridge, North Bengal Dental College & Hospital, Darjeeling, WB
- b. Consultant Prosthodontist and Implantologist
- c. Associate Professor, Department of Prosthodontics and Crown & Bridge, Dr. R. Ahmed Dental College & Hospital, WB
- d. Senior Lecturer, Department of Prosthodontics and Crown & Bridge, Institute of Dental Sciences, S'O'A (Deemed to be University), Bhubaneswar, Odisha
- e. Prof & Head, Department of Prosthodontics and Crown & Bridge, Institute of Dental Sciences, S'O'A (Deemed to be University), Bhubaneswar, Odisha

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## **ABSTRACT**

**Introduction:** Fixed Prosthodontics Treatment can only be successful with a good Interim restoration. Increase in demand of cosmetic dental procedures, provisional restorations have become a diagnostic tool rather than a space maintainer.

**Aims:** A Comparative Analysis of Wear Resistance, Surface Hardness and Fracture Resistance of Interim Restoration Fabricated By CAD/CAM and Conventional Method.

**Materials and Methods:** The present study was a Comparative study. This Study was conducted for 1 year 6 months in Department of Prosthodontics and Crown & Bridge at Institute of Dental Sciences, Siksha 'O' Anusandhan (Deemed to be University)

**Result:** The distribution of data for the groups was found to be non-normal, as was seen from histogram and applying tests of normality (Shapiro-Wilk test and Kolmogorov Smirnov test).

**Conclusion:** Mechanical properties hold one of the most important criteria for the longevity of the Interim restorations. Recent advancement and cosmetic needs had led to huge advancement in the materials which are commercially available for temporary restorations. Evaluation of materials is necessary to estimate their mechanical properties so that they can be easily fabricated and used for long term.

**Keywords:** Conventional Method, Fixed Prosthodontics Treatment, provisional restorations and CAD/CAM.

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## **INTRODUCTION**

Fixed Prosthodontics Treatment can only be successful with a good Interim restoration. Increase in demand of cosmetic dental procedures, provisional restorations have become a diagnostic tool rather than a space maintainer. An interim restoration must function like that of the definitive restoration,

longevity and particular colour matching might be of question.<sup>1</sup> Glossary of Prosthodontic Terms –9 states that- A fixed or removable dental prosthesis, or maxillofacial prosthesis, designed to enhance esthetics, stabilization, and/or function for a limited period of time, after which it is to be replaced by a definitive dental or maxillofacial

prosthesis; often such prostheses are used to assist in determination of the therapeutic effectiveness of a specific treatment plan or the form and function of the planned for definitive prosthesis. The Temporary Fixed Prosthesis protects the health of pulp and periodontia. It also helps in guided tissue healing to get an acceptable emergence profile, restricting abutment movements and occlusal scheme preservation.<sup>4</sup> Provisional restoration plays a key role for diagnosing the complex prosthodontics treatment related to change in vertical dimension of occlusion, relationship of centric occlusal contact, anterior guidance, lip support, length of the tooth, position of the incisal edge and occlusal plane or plane of incisors. The Temporary Fixed Prosthesis not only protects pulp but also provides positional and occlusal stability, cleansing ability, accurate marginal integrity, wear resistance and sufficient strength.<sup>3</sup> Insulation of the exposed dentinal tubules necessitates temporisation. Dentinal tubules comprises of cytoplasmic process which is a continuation of the odontoblastic cell lining of the pulp. Temporary Fixed Prosthesis helps in sealing the exposed dentinal tubules cutting it off from the oral cavity hereby decreasing the sensitivity and irritation to the pulp. It is always good appearance that boosts up esthetic dentistry. In this contrast; the appearance of the Temporary fixed restoration comes in to action. The temporary restorative materials must match with the shade of the adjacent tooth so that it becomes hard to distinguish between the temporary crown and the natural tooth. Most prevailing material for fabricating custom provisional restoration is acrylic. Methyl methacrylate introduced in 1940 is the most widely used temporisation material which is available in powder and liquid formulations, when mixed in stipulated proportion gives a solid mass by chemical reaction. Conventionally there are mainly three types of acrylic material present namely Polymethyl Methacrylate(PMMA), Polyethyl methacrylate(PEMA), Polyvinylethyl methacrylate(PVEMA). Researches in the field of material sciences for temporary crown

had led to the introduction of newer temporisation material such as Bis-acryl composite resin (eg. Protemp4), Bis-acryl composite nano-filled resin (eg. Structur 3) and Bis-Gma resins.

## **MATERIALS AND METHODS**

**STUDY DESIGN:** Comparative study

**PLACE OF STUDY:** Institute of Dental Science, Siksha 'O' Anusandhan (Deemed to be University)

**PERIOD OF STUDY:** 1 year 6 months

**STUDY POPULATION:** In- vitro

**SAMPLE SIZE:** A total of 20 observations were recorded for each of the groups of conventional methods (Structur 3, Protemp4 and Self cure), and also for the reference group (CAD/CAM PMMA) with regard to three components – wear resistance, surface hardness and fracture resistance. Total 80 samples were included in this study.

**INCLUSION CRITERIA:-** All good smooth finished temporary restoration were included in study.

**EXCLUSION CRITERIA:-** Cracked, Incomplete seating, rocking, large pores present temporary restorations were not included in the study.

**METHODOLOGY:-** A maxillary first molar was prepared to receive metal-ceramic crown with 2mm of shoulder cervical finish line, 2mm occlusal surface and a total of 6° tapering occlusally on the labio-lingual walls and the mesio-distal walls were made parallel to each other on a NISSIN typhodont model, which was scanned and master stainless steel model was produced by milling in CNC Machine.[Fig1] This model was scanned and fed in to the CERAMILL®MIKRO CAD/CAM milling machine to fabricate the 20 Polymethyl Methacrylate Temporary

Crowns from Ceramill® TEMP [Fig2] and their fit were checked with the metal model.

Metal master model was duplicated in Type IV die stone (KALSTONE - KALABHAI) to make dies. Polyvinyl siloxane material (SOFT PUTTY 3M) was manipulated and was placed on the CAD/CAM crown cemented with Rely-X TEMP on the respective die stone models and temporary crowns of the other materials such as PROTEMP™ 4 (3M ESPE), STRUCTUR 3 (VOCO) and the SC-10 Self Cure (PMMA) were fabricated by direct method over the die stone model after applying a thin layer of cocoa-butter. Thus crowns of all the four groups were fabricated [Fig3] were subjected to wear resistance test in CHEWING SIMULATOR CS-4 (SD MEKATRONIK), [Fig4] all the crown samples were weighed before and after putting in to chewing simulator. The loss in weight percentage was calculated was used to detect the wear away of the material. Hence wear resistance of the materials is calculated.

Bar of 25x3x2mm and disks of 10x3mm fabricated from stainless steel milling in CNC Machine. These metal models were scanned and milled from CAD/CAM PMMA block. Bars and Disks of other materials were fabricated from a vacuum formed sheet that was used as plastic mould. [Fig5,6] These bar made of all 4 groups were subjected to four point bending test in universal testing machine (TINUS OLSEN) and load was applied till the specimen break to evaluate fracture resistance of the materials. [Fig7] The disks of all 4 groups were subjected to Vickers Hardness test in Micro hardness tester (LECO LM247AT) to evaluate surface hardness of the materials at a force of 25gf for 13 seconds. [Fig8]

## **RESULT AND DISCUSSION**

Interim prosthesis is a mandatory part of fixed prosthodontics treatment. Temporary crown must be placed from initial tooth preparation till the definitive prosthesis is fabricated. Temporary restoration is that prosthesis which is either fixed or removable that provide esthetics enhancement, stabilization and function over a limited period of time.

Provisional restoration plays a key role for diagnosis of complex prosthodontics treatment related to change in vertical dimension of occlusion, relationship of centric occlusal contact, anterior guidance, lip support, length of the tooth and position of the incisal edge, occlusal plane or plane of incisors.<sup>4</sup>

Prepared tooth needs protection from all type mechanical, physical, bacterial contamination and thermal injures. Thus the importance of interim restoration or temporary crown plays a significant role. The success of a fixed prosthesis is only possible from a good temporary restoration. Due to increase in high esthetics and cosmetic concern, the temporary restoration has become a diagnostic tool rather than a space maintainer.

Most prevailing material for fabricating custom provisional restoration is acrylic. Methyl methacrylate introduced in 1940 is the most widely used temporisation material which is available in powder and liquid formulations, when mixed in stipulated proportion gives a solid mass by chemical reaction<sup>5</sup>. Researches in the field of material sciences for temporary crown had led to the introduction of newer temporisation material such as Bis-acryl composite resin, Bis-acryl composite nano-filled resin and Bis-

Gma resins.<sup>5</sup> Superior technology evolving in the field of dentistry produces fine temporary restorations made from CAD/CAM technology. This technology use poly-methyl methacrylate of higher strength so that it can withstand milling process therefore has high strength and better marginal adaptation.<sup>2</sup>

Newer material arrival make it obvious for a test for mechanical properties mainly wear resistance, fracture resistance and surface hardness to sustain in the oral cavity tolerating the force of mastication till the final prosthesis is fabricated. During mastication the highest force is applied on the temporary fixed prosthesis, so material must be of durable quality and have wear resistance and sufficient strength so that it does not break off during loading.

In this study newer advanced materials are taken in to consideration such as CAD/CAM milled PMMA reinforced by methacrylate acid ester based cross-linked polymer, Self Cure PMMA SC-10, Bis-acryl composite resin PROTEMP<sup>TM</sup>4, Nanofilled Bis-acryl STRUCTUR 3. The mechanical properties of the newer advanced materials had been taken in to consideration such as Wear Resistance, Fracture Resistance and Surface Hardness.

CAD/CAM is a digital procedure where the precision milling of a block of PMMA or waxes or metal can be milled by a software guided milling machine. The blocks used for milling in a CAD/CAM machine are generally industrially made under controlled environment so there is no incorporation of air void or non-homogeneity of the material in the block. The mechanical properties of the milled prosthesis also remain intact. Thus there is no other better

alternative to select the CAD/CAM fabricated PMMA temporary crowns as a control for this study.<sup>6</sup>

Wear resistance being an important property of temporary crown, higher the wear resistance lesser is the chance of getting perforation. Wearing away of the temporary crowns will lead to supra-eruption of the opposing teeth, hence the final restoration will interfere with the vertical dimension of occlusion leading to adjustment of the occlusion or re-preparation of the tooth surface and making an impression for repeat of the final restoration.

In this conducted study, the wear resistance is determined by calculating the weight loss before and after putting the samples in a chewing simulator. It has been obtained that CAD/CAM fabricated PMMA temporary crowns showed the best wear resistance amongst the other group of 0.0081% of volumetric weight loss followed by that of Self cure SC-10 with 0.0015% of total volumetric. Nano filled Bis – acryl composite resin Structur 3 showed 0.0019% volumetric weight loss and is more resistant to fracture than Bis - acryl composite resin Protemp<sup>tm</sup> 4 which showed 0.0021% volumetric loss by weight.

Resin matrix composition affects the fracture resistance of the temporary materials. Being industrially fabricated CAD/CAM PMMA blocks and almost no distortion in milling makes the CAD/CAM PMMA crowns exhibit better wear resistance than those of manually fabricated temporary crowns.<sup>6</sup>

Some authors in their publication shared a common view and had dictated that PMMA is widely used temporary restoration material due to its good wear resistance, better fracture resistance, durability<sup>7</sup>

Bisphenol-A-Glycidyl methacrylate is

the main component of Bis-Acryl composite resin. Its resin matrix contains monomers that are multifunctional. Conventional methacrylate resins contain mono-functional monomers with low molecular weight, linear molecules which decrease strength and rigidity. Protemp 4 showed higher wear resistance but according to this conducted study Protemp<sup>TM</sup>4 didn't showed highest wear resistance, Nano-filled bisacryl resin showed better wear resistance than Protemp<sup>TM</sup>4.

Fracture resistance is the property by which a temporary crown withstands the masticatory load during chewing. Repeated chewing increase the masticatory loads. More resistant to fracture, more is the longevity of a temporary crown. Temporary restoration material had undergone many researches and published records had suggested that bis-acryl composite material Protemp 4 revealed higher strength, than auto-polymerising PMMA resins.

In this conducted study fracture resistance was determined by putting a bar shaped specimen to a load on 4 head load by universal testing machine and force had been applied till the specimen underwent fracture. After the samples undergoing the test, it was found that CAD/CAM PMMA specimen showed the highest fracture resistance of 67N followed by Self-cure PMMA 53.5N. Bis- Acryl composite resin Protemp<sup>TM</sup> 4 had a fracture resistance of 43N followed by nano filled Bis Acryl resin Structur 3 with 38N.

From this result it is evident that CAD/CAM fabricated temporary crowns shows higher fracture strength than conventionally fabricated PMMA crowns which is followed by Nano Filled Bis-acryl resin Structur 3 and Protemp<sup>tm</sup>4. It is worth mentioning that

computer assisted and software controlled CAD/CAM milled prosthesis shows more mechanical strength than of directly fabricated interim prosthesis even if same material is concerned.

Protemp<sup>TM</sup>4 and Structur 3 being bis-acryl resin showed lesser fracture resistance than CAD/CAM PMMA and Self cure PMMA.

Surface hardness is that property which prevents the temporary crown from getting deformed. If proper occlusal contact is to be maintained then deformity of the temporary crown cannot be hailed. According to the conducted study Vickers hardness test was done.

In this conducted study Surface Hardness of CAD/CAM PMMA came out to be the highest with 27.5VHN followed by Protemp<sup>TM</sup>4 with 25VHN. Self-cure acrylic resin had surface hardness of 21VHNN followed by Structur3 being 17VHN.

Authors published that surface hardness of Bis-acryl resin is far superior than Self-cured PMMA Interim Restorations.<sup>8</sup> Authors also reported that due to absence of filler particles the surface hardness of Self-cure PMMA exhibited low value as compared to the Bis-acryl resins. But in this study it is quite evident from the result that CAD/CAM fabricated PMMA interim crowns showed higher surface hardness than any other Interim Crown Material used.

Recent advanced technology that had been put into the field of dentistry is CAD/CAM milling of Blocks made of biocompatible materials fabricated by industrial control. CAD/CAM milled PMMA also available for Interim Restoration purpose.

Computer assisted and software controlled CAD/CAM milled prosthesis shows more mechanical



strength than of directly fabricated interim prosthesis even if same material is concerned. This new technological advancement in the field of dentistry, CAD/CAM fabricated temporary crowns reduces the risk of failures and chair side time.

Claudia Florina Andreescu mentioned that CAD/CAM fabricated temporary crowns are have good fracture strength and fracture resistance so they tend not to fracture under load as CAD/CAM materials have almost zero porosity and homogeneity is very high so they have high resistance to fracture and wear resistance. The main advantage of CAD/CAM fabricated PMMA temporary crown described by Flávia Pires Neves Pascutti et al in the year 2017 as less time consuming, cost-effective and quality control, hence are more suitable for prolong treatment. More over as per the outcome of the conducted study it can be said that the second best material to use as temporary restoration is SC-10 Self cure PMMA made by conventional method. Z Vally et al also said the same thing that this fracture resistance makes the Self Cured PMMA suitable for day to day practice. It is also mentioned in the published report that fracture resistance of PMMA crowns are more than that of bis-acryl resin making PMMA the second best temporisation material.<sup>9</sup>

### **CONCLUSION**

Mechanical properties hold one of the most important criteria for the longevity of the Interim restorations.

Recent advancement and cosmetic needs had led to huge advancement in the materials which are commercially available for temporary restorations. Evaluation of materials is necessary to estimate their mechanical properties so that they can be easily fabricated and used for long term.

With the limitation of the in-vitro study it is observed from the conducted study that there is a significant difference in wear resistance, surface hardness and fracture resistance among the groups. It is seen that there was a definite order for wear resistance, surface hardness and fracture resistance in the group items as given below.

1. CAD/CAM PMMA > Self cure >> Structur 3 >> Protemp4 (wear resistance)
2. CAD/CAM PMMA > Protemp4 >> Self cure >> Structur 3 (surface hardness)
3. CAD/CAM PMMA > Self cure >> Protemp4 >> Structur 3 (fracture resistance)

It can be concluded that interim restoration fabricated by CAD/ CAM was found to be best overall followed by other conventional restoration methods (Self cure) qualifying in two out of three criteria can be considered as the next best).

Lately it must be kept in mind that as in-vitro studies are controlled study, it is difficult to co – relate with the intra-oral or clinical performance but an inference can be drawn about the best suitable material available that can be used as an interim restoration.

<b>Wear resistance</b>	<b>Median</b>	<b>IQR</b>	<b>z-value</b>	<b>P value</b>	
STRUCTUR 3	.0019	.0018	.0019	-5.560	<b>0.000</b>
PROTEMP 4	.0021	.002	.0021	-5.563	<b>0.000</b>
SELF CURE	.0015	.0014	.0015	-5.515	<b>0.000</b>

### **Comparison of wear resistance of interim restoration fabricated by conventional**

**method with standard CAD/ CAM**

**Comparison of fracture resistance of interim restoration fabricated by conventional methods with standard CAD/ CAM**

Fracture resistance	Median	IQR	z-value	P value
STRUCTUR 3	38	36.5 38	5.504	<b>0.000</b>
PROTEMP4	43	42 43	5.489	<b>0.000</b>
SELF CURE	53.5	52 54.5	5.475	<b>0.000</b>

**Comparison of surface hardness of interim restoration fabricated by conventional method with standard CAD/ CAM**

Surface Hardness	Median	IQR	z-value	P value
STRUCTUR 3	17	17 18	5.496	<b>0.000</b>
PROTEMP4	25	25 26	5.426	<b>0.000</b>
SELF CURE	21	21 22	5.499	<b>0.000</b>

FIGURES



Fig. No. – 1. METAL MODEL OF PREPARED MAXILLARY 1<sup>ST</sup> MOLAR.



Fig. No: - 2. TEMPORARY CROWNS ARE BEING MILLIED IN CAD/CAM



Fig.No.- 3. TEMPORARY CROWNS ON DIE-STONE MODELS.

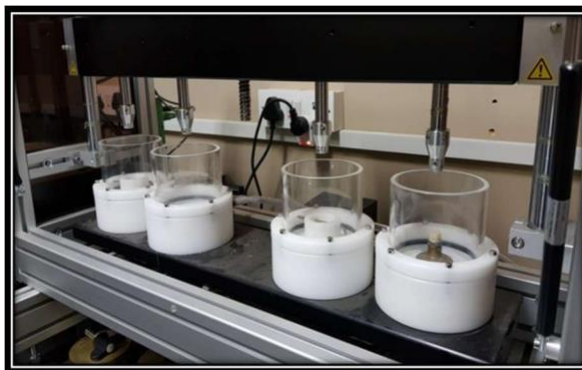


Fig.No.- 4. SAMPLES BEING TESTED IN THE CHEWING SIMULATOR.

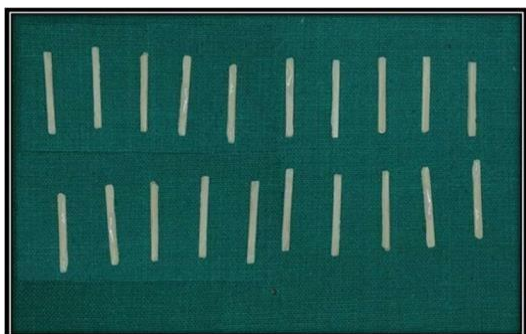


Fig.No.- 5. BARS MADE UP OF TEMPORARY MATERIALS.



Fig.No -6. DISKS MADE UP OF TEMPORARY MATERIALS.

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