Original Article

DOI: 10.7860/JCDR/2025/74110.20799

Dentistry Section

Evaluation of Marginal Fit of Provisional Restoration Fabricated Using Tooth Moulding Acrylic Powder, Bisacryl Composite and 3D Printed Resin: An In-vitro Study

PRIYANKA GOPALAKRISHNAN[1], MATHEW CHALAKUZHIYIL ABRAHAM[2], N VIDHYASANKARI[3], SAKTHI GNANAVEL SHANMUGAM[4], VISHNUPRIYA VENKATASUBRAMANIAN[5], SINDHUJA NAGARAJAN[6]

ABSTRACT

Introduction: Provisional restorations should have a good marginal fit with non impinging margins and ease of cleansability to protect the gingiva and periodontal tissues. Impinging margins can result in gingival inflammation, while an improper marginal fit can lead to microleakage, recurrent caries and postoperative sensitivity.

Aim: To evaluate and compare the marginal fit of provisional restorative materials made using Dental Products of India (DPI) tooth moulding acrylic powder, Bisacryl composite (Protemp IV) and 3D printed resin.

Materials and Methods: In this in-vitro study was conducted at the Department of Prosthodontics, KSR Institute of Dental Science and Research, Tiruchengode, Tamil Nadu, India from October 2023 to February 2024, 42 samples were divided into three groups. Group-A samples were prepared using DPI self-cure tooth moulding powder; Group-B samples were prepared using Protemp IV; and Group-C samples were prepared using 3D printed resin (n=14). The provisional crowns were fabricated using a prepared typodont tooth to evaluate their marginal fit. The marginal fit was assessed using a stereomicroscope. Photographs were taken and the marginal gap was measured using Image J software. The results were then tabulated and statistical analysis was performed.

Results: The results of the study showed that the marginal fit was better in 3D printed resin (107.97 µm) compared to DPI tooth moulding acrylic powder (192.56 µm) and Bisacryl composite (Protemp IV) (177.67 µm).

Conclusion: The marginal fit of the 3D printed provisional restorative resin was significantly better than that of the provisional restorations fabricated with Protemp IV and the DPI self-cure tooth moulding powder.

Keywords: Marginal adaptation, Polymethacrylate, Stereomicroscope

INTRODUCTION

Provisional restoration is defined as a fixed or removable dental prosthesis or maxillofacial prosthesis designed to enhance aesthetics, stabilisation and/or function for a limited period, after which it is to be replaced by a definitive dental or maxillofacial prosthesis. Often, such prostheses are used to assist in determining the therapeutic effectiveness of a specific treatment plan or the form and function of the planned definitive prosthesis (GPT 10) [1]. Provisional restorations are used to protect the prepared teeth between treatment sessions [2]. Provisional restorations should be similar to final restorations in functional, biological and mechanical aspects. They should also fulfill the aesthetic requirements of patients. Additionally, they help to decide the size, shape, contour and shade of the final restoration. Moreover, provisional restorations should have a good marginal fit with non impinging margins and ease of cleansability to protect the gingival and periodontal tissues [3].

The provisional restorative material should be hard, durable and non irritating to the pulp. Therefore, the ideal provisional restorative material should be non-porous, dimensionally stable and possess a low exothermic reaction. Provisional restorations are most commonly made using Polymethyl Methacrylate (PMMA), polyethyl methacrylate and bisacryl composites [4]. The methods of provisional restoration fabrication include direct, indirect and direct-indirect methods. The direct method involves making a temporary restoration intraorally, while the indirect method involves making a restoration in the lab. The direct-indirect method combines making a restoration in the lab and then relining it intraorally. Both direct and indirect methods of provisional restoration fabrication have their advantages and disadvantages [5-7]. Among these, bisacryl composites are more commonly used because of their ease of manipulation intraorally. Although these conventional materials have better aesthetics and mechanical properties, the manipulation of materials may include voids that affect the fit of provisional restorative materials [8]. To avoid the shortcomings of conventional provisional restorative materials, Computer Aided Design-Computer Aided Manufacturing (CAD-CAM) is used to design and fabricate provisional restorations, which reduces chairside time for the dentist in fabricating them [9].

The precision of the fit between restorations and prepared teeth is essential for the long-term viability of fixed partial dentures and crowns. To prevent periodontal irritation and protect pulpal structures after tooth preparation, the marginal fit of a provisional restoration must be precise [10]. If the marginal fit of a provisional restoration is poor, it increases plaque accumulation, thereby increasing the incidence of periodontal diseases. Decementation of the prosthesis may occur if the marginal discrepancy is significant, which increases the risk of dissolution of the temporary luting agent [4]. Previous studies have compared the marginal fit of provisional restorative materials fabricated using conventional techniques and CAD-CAM techniques (milled restorations), but data on 3D printed resin are limited [4-6,10]. Thus, the present study aimed to evaluate and compare the marginal fit of provisional restorative materials fabricated using tooth-moulding acrylic powder, bisacryl composite and 3D printed resin. The null hypothesis was that there would be no difference in the marginal fit of provisional restorative materials

fabricated using tooth-moulding acrylic powder, bisacryl composite and 3D printed resin.

MATERIALS AND METHODS

The in-vitro comparative study was conducted at was conducted at the Department of Prosthodontics, KSR Institute of Dental Science and Research, Tiruchengode, Tamil Nadu, India from October 2023 to February 2024. The Ethical Committee approval number is IEC-PG/DEC/2023/159.

Inclusion and Exclusion criteria: Samples without any obvious marginal discrepancies and porosities were included, while samples with marginal discrepancies, margin chipping and porosities visible to the naked eye were excluded.

Sample size calculation: The sample size was calculated using G Power software, resulting in a total sample size of 42 (14 per group). The three provisional restorative materials used in the study were DPI tooth molding acrylic powder, Protemp IV and 3D printed resin.

Group-A: DPI tooth molding acrylic powder

Group-B: Protemp IV (Bisacryl Composite)

Group-C: 3D printed resin.

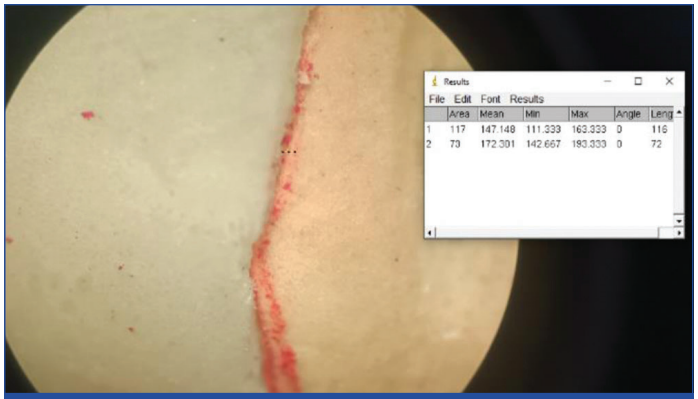
Study Procedure

Sample preparation: The putty index of unprepared typodont teeth was created (N=42). Tooth preparation was then performed on a typodont mandibular molar for a metal-ceramic crown, involving 2 mm of occlusal reduction, 1.5 mm of axial reduction and a 6-degree convergence, in accordance with Shillingburg's principles for tooth preparation. The preparation was verified under a magnifying lens for any undercuts and refined as necessary. The preparation was standardised using a Computerised Numerical Control (CNC) machine. Impressions were made using putty and light body condensation silicone impression material with sectional impression trays (n=42). The impressions were poured using die stone to obtain casts (n=42). The casts were lubricated and provisional restorations were fabricated on them using DPI Tooth Moulding Powder and Protemp IV, with the assistance of the initially made putty index.

For the 3D printed resin group, a lab scanner was used to scan the model and provisional restorations were designed using Exocad software and printed with 3D printed resin.

Evaluation of marginal fit: The temporary crowns obtained were placed on the casts and observed under a stereomicroscope at 40x magnification to evaluate their marginal fit. Photographs were taken [Table/Fig-1] and the images were analysed using Image J software to measure the marginal discrepancy [Table/Fig-2]. For each sample, nearly 20 measurements were made and tabulated in an Excel sheet.

[Table/Fig-1]: Photograph of samples to evaluate marginal fit.



[Table/Fig-2]: Analysis of image using image J software.

STATISTICAL ANALYSIS

The data were analysed using the statistical package Statistical Package for the Social Sciences (SPSS) 26.0 (SPSS Inc., Chicago, IL), with a significance level set at $p < 0.05$. Descriptive statistics were performed to assess the mean and standard deviation of the respective groups. The normality of the data was assessed using the Shapiro-Wilk test. Inferential statistics were employed to determine the differences between the groups using the independent t-test and within-group comparisons were made using the one-way Analysis of Variance (ANOVA) test, followed by the Bonferroni post-hoc test.

RESULTS

The Shapiro-Wilk test for normality reported a significant difference ($p<0.05$); therefore, parametric tests were used for the analysis. The marginal discrepancy was lower in the 3D printed resin (107.97 µm) compared to DPI tooth molding acrylic powder (192.56 µm) and bisacryl composite (Protemp IV) (177.67 µm). Analysis by One-way ANOVA reported a statistically significant difference between the groups ($p=0.0001$). The Bonferroni post-hoc test indicated a significant difference between Group-A and Group-C ($p=0.0001$) and between Group-B and Group-C ($p=0.0003$) [Table/Fig-3].

Variables		Mean (µ)	SD
Group-A		192.56	43.37
Group-B		177.67	49.25
Group-C		107.97	39.67
p-value (One-way ANOVA Test)		0.0001*	
p-value (Bonferroni post-hoc test)	G1 vs G2	0.63	
	G1 vs G3	0.0001*	
	G2 vs G3	0.0003*	

[Table/Fig-3]: Comparison of marginal fit between tooth moulding acrylic powder, bisacryl composite and 3D printed resin.

DISCUSSION

The study was conducted to evaluate and compare the marginal fit of provisional restorations fabricated using tooth moulding powder, Protemp IV and 3D-printed resin. The null hypothesis was rejected, as there were differences in the marginal fit of the provisional restorative materials. The study concluded that 3D-printed resin had a better marginal fit in contrast to Bisacryl composite and DPI tooth moulding acrylic powder. Hence, 3D-printed resin is a superior provisional restorative material when considering marginal fit.

In the present study, 3D-printed resin was compared against DPI tooth moulding acrylic powder and Bisacryl composite. The 3D-printed resin used was JAMG H E photopolymer resin, which was printed using a Sonic 4K 3D printer. 3D-printed resin consists of oligomers, monomers and photoinitiators that improve the cross-linkages in the resin. The 3D printing offers better precision and accuracy in printing structures, thereby enhancing the marginal fit of provisional restorative materials [11]. Thus, the findings indicated

S. No.	Author's name and year	Place of study	Sample size	Materials compared	Parameters assessed	Conclusion
1.	Dureja I et al., 2018 [4]	SGT University, Haryana, India	40	Bisacryl composite vs Milled temporary crowns	Marginal fit and flexural strength	Bisacryl composite and CAD-CAM provisional materials showed comparable flexural strength. CAD-CAM crowns showed a more accurate and precise marginal adaptation
2.	Shetty K et al., 2020 [6]	IBN Sina National College of Medical Sciences, Jeddah, KSA	16	Charm temp temporary crown and bridge material, Harvard temp C and B PRO and Structur 2SC, VOCO temp crown and bridges.	Marginal fit evaluated after immersing in tea, coffee and Pepsi	All three temporary crowns fabricated from different materials showed significant marginal discrepancies when dipped in three different beverages
3.	Patel AA et al., 2020 [13]	Pune, India	20	Protemp 4, Revotek and Tuff Temp plus (dual cure resin material)	Marginal fit	Tuff Temp Plus had a better marginal fit than Protemp 4 and Revotek
4.	Nivedita S and Prithviraj DA, 2006 [12]	GDC, Bengaluru	45	Self-cure autopolymersing resin and light cure-activated resin	Marginal discrepancy was assessed using a scanning electron microscope.	The vertical marginal discrepancy of the provisional restorations fabricated using light-cured composite resins by direct technique was the least and had a better marginal fit compared to the provisional restorations fabricated using autopolymerised resin by direct and indirect techniques.
5.	Khaled N et al., 2023 [5]	Egypt	20	Bisacryl composite vs 3D printed resin	Marginal adaptation evaluated using stereomicroscope	Interim crowns fabricated by 3D printing showed superior marginal accuracy than conventionally constructed crowns.
6.	Present study, 2024	Tiruchengode, Tamil Nadu	42	DPI tooth acrylic powder vs bisacryl composite vs. 3D printed resin	Marginal fit was evaluated using a stereomicroscope.	The 3D-printed resin had a better marginal fit.

[Table/Fig-4]: Comparison of marginal fit of provisional restorative materials of various studies [4-6,12,13].

that the marginal fit was best in 3D-printed resin, followed by Bisacryl composite (Protemp IV) and then DPI tooth moulding acrylic powder.

There was a significant difference in marginal fit between DPI tooth moulding powder and 3D-printed resin, as well as between Bisacryl composite and 3D-printed resin. The outcome of the study was consistent with a study conducted by Dureja I et al., which also showed a better marginal fit with 3D-printed resin, attributed to reduced polymerisation shrinkage and improved cross-linkage of the resin [4]. In the study by Nivedita S and Prithviraj DR the marginal fit of provisional restorations fabricated from autopolymerising and Bisacryl composite resins was evaluated under a scanning electron microscope. The outcome of that study proved that Bisacryl composite resin had a better marginal fit compared to autopolymerising resin due to less monomer content, reduced polymerisation shrinkage and a higher concentration of cross-linking agents [12].

In a research study conducted by Patel AA et al., which compared the marginal fit between Protemp 4, Revotek and Tuff Temp Plus (a dual-cure resin material), it was found that Tuff Temp Plus exhibited better marginal fit than Protemp 4 and Revotek after a storage period of about one week. The dual-cure resin showed lesser marginal discrepancy compared to the autopolymerising resin due to the presence of the cross-linking agent Urethane Dimethacrylate (UDMA) in the resin [13]. Further, in a study by Gudapathi S et al., it was noted that light-cure resin had lesser marginal discrepancy when compared to autopolymerising resin after thermocycling [14]. A comparison of the marginal fit of provisional restorative materials from various studies is presented in [Table/Fig-4] [4-6,12,13].

Limitation(s)

The main limitation of the present study is that it is an in-vitro study, which does not reflect the exact oral conditions and can only be used as a predictor of clinical performance. Another limitation includes the finishing of provisional restorations, which might affect the marginal fit. This issue was mitigated by having another observer review the crowns after fabrication. The major drawback of the study was that the provisional crowns were not exposed to the thermo-cycling changes that occur in the oral cavity during use. Therefore, further research will be needed to expose samples to thermo-cycling changes after fabrication in order to better imitate the oral environment.

CONCLUSION(S)

Within the constraints of the study, the following conclusions were drawn: 3D printed resin exhibited a better marginal fit in contrast to Bisacryl composite and DPI tooth molding acrylic powder. Therefore, 3D printed resin is considered a superior provisional restorative material when evaluating marginal fit. However, in situations where 3D printed resin provisional crowns cannot be fabricated due to certain constraints, Bisacryl composite serves as a better provisional restorative material, as it can be fabricated chairside in the clinical setting.

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PARTICULARS OF CONTRIBUTORS:
1. Postgraduate Student, Department of Prosthodontics, KSR Institute of Dental Science and Research, Tiruchengode, Tamil Nadu, India.
2. Professor, Department of Prosthodontics, KSR Institute of Dental Science and Research, Tiruchengode, Tamil Nadu, India.
3. Professor and Head, Department of Prosthodontics, KSR Institute of Dental Science and Research, Tiruchengode, Tamil Nadu, India.
4. Senior Lecturer, Department of Prosthodontics, KSR Institute of Dental Science and Research, Tiruchengode, Tamil Nadu, India.
5. Senior Lecturer, Department of Prosthodontics, KSR Institute of Dental Science and Research, Tiruchengode, Tamil Nadu, India.
6. Postgraduate Student, Department of Prosthodontics, KSR Institute of Dental Science and Research, Tiruchengode, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Mathew Chalakuzhiyil Abraham,
Professor, Department of Prosthodontics, KSR Institute of Dental Science and Research, Tiruchengode-637215, Tamil Nadu, India.
E-mail: camathew@ksridsr.edu.in

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 09, 2024
- Manual Googling: Oct 16, 2024
- iThenticate Software: Dec 05, 2024 (15%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jul 08, 2024**
Date of Peer Review: **Sep 25, 2024**
Date of Acceptance: **Dec 07, 2024**
Date of Publishing: **Mar 01, 2025**