



# Comparative Evaluation of Microbial Adhesion on Commercially Available Provisional Fixed Prosthodontic Materials - An in Vitro Study

S.Rakshini<sup>1</sup>, K.Sheela Kumari\*<sup>2</sup>, K. Murugesan<sup>3</sup>, A.Nida Fathima<sup>4</sup>

<sup>1,2,3,4</sup>Priyadarshini Dental College & Hospital (Affiliated to the Tamil Nadu Dr.M.G.R. Medical University, Thiruvallur-631203)

(Received: 16 June 2025

Revised: 20 July 2025

Accepted: 04 August 2025)

## KEYWORDS

Polymethylmethacrylate, Bisacrylate composite resin, Surface roughness, Zone of inhibition.

## ABSTRACT:

**Introduction:** Provisional restorative materials are fabricated immediately after tooth preparation and play a crucial role in maintaining gingival and periodontal health. They help prevent secondary caries, plaque accumulation, and ensure both intra- and inter-arch stability. However, microbial adhesion, particularly on long-term provisional restorations, may lead to oral complications and compromise the longevity of the final prosthesis.

**Objectives:** This in vitro study aims to compare two commercially available provisional fixed prosthodontic materials, polymethylmethacrylate (PMMA) and bisacrylate composite resin, regarding their susceptibility to adhesion by *Streptococcus mutans* and *Staphylococcus aureus*, and to evaluate the influence of surface roughness further.

**Methods:** A total of 20 disc-shaped specimens (10 PMMA and 10 bisacrylate composite resin) were fabricated, each with a diameter of 10.0 mm and a height of 2.0 mm. Surface roughness was measured using a surface profilometer. The specimens were incubated with *Streptococcus mutans* and *Staphylococcus aureus* at 37°C for 24 hours. Bacterial adhesion was assessed by measuring the zone of inhibition. The data were statistically analyzed using the Kolmogorov-Smirnov test, with significance set at  $p \leq 0.05$

**Results:** Surface roughness showed a statistically significant difference between PMMA and bisacrylate composite resin ( $p \leq 0.05$ ). Bisacrylate composite resin exhibited significantly lower bacterial adhesion by *Streptococcus mutans* compared to PMMA. However, there was no significant difference in adhesion by *Staphylococcus aureus* between the two materials.

**Conclusions:** Bacterial adhesion to provisional restorative materials varies significantly between PMMA and bisacrylate composite resin. While bisacrylate composite resin demonstrated lower adhesion by *Streptococcus mutans*, no correlation was found between surface roughness and bacterial adhesion in this strain.

## 1. Introduction

Provisional restorative materials are fabricated immediately after tooth preparation and are intended to maintain gingival and periodontal health, prevent secondary caries and plaque accumulation, and preserve intra- and inter-arch stability.<sup>1</sup> It is well documented that bacterial colonization on provisional fixed materials is higher than on permanent fixed materials.<sup>2</sup> The oral microflora is complex and consists of a diverse array of bacterial species, with bacterial adhesion varying among different species. Microbial adhesion of specific microorganisms in the oral cavity can lead to adverse health complication.<sup>3</sup> Various studies have identified *Streptococcus* species as "early colonizing bacteria." *Streptococcus mutans*, a gram-positive coccus and primary cariogenic bacterium, is notable for its ability to adhere to smooth tooth surfaces and

for its acidogenic and aciduric properties.<sup>4</sup> *Staphylococcus aureus*, another gram-positive coccus, is responsible for a wide range of diseases, including many nosocomial infections, and is known for adhering to medical devices and releasing toxins that cause severe infections.<sup>5</sup> Prolonged bacterial adhesion on provisional materials can compromise oral health and affect the longevity of permanent restorations.<sup>6,7</sup> Bacterial adherence to surfaces is influenced by surface characteristics such as irregularities, pits, and grooves, which promote higher bacterial adhesion.<sup>8</sup>

## 2. Objectives

The objective of this in vitro study is to compare two different commercially available provisional fixed prosthodontic materials in terms of their adherence to *Streptococcus mutans*



and *Staphylococcus aureus*, and to evaluate the influence of surface roughness. The research hypothesis is that surface roughness has a significant impact on bacterial adherence.

### 3. Methods

All tested materials were commercially available and widely used. The materials evaluated were Ivoclar crown and bridge material (polymethylmethacrylate), which is the control group, and Avue T Crown (bisacrylate composite resin) is the test group. Surface roughness was assessed using a profilometer, while antimicrobial activity was tested using Mueller-Hinton agar plates. Ten specimens of each material were prepared in a uniform disc shape (10 mm × 2 mm) using a custom metal mold (Figure 1 and 2).

The specimens were polished, and their surface roughness was measured using a surface profilometer. The profilometer, equipped with a diamond stylus, measures minute surface variations by moving the stylus vertically in contact with the sample and laterally across it over a specified distance and contact force. The vertical displacement of the diamond stylus generates an analog signal, which is converted into a digital signal, stored, analyzed, and displayed for each sample (Figure 3).

For the antimicrobial activity test, bacterial cultures (*Streptococcus mutans* and *Staphylococcus aureus*) were spread on Mueller-Hinton agar plates. Wells were then created in the agar using a sterile core borer. Each well was loaded with either polymethyl methacrylate or bisacrylate composite resin. The plates were incubated at 37°C for 24 hours, and the zones of inhibition were measured in millimeters (Figures 4 and 5).

### 4. Results

#### Zone of inhibition:

The antimicrobial efficacy of the polymethyl methacrylate and bis-acrylate composite resin was evaluated using the zone of inhibition test against *Streptococcus mutans* and *Staphylococcus aureus*. The mean zone of inhibition for the test group (bis-acrylate composite resin) was 2.8mm for *Streptococcus mutans* and 12.8mm for *Staphylococcus aureus*, whereas the control group (Polymethylmethacrylate) exhibited 11.4mm for *Streptococcus mutans* and 12.6mm for *Staphylococcus aureus* ( $P < 0.001$ )

Table 1 and 2 depicts the statistical comparison of the mean antimicrobial activity among commercially available provisional fixed prosthodontic materials. According to Levene's Test for Equality of Variances and t-test for Equality of Means, it was found that the antimicrobial activity of the *Streptococcus mutans* group was statistically significant.

The table 3 depicts that the surface roughness among commercially available provisional fixed prosthodontic materials with the highest mean surface roughness value of

0.5974 in the Ivoclar group, followed by the Avue group (0.2511). The table 4 depicts the statistical comparison of the mean surface roughness among commercially available provisional fixed prosthodontic materials. According to Levene's Test for Equality of Variances and the t-test for Equality of Means, it was found to be statistically significant.

### 5. Discussion

As per the result in this in vitro study, the surface roughness of bisacrylate composite resin (test group) was significantly lower than the polymethylmethacrylate (control group), with a significant difference. For antimicrobial activity, *Streptococcus mutans* showed less bacterial adherence in the control group than in the test group, whereas *Staphylococcus aureus* showed equal zone of inhibition in both groups. Therefore, the null hypothesis was rejected, indicating a significant difference in both the surface roughness and bacterial adherence between the materials tested. In the control group, PMMA crown and bridge material demonstrated a mean surface roughness of 0.5974µm. In the test group, bisacrylate composite resin crown and bridge material exhibit a mean surface roughness of 0.2511µm. The p-value was 0.001, indicating a significant difference in the surface roughness between the two groups.

The same samples were used to determine bacterial adherence (Zone of inhibition), control group (PMMA), *Streptococcus mutans* showed an 11.4 mm zone of inhibition, and *Staphylococcus aureus* showed a 12.6mm zone of inhibition. In the test group (bisacrylate composite resin) *Streptococcus mutans* showed a 2.8mm of zone of inhibition, and *Staphylococcus aureus* showed a 12.8mm zone of inhibition. The increased adhesion of *Streptococcus mutans* to the composite resin is attributed to its filler content and monomer composition<sup>9</sup>. In previous studies, various methods have been employed to evaluate bacterial adherence. The zone of inhibition method, used in this study, is widely accepted due to its simplicity, cost-effectiveness, and ability to provide clear, quantitative results regarding the antimicrobial efficacy of a substance. However, it primarily assesses the ability of an agent to inhibit bacterial growth rather than directly measuring bacterial adherence<sup>10</sup>. The organic and inorganic content of the resin also directly influences the surface characteristics of restoration<sup>11,12</sup>. The quality of bacterial adherence differs based on the matrix and the resin content<sup>13</sup>. Burgers et al reported that no correlation was found between the quantity of bacterial adhesion and surface roughness and the surface hydrophobicity. Additionally, bisacrylate composite resin and acrylic PMMA showed lower bacterial adhesion than the improved methacrylates<sup>14</sup>. Gulsum Sayin Ozel observed that the adhesion of *Candida albicans* was higher than that of *S.mutans*.<sup>13,15</sup> Quirynen M et al, indicated that surface roughness of less than 0.2micrometer does not influence microbial composition. c.zortukM, observed that surface roughness and the degree of bacterial adhesion differed significantly. Mirjam Kozmos<sup>16</sup> concluded that *s.mutans* adhere less on the amalgam than the tooth surface. Néstor Usiel Lara-Jara<sup>17</sup> concluded that lower bacterial adherence was seen in bisacrylate composite resin either in the polished or unpolished samples. Vinayaga kumar et al<sup>18</sup>, evaluated the



surface roughness and porosity of different provisional restorative material, they found that surface roughness and porosity was least in bis-acrylate composite resin (protemp)<sup>18</sup>. Several previous in-vitro studies used a flow chamber, the precoating procedure to mimic the intraoral environment, bacterial adhesion on surfaces within the oral cavity, accounting for salivary wash, pellicle formation by salivary proteins, and the cohesion effects of fungi<sup>19</sup>. However, this study did not employ these techniques, as the primary objective was to evaluate the impact of material composition alone on microbial adhesion. In future research, these techniques could be incorporated alongside our method to more thoroughly evaluate and develop materials that prevent microbial adhesion.

### Conclusion:

According to this study, the quantity of bacterial adhesion by *Streptococcus mutans* shows a significant difference between polymethylmethacrylate and bisacrylate composite resin which may be due to inherent material properties such as surface energy, chemical composition and microstructural characteristics that influence the bacterial affinity of *Streptococcus mutans* towards one material over the other. However, the adhesion of *Staphylococcus aureus* shows no significant difference between the two materials portraying their less dependent potency on surface characteristics. Further in vitro and clinical trial investigation are required to study the complex interplay between material properties and microbial behaviour.

### References

- Rosenstiel SF, Land MF, Walter R, editors. Contemporary fixed prosthodontics-e-book: Contemporary fixed prosthodontics-e-book. Elsevier Health Sciences; 2022 Jun 22.
- Swetha S, Jain AR. Assessment of microbial growth and salivary pH in patients wearing fixed partial denture. *Journal of Pure and Applied Microbiology*. 2017 Dec 30;11(4):1925-8.
- Marsh PD. Are dental diseases examples of ecological catastrophes?. *Microbiology*. 2003 Feb;149(2):279-94.
- Hamada S, Slade HD. Biology, immunology, and cariogenicity of *Streptococcus mutans*. *Microbiological reviews*. 1980 Jun;44(2):331-84.
- Kouidhi B, Zmantar T, Hentati H, Bakhrouf A. Cell surface hydrophobicity, biofilm formation, adhesives properties and molecular detection of adhesins genes in *Staphylococcus aureus* associated to dental caries. *Microbial pathogenesis*. 2010 Jul 1;49(1-2):14-22.
- Haselton DR, Diaz-Arnold AM, Vargas MA. Flexural strength of provisional crown and fixed partial denture resins. *The Journal of prosthetic dentistry*. 2002 Feb 1;87(2):225-8.
- Idrissi HA, Annamma LM, Sharaf D, Jaghsi AA, Abutayyem H. Comparative evaluation of flexural strength of four different types of provisional restoration materials: an in vitro pilot study. *Children*. 2023 Feb 15;10(2):380.
- Buergers R, Rosentritt M, Handel G. Bacterial adhesion of *Streptococcus mutans* to provisional fixed prosthodontic material. *The Journal of prosthetic dentistry*. 2007 Dec 1;98(6):461-9.
- Takahashi Y, Imazato S, Russell RR, Noiri Y, Ebisu S. Influence of resin monomers on growth of oral streptococci. *Journal of dental research*. 2004 Apr;83(4):302-6.
- Balouiri M, Sadiki M, Ibsouda SK. Methods for in vitro evaluating antimicrobial activity: A review. *Journal of pharmaceutical analysis*. 2016 Apr 1;6(2):71-9.
- Cazzaniga G, Ottobelli M, Ionescu A, Garcia-Godoy F, Brambilla E. Surface properties of resin-based composite materials and biofilm formation: A review of the current literature. *Am J Dent*. 2015 Dec 1;28(6):311-20.
- Hao Y, Huang X, Zhou X, Li M, Ren B, Peng X, Cheng L. Influence of dental prosthesis and restorative materials interface on oral biofilms. *International journal of molecular sciences*. 2018 Oct 14;19(10):3157.
- Ozel GS, Guner MB, Inan O, Eldeniz AU. Evaluation of *C. Albicans* and *S. Mutans* adherence on different provisional crown materials. *The journal of advanced prosthodontics*. 2017 Oct 1;9(5):335-40.
- Hjerpe J, Rodas S, Korvala J, Pesonen P, Kaisanlahti A, Özcan M, Suojanen J, Reunanen J. Surface roughness and streptococcus mutans adhesion on metallic and ceramic fixed prosthodontic materials after scaling. *Materials*. 2021 Feb 22;14(4):1027.
- Schubert A, Wassmann T, Holtappels M, Kurbad O, Krohn S, Bürgers R. Predictability of microbial adhesion to dental materials by roughness parameters. *Coatings*. 2019 Jul 22;9(7):456.
- Zortuk M, Kesim S, Kaya E, Özbilge H, Kiliç K, Çölgeçen Ö. Bacterial adhesion of porphyromonas gingivalis on provisional fixed prosthetic materials. *Dental research journal*. 2010;7(1):35.
- Zortuk M, Kesim S, Kaya E, Özbilge H, Kiliç K, Çölgeçen Ö. Bacterial adhesion of porphyromonas gingivalis on provisional fixed prosthetic materials. *Dental research journal*. 2010;7(1):35.
- Lara-Jara NU, Romo-Ramírez GF, del Pilar Goldaracena-Azuara M, Aragón-Piñ A, Girón CB, Méndez-González MV, González-Amaro AM. Effect of polishing procedure on the roughness and bacterial adhesion of provisional restorative materials. *Microscopy Research*. 2018 Jul 24;6(2):9-18.
- Kumar GV, Devi R, Anto N. Evaluation and comparison of the surface roughness and porosity of different provisional restorative materials: an in vitro study. *CODS-Journal of Dentistry*. 2007 Sep 1;8(1):39-45.



Figure 1 Bis-acrylate composite resin specimens



Figure 2 PMMA resin specimens



Figure 3 Zone of inhibition assessed for PMMA and bis-acrylate composite resin on Streptococcus mutans



Figure 3 Surface profilometer with the sample



Figure 4 Zone of inhibition for PMMA and bis-acrylate composite resin on staphylococcus aureus

Antimicrobial Activity		N	Mean (mm)	Std. Deviation	Std. Error of Mean	Median	Minimum	Maximum	Range
Streptococcus mutans	IVOCLAR	10	11.4	1.81659	0.8124	12	9	13	4
	AVUE	10	2.8	1.92354	0.86023	3	0	5	5
Staphylococcus aureus	IVOCLAR	10	12.6	1.67332	0.74833	13	10	14	4
	AVUE	10	12.8	1.30384	0.5831	13	11	14	3

Table 1 Descriptive analysis of antimicrobial activity among commercially available provisional fixed prosthodontic materials



**Statistical analysis of the frequency of antimicrobial activity among the two study groups using an independent sample t test**

Variable	Levene's Test for Equality of Variances		t-test for Equality of Means							
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
Streptococcus mutants	Equal variances assumed	0.021	0.888	7.268	8	<0.001**	8.6	1.18322	5.8715	11.3285
	Equal variances not assumed			7.268	7.974	<0.001**	8.6	1.18322	5.86995	11.33005
Staphylococcus aureus	Equal variances assumed	0.262	0.623	0.211	8	0.838	-0.2	0.94868	2.38767	1.98767
	Equal variances not assumed			0.211	7.549	0.839	-0.2	0.94868	2.41063	2.01063

**Table 2** Statistical comparative analysis of the frequency of antimicrobial activity among commercially available provisional fixed prosthodontic materials

Surface roughness	N	Mean	Std. Deviation	Std. Error of Mean	Median	Minimum	Maximum	Range
IVOCLAR	10	0.5974	0.29525	0.09337	0.55	0.2	0.92	0.71
AVUE	10	0.2511	0.1172	0.03706	0.2255	0.1	0.39	0.28

**Table 3** Descriptive analysis of surface roughness among commercially available provisional fixed prosthodontic materials.

**Statistical analysis of the frequency of surface roughness among the two study groups using an independent sample t-test**

Variable	Levene's Test for Equality of Variances		t-test for Equality of Means							
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
Surface	Equal	18.9	<0.001*	3.44	18	0.003	0.3463	0.10045	0.1352	0.5573



Roughness	variances assumed	5	*	7					6	4	
	Equal variances not assumed				3.447	11.768	0.005	0.3463	0.10045	0.12695	0.56565

**Table 4** Statistical comparative analysis of the frequency of surface roughness among commercially available provisional fixed prosthodontic materials