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Research Paper

Comparative Evaluation of Interim Crowns Fabricated by CAD/CAM Milling, 3D Printing, and Conventional Technique for Internal Fit and Fracture Resistance – An In Vitro Study.

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ABSTRACT: *Provisional crowns play a crucial role in protecting prepared teeth, preserving periodontal health, and ensuring functionality during the interim period of prosthodontic treatment. The success of these restorations significantly depends on internal fit and fracture resistance. This in vitro study aimed to compare the internal fit and fracture resistance of interim crowns fabricated by three different techniques: conventional (direct), CAD/CAM milling, and 3D printing. A total of 30 interim crowns were fabricated and divided into three groups (n=10 each). Group 1 included crowns made using the conventional direct technique with bis-acryl composite; Group 2 comprised 3D printed crowns using photo-polymerized bis-acrylate resin; and Group 3 included CAD/CAM milled crowns fabricated from PMMA blocks. Internal fit was evaluated using the silicone replica technique under stereomicroscopic analysis, and fracture resistance was tested using a universal testing machine. Statistical analysis with one-way ANOVA and post-hoc Tukey's test revealed significant differences in internal fit and fracture resistance among the three groups. CAD/CAM crowns showed the best internal fit, followed by 3D printed and conventional crowns. In contrast, the highest fracture resistance was observed in 3D printed crowns, followed by conventional and CAD/CAM crowns. The findings suggest that CAD/CAM techniques are more suitable where precise fit is critical, while 3D printed crowns may offer superior strength for extended use. The study emphasizes the importance of selecting the appropriate fabrication technique based on clinical requirements.*

KEYWORDS: *Provisional, surface roughness, micro hardness, CAD-CAM, 3D printed.*

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I. INTRODUCTION

Provisional restorations are indispensable in fixed prosthodontics, serving both protective and functional roles during the interim phase before final prosthesis delivery. They safeguard the prepared tooth, maintain periodontal health, support occlusal relationships, and preserve aesthetics (1). In cases such as full mouth rehabilitation, temporomandibular joint disorders, or delayed prosthesis fabrication, interim crowns may be required for an extended period, making their mechanical and biological performance crucial (2,3).

Among the essential factors influencing the success of provisional restorations are internal fit and fracture resistance. Internal adaptation influences seating, retention, and marginal sealing, directly impacting biological outcomes such as plaque accumulation, secondary caries, and gingival inflammation (4,5). Likewise, fracture resistance determines the prosthesis's durability under intraoral forces, especially in long-span prostheses or in patients with parafunctional habits (6).

Conventionally, materials like polyethyl methacrylate (PEMA) and polymethyl methacrylate (PMMA) have been widely used in chairside fabrication of interim crowns (7). (8,9).The advent of digital dentistry has introduced CAD/CAM milling—a subtractive technology using pre-polymerized resin blocks—and 3D printing—an additive technique involving layer-by-layer photo-polymerization using resins such as bis-acrylate (10,11). The present in vitro study was conducted to compare interim crowns fabricated by conventional, CAD/CAM milling, and 3D printing methods, focusing on their internal fit and fracture resistance (12**).**

II. MATERIALS AND METHODS

This in vitro study was conducted in the Department of Prosthodontics and Crown & Bridge, College of Dental Sciences and Research Centre, Bopal, Ahmedabad, with prior approval from the institutional ethics committee.

1) Study Design and Sample Size

A total of 30 interim crowns were fabricated and equally divided into three experimental groups (n = 10 per group):

- Group 1: Conventional technique using bis-acryl composite resin
- Group 2: 3D printing technique using photo-polymerized bis-acrylate resin
- Group 3: CAD/CAM milling technique using PMMA blocks

2) Materials Used

Material	Type	Technique	Manufacturer
Protemp 4	Bis-acryl composite resin	Conventional direct	3M ESPE, Seefeld, Germany
Brylic Solid	Highly polymerized PMMA	CAD/CAM milling	Sagemax Bioceramics, WA, USA
Freeprint Temp	Photo-polymerized bis-acrylate resin	3D printing	Detax GmbH, Ettlingen, Germany

3) Model Preparation

An ivorine mandibular right first molar was prepared as a master model with 1.5 mm occlusal reduction, 1 mm shoulder finish line, and a convergence angle of approximately 6° using a high-speed handpiece and surveyor (Marathon-103). A custom mold with self-polymerizing acrylic resin (DPI RR Cold Cure) was used to embed the master model.

4) Fabrication Techniques

- Group 1 – Conventional: A putty index was made from the master model using C-silicone (Zhermack). Protemp 4 was inserted into the index and positioned over the master model. After setting, the crown was finished and polished.
- Group 2 – 3D Printing: The master model was scanned using CEREC 3D (v3.60). STL files were generated with a cement space of 85 µm, and crowns were printed using FreeprintTemp resin.
- Group 3 – CAD/CAM Milling: The master model was scanned and milled using Shape DWX-520, utilizing Brylic PMMA blocks. Crowns were designed with the same CAD software and a cement space of 85 µm.

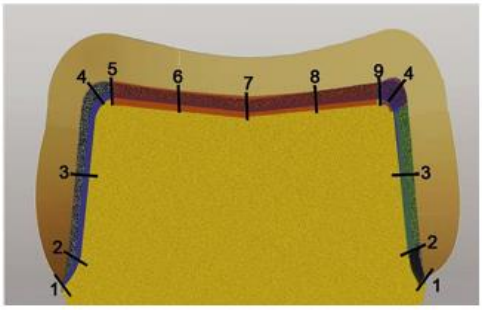
5) Evaluation Parameters

a) 1. Internal Fit Assessment

The Silicone Replica Technique (SRT) was used. Light-body silicone was injected into the crown and seated on the model with a 50N load. The cured silicone was sectioned and evaluated under a stereomicroscope (×20) at four measurement sites:

- Point A – Marginal area
- Point B – Axial area
- Point C – Axio-occlusal area
- Point D – Occlusal area

Measurements were recorded at 15 points per specimen.



Measurement regions and points for marginal and internal adaptation of crowns as per above diagram.

(a) Marginal gap (points 1, 2),

(b) Axial wall (point 3),

b) 2. Fracture Resistance

Crowns were filled with temporary cement (Templute) and seated on their respective models. They were then subjected to load testing using a Universal Testing Machine at a crosshead speed of 1 mm/min until fracture occurred. Fracture load was measured in Newtons (N).

Statistical Analysis

Data were analyzed using SPSS v15.0. One-way ANOVA was used to evaluate dififerences between groups for both internal fit and fracture resistance. Post-hoc Tukey's test was applied for intergroup comparisons. Significance was set at $p < 0.05$.

III. RESULTS & DISCUSSION

This in vitro study evaluated the internal fit and fracture resistance of interim crowns fabricated by three different techniques—conventional direct method, CAD/CAM milling, and 3D printing. The results demonstrated statistically significant differences between the groups for both parameters.

a) Internal Fit

Using the silicone replica technique (SRT), internal fit was assessed at four regions: marginal (Point A), axial (Point B), axio-occlusal (Point C), and occlusal (Point D). The CAD/CAM group consistently demonstrated the lowest internal gap across all regions, followed by the 3D-printed group and the conventional group, indicating superior adaptation.

The lowest mean internal gap was observed at the marginal area (Point A) in the CAD/CAM group (49.91 µm), while the highest was noted in the conventional group at the occlusal area (Point D) (129.63 µm) (13). These findings align with McLean and von Fraunhofer, who proposed that internal gaps up to 120 µm are clinically acceptable (14).

ANOVA results showed significant differences across all groups at all measurement points ($p < 0.05$), and post-hoc Tukey's tests confirmed that the CAD/CAM technique provided significantly better fit than the conventional method (15). Though the 3D printed crowns also demonstrated good internal adaptation, some studies report slightly greater discrepancies than CAD/CAM due to polymerization and build-angle artifacts (16,17).

These findings are in agreement with studies by Mai et al. (18) and Bhaskaran et al. (19), who also reported improved internal adaptation with CAD/CAM crowns compared to conventional and 3D printed ones. However, other investigations (20, 21) have favored 3D printing due to its ability to achieve layer-by-layer precision and material homogeneity.

b) Fracture Resistance

The fracture resistance test using a universal testing machine revealed that 3D printed crowns exhibited the highest mean fracture resistance, followed by conventional crowns and CAD/CAM crowns. The superior mechanical strength of the 3D-printed group may be attributed to the cross-linked bis-acrylate resin and layered polymerization that enhance internal strength through interlayer chemical bonding (22).

Statistical analysis (ANOVA and Tukey's test) confirmed that the difference in fracture resistance between 3D-printed and CAD/CAM crowns was significant ($p < 0.05$). This is consistent with Ibrahim et al. (23) and Angwarawong et al. (21), who demonstrated better mechanical durability of 3D-printed interim crowns under thermomechanical loading.

Despite the PMMA material used in CAD/CAM crowns being pre-polymerized (thus reducing shrinkage), it is milled in a subtractive fashion, which may introduce micro-defects and reduce bulk integrity (24,25). In contrast, additive manufacturing avoids material waste and maintains homogeneity.

Clinical Interpretation

- When internal fit is the clinical priority—such as in long-term temporization or cases with periodontal concerns—CAD/CAM crowns are advisable.
- When fracture resistance is more critical—such as in patients with bruxism or extended use—3D-printed crowns offer superior strength.
- Conventional methods, though cost-effective, present greater marginal discrepancies and lower mechanical stability, and may be better suited for short-term use only.

IV. CONCLUSION

This in vitro study evaluated the internal fit and fracture resistance of interim crowns fabricated by conventional, CAD/CAM milling, and 3D printing techniques. Within the limitations of the study, the following conclusions can be drawn:

- CAD/CAM milled interim crowns demonstrated the best internal fit, with significantly lower marginal and internal gaps compared to 3D printed and conventional crowns.
- 3D printed crowns exhibited the highest fracture resistance, making them more suitable for extended clinical use or high-stress environment.

- Conventional crowns, while widely used, showed inferior performance in both internal fit and fracture resistance compared to digital techniques.

Thus, the selection of interim crown fabrication technique should be based on the clinical priorities—whether precision fit or mechanical strength is paramount.

Future clinical studies with larger sample sizes and in vivo conditions are recommended to further validate these findings and assess long-term clinical outcomes.

REFERENCES

[1]. Gupt P, Nagpal A, Samra RK, et al. A comparative study to check fracture strength of provisional fixed partial dentures made of autopolymerizing polymethylmethacrylate resin reinforced with different materials: An in vitro study. J Indian Prosthodont Soc. 2017;17(3):301.
[2]. Young HM, Smith CT, Morton D. Comparative in vitro evaluation of two provisional restorative materials. J Prosthet Dent. 2001;85:129-32.
[3]. Haselton DR, Diaz-Arnold AM, Vargas MA. Flexural strength of provisional crown and fixed partial denture resins. J Prosthet Dent. 2002;87:225-8.
[4]. Wiskott HWA. Fixed prosthodontics: principles and clinics. London: Quintessence Publishing Co Ltd; 2011. p. 529–57.
[5]. Burns DR, Beck AD, Nelson SK. A review of selected dental literature on contemporary provisional fixed prosthodontic treatment. J Prosthet Dent. 2003;90:474–97.
[6]. Lodding DW. Long-term esthetic provisional restorations in dentistry. Curr Opin Cosmet Dent. 1997;4:16–21.
[7]. Abouelatta OB, El-Bediwi A, Sakrana A, et al. Surface integrity of provisional resin materials. Meas Sci Technol. 2006;17:584–91.
[8]. Nejatidanesh F, Lotfi HR, Savabi O. Marginal accuracy of interim restorations fabricated from four interim autopolymerizing resins. J Prosthet Dent. 2006;95:364–7.
[9]. Michalakis KX, Pissiotis A, Hirayama H, et al. Comparison of temperature increase in the pulp chamber during polymerization of materials used for direct fabrication of provisional restorations. J Prosthet Dent. 2006;96:418–23.
[10]. Fusayama T. Factors and technique of precision casting Part I. J Prosthet Dent. 1959;9(3):468–85.
[11]. Schwartz IS. Methods and techniques to improve the fit of cast restorations. J Prosthet Dent. 1986;56:279–83.
[12]. Ucar Y, Akova T, Akyil MS, et al. Internal fit evaluation of crowns prepared using a new dental crown fabrication technique: laser-sintered Co–Cr crowns. J Prosthet Dent. 2009;102:253–59.
[13]. Plekavich EJ, Joncas JM. The effect of impression-die systems on crown margins. J Prosthet Dent. 1983;49(6):772–76.
[14]. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. Br Dent J. 1971;131:107–11.
[15]. Bhaskaran E, Azhagarasan NS, Miglani S, et al. Comparative evaluation of marginal and internal gap of Co-Cr copings fabricated from conventional wax pattern, 3D printed resin pattern, and DMLS tech: An in vitro study. J Indian Prosthodont Soc. 2013;13:189–95.
[16]. Reeponmaha T, Angwaravong O, Angwarawong T. Comparison of fracture strength after thermo-mechanical aging between provisional crowns made with CAD/CAM and conventional method. J Adv Prosthodont. 2020;12(4):218.
[17]. Ibrahim A, El Shehawy D, El-Naggar G. Fracture resistance of interim restoration constructed by 3D printing versus CAD/CAM technique. Ain Shams Dent J. 2020;23:e14–20.
[18]. Mai, H.-N.; Lee, K.-B.; Lee, D.-H. Fit of interim crowns fabricated using photopolymer
[19]. Bhaskaran E, Azhagarasan NS, Miglani S, Ilango T, Krishna GP, Gajapathi B, et al.
[20]. Comparative evaluation of marginal and internal Gap of Co-Cr copings fabricated from conventional wax pattern, 3D printed resin pattern and DMLS tech: An in vitro study. J Indian Prosthodont Soc 2013;13:189-95.
[21]. Riccitiello F, Amato M, Leone R, Spagnuolo G, Sorrentino R. In vitro evaluation of the marginal fit and internal adaptation of zirconia and lithium disilicate single crowns: micro CT comparison between different manufacturing procedures. The open dentistry journal. 2018;12:160.
[22]. Angwarawong T, Reeponmaha T, Angwaravong O. Influence of thermomechanical aging on marginal gap of CAD-CAM and conventional interim restorations. The Journal of Prosthetic Dentistry. 2020 Nov 1;124(5):566.
[23]. jetting 3D printing. J. Prosthet. Dent. 2017, 118, 208–215.
[24]. Ibrahim A, El Shehawy D, El-Naggar G. Fracture resistance of interim restoration constructed by 3D printing versus CAD/CAM technique (In vitro study). Ain Shams Dent. J. 2020;23:e14-20.
[25]. Alharbi N, Osman R, Wismeijer D. Effects of build direction on the mechanical properties of 3D-printed complete coverage interim dental restorations. J Prosthet Dent. 2016;115:760–67.
[26]. Peng CC, Chung KH, Yau HT, Ramos V Jr. Assessment of the internal fit and marginal integrity of Provisional crowns made by different manufacturing methods. J Prosthet Dent. 2020;123(3):514–22.