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Investigating the Fracture Strength of Cad/Cam Pmma and Bis-Acrylic Resin in Temporary Crown Materials

Tahir Karaman, [1*] Mustafa Hayati Atala[2]

[1] DDS, PhD. Department of Prosthodontics, Faculty of Dentistry, Firat University, Elazig, Turkey
[2] DDS, PhD Department of Prosthodontics, Faculty of Dentistry, Abant Izzet Baysal University, Bolu, Turkey

Abstract

Aim: This study investigated the fracture strength of CAD/CAM polymethyl methacrylate (CAD/CAM PMMA) and Bis-acrylic resin temporary crowns to determine which material was more appropriate.

Materials and Methods: Chamfer and rounded shoulder preparations were made using a total of 80 stainless steel dies, with 20 in each group (cervical finish line width: 1.0 mm; taper degree: 6). CAD/CAM PMMA and Bis-acrylic resin were poured into the obtained left mandibular first molar silicone mold to cast temporary crowns. Their fracture resistances were then evaluated using an Instron device (speed: 1.0 mm/min), and the data were recorded.

Results: The lowest and highest fracture strength averages were found in the rounded shoulder preparation groups that used Bis-acrylic resin (1137.1 N) and CAD/CAM PMMA (1498.75 N). No significant differences were found between the chamfer preparation groups with CAD/CAM PMMA and Bis-acrylic resin ($p > 0.05$). However, the fracture resistances of Bis-acrylic resin and CAD/CAM PMMA in rounded shoulder preparations were significantly different ($p < 0.05$).

Conclusion: CAD/CAM PMMA temporary crowns are recommended for rounded shoulder preparations as they had the highest average fracture resistance when compared to other materials.

Keywords: Fracture Strength, Temporary Crown, CAD/CAM PMMA, Bis-Acrylic Resin,

***Corresponding Author:**

Tahir Karaman, Department of Prosthodontics, Faculty of Dentistry, Fırat University, Elazig, Turkey Tel.: +905375679559, Fax.:+904242378986, e-mail: tkaraman@firat.edu.tr

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Introduction

Temporary restorations are applied to prepared teeth until permanent restoration can be completed (1). Specifically, temporary crowns are used in a variety of applications, such as preserving pulp tissue, maintaining periodontal health, maintaining occlusal continuity and the positions of teeth, maintaining chewing functions, and improving the aesthetic of teeth (1-4). They should not adversely affect functions such as chewing and speaking.

Temporary crowns are built using various materials and methods (1). For example, prefabricated temporary crowns employ polycarbonate, cellulose acetate, aluminum, tin-silver, and stainless steel (3). However, individual temporary crowns are often made using polymethyl methacrylate (PMMA), poly-R-methacrylate, microfilled composite resin, and light-polymerized resin (1,2,5,6). Furthermore, temporary crowns can be constructed using direct (preparing the tooth in the patient's mouth) and the indirect (using the patient's measurements to build and restore a model) methods (1).

PMMA's strength, color stability, and simple restoration have contributed to its popularity. However, it may cause significant heat and pulp damage during the polymerization phase. This could result in polymerization shrinkage, leading to deformed restoration. As a result, alternative materials have been suggested, such as Bis-acrylic resin (7).

The use of technology in dentistry is becoming more widespread, and CAD/CAM (Computer-Aided Design and Computer-Aided Manufacturing) technology has led to its accelerated development (8,9). As a result, both temporary and permanent restoration can be performed (10). CAD/CAM technology can be used to construct temporary crowns, from materials such as PMMA and resin, which exhibit neither polymerization shrinkage nor heat generation (11-14). In general, all temporary crowns should have sufficient fracture resistance against chewing to have clinical success (15-16).

This study compares the fracture resistance of CAD/CAM PMMA and Bis-acrylic resin as temporary crown materials for left mandibular first molar.

Materials and Methods

To imitate prepared teeth, chamfer and rounded shoulder preparations were machined using 80 master model CNC devices (height: 6 mm; cervical diameter: 8.4 mm; taper degree: 60). These models were divided evenly between the CAD/CAM PMMA and Bis-acrylic resin temporary crowns (Table 1).

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Table 1: Temporary crown materials used in the study.

Brand Name	Manufacturer	Mixing Ratio	Composition
TEMPO-CAD	Ondent Tıbbi Malz./Izmir, Turkey		Polymethyl methacrylate
Acrytemp	Zhermack S.p.A./via Bovazecchino, Italy	4:1	Bisacrylic composite resin

The models were then scanned using the laboratory scanning device (7 Series, Dental Wings, Montreal, Canada). The left mandibular first molar were aligned using the scanned models and scraping was performed using the CAD PMMA (TEMPO-CAD Disc, Ondent, Turkey) block located in the scraping unit (D43, Yenadent, Turkey).

To maintain consistency with the left mandibular first molar produced using Bis-acrylic resin, a two-piece silicone mold was made using vinyl polysiloxane (Elite HD, Zhermack, Badia Polesine, Italy). Bis-acrylic resin was then poured into the silicone molds using the cartridge system and left to cure. The silicone molds were then carefully separated and the temporary crowns were removed. Temporary crowns with surface deformities were not included in the study.

The temporary crowns were fixed to the models using zinc oxide based temporary cement (Cavex Temporary Cement, Cavex, Holland) as specified by the manufacturer. A 10 N loading force was used and, after about 30 minutes, the cement hardened and the excess was removed without damaging the crowns. The models were soaked in deionized distilled water at 37 °C for 24 h and then placed in the Instron device (INSTRON 8801, INSTRON Ltd., England). To determine the fracture resistance, a speed of 1 mm/min (for a total of 900 mm) was applied to the central fossa of the temporary crowns. The data obtained were recorded and evaluated statistically.

Statistical Analysis

All analyses were performed using the IBM SPSS Statistics Version 22.0 statistical software package. Continuous variables were summarized using mean and standard deviation. The normal distribution was confirmed using the Shapiro–Wilk test. A Student’s t-test was used to compare the continuous variables between the two groups. For all tests, the statistical significance was considered to be $p \leq 0.05$.

Results

The fracture strength of CAD/CAM PMMA and Bis-acrylic resin temporary crowns on models with chamfer and rounded shoulder preparations are shown in Tables 2 and 3.

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Table 2: The fracture strength of the provisional crowns made with the chamfer preparation

Material	n	Mean	SD	SEM
CAD-CAM PMMA	20	1267.5	236.637	52.914
Bis-Acrylic	20	1385.6	680.856	152.244

Table 3: The fracture strengths of temporary crowns applied to models with rounded shoulder preparation.

Material	n	Mean	SD	SEM
CAD-CAM PMMA	20	1498.75	249.272	55.739
Bis-Acrylic	20	1137.1	449.825	100.584

The fracture strengths of temporary crowns applied to models with chamfer preparation is presented in Table 2. The average fracture resistance of the CAD/CAM PMMA crowns applied to models with chamfer preparation was 1267.5 N. The average fracture strength of the Bis-acrylic resin crowns for these same models was 1385.6 N. There was no significant difference between the CAD/CAM PMMA and Bis-acrylic resin crowns in terms of mean fracture resistance for this group ($p > 0.05$).

The fracture strengths of temporary crowns applied to models with rounded shoulder preparation is presented in Table 3. The temporary crowns with the lowest averages consisted of CAD/CAM PMMA and Bis-acrylic resin crowns applied to models with rounded shoulder preparation, with values of 1498.75 N and 1137.1 N, respectively. There was a significant difference between the CAD/CAM PMMA and Bis-acrylic resin temporary crowns in terms of the mean fracture resistance for this group ($p < 0.05$).

When comparing the fracture strength of CAD/CAM PMMA crowns used on models with chamfer and rounded shoulder preparations, a significant

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difference was found ($p < 0.05$). The fracture resistance of CAD-CAM PMMA crowns applied to models with rounded shoulder preparation was higher than those applied to models with chamfer preparations.

When comparing the fracture strength of Bis-acrylic resin crowns used on models with chamfer and rounded shoulder preparations, no significant difference was found ($p > 0.05$). However, the average tensile strength of Bis-acrylic crowns applied to models with chamfer preparations was higher than those applied to models with rounded shoulder preparations.

Discussion

This study evaluated the fracture strength of temporary restoration materials in dentistry. Since it was an *in vitro* study, it does not completely mimic the behavior of oral tissues.

Previous research has examined the durability of temporary crown materials formed in rectangular (17, 18), disc-shaped (19), and natural tooth structures (20,21). The temporary crowns used in this study mimicked M1's anatomical structure.

Moreover, some studies have investigated the fracture resistance of temporary crowns without cementation (21), while others have applied temporary cement at different loading forces (14,22,23,24). This study adhered temporary crowns to the models using temporary cement at a force of 10 N to imitate clinical conditions as much as possible.

Keyf et al. examined the marginal adaptation of temporary crowns with different types of preparations and reported that there was no statistically significant difference between type and marginal fit (25). Karaokutan et al. evaluated the fracture strength of temporary crowns applied to maxillary second premolars with round shoulder preparation and found that composite resin crowns had a higher fracture strength (1392.1 ± 344.11 N) than CAD-CAM PMMA crowns (1106 ± 134.65 N) (21). This study found that CAD/CAM PMMA crowns applied to models with rounded shoulder preparation had the highest average fracture strength (1498.75 N).

Temporary crowns were expected to have sufficient resistance to bite force. Calderon et al. examined the maximum bite force of bruxist and non-bruxist patients and found that males had a higher average bite force (262.8–999.3 N; mean: 587.2 N) than females (108.9–834.6 N; mean: 424.2 N) (26). Our study found that rounded shoulder finish line type CAD/CAM PMMA crowns had a higher average fracture strength than Bis-acrylic resin crowns.

Conclusion

This *in vitro* study examined the fracture strength of CAD/CAM PMMA and Bis-acrylic resin temporary crowns. CAD/CAM PMMA crowns used for models with rounded shoulder preparation had the highest average fracture strength

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average (1498.75 N), while Bis-acrylic resin crowns used for models with rounded shoulder preparation had the lowest average fracture strength (1137.1 N). The use of CAD/CAM PMMA temporary crowns with rounded shoulder preparation is recommended and has high clinical expectations.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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