

Fracture Resistance of Various Temporary Crown Materials

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Abstract

Aim: The aim of this study was to evaluate the fracture resistance of various provisional crown materials using an *in vitro* model test system.

Methods and Materials: In the present study polycarbonate crowns, prefabricated by the manufacturer (3M Polycarbonate Crown), and the temporary crowns, fabricated in the dental laboratory environment, were fabricated using bis-acryl composite (Protemp II), autopolymerizing PMMA resin (BISICO Temp S), and heat-polymerized PMMA resin (Major C&B-V Dentine). All temporary crowns were stored in distilled water for 24 hours at room temperature prior to testing. The crowns were seated on metal dies, fabricated from Cr-Co alloy (AZ Dental, Konstanz, Germany), and then tested using the indenter of a Hounsfield testing machine (Hounsfield Tensometer, Hounsfield Test Equipment, Raydon, England). The tip of the indenter was located at a position one-third of the way down the inciso-palatine surface at 135°. The data were statistically analyzed for differences using one-way analysis of variance (ANOVA) and the Tukey HSD test ($P < .05$). Additionally, the types of failure obtained from the fracture load test were examined using 10X magnification with a stereo microscope.

Results: The results of the present study indicated polycarbonate crowns were significantly different from the BISICO Temp S, Protemp II, and Major C&B-V Dentine ($P < .05$) groups.

Conclusion: This *in vitro* study shows polycarbonate crowns may be preferable to the other types of temporary crowns used in this study.

Keywords: Temporary crown materials, temporary crowns, fracture toughness

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Introduction

Temporary crowns are fabricated to protect prepared teeth and adjacent gingiva until permanent crowns can be placed. These restorations allow the clinician and patient a chance to determine the appropriate esthetic, phonetic, and functional occlusal features for each individual situation as well as reduce teeth mobility, protect the pulp, and maintain the positions of the prepared teeth.^{1,2} Temporary restorations can be either fabricated in the clinic or laboratory environment by using polymethylmethacrylate (PMMA) resin and bis-acryl composite resin materials or by using a pre-fabricated polycarbonate form. The preparation of temporary crowns using different fabrication methods with autopolymerizing and heat-polymerized PMMA resins and bis-acryl composite resins has been described by various researchers, and the fracture strength of these materials has been tested.^{2,21}

Rose¹⁰ defined the fabrication technique for temporary crowns in the mouth using autopolymerizing acrylic resin and copper bands. Gegauff and Pryor²² polymerized PMMA resin, epimin resin, bis-acryl composite resin, and polyethylmethacrylate (PEMA) resin materials in both open air and under pressure then compared their fracture strengths. Their study determined that epimin resin material exhibited the highest fracture strength followed by PMMA resins. They found polymerization under pressure did not have any significant effect on fracture strength but did reduce porosity. In another study the flexural strengths of specimens prepared with PMMA, PEMA, bis-acryl composite, and epimin resin materials were compared; PEMA resin was determined to have the highest value followed by PMMA resin.²³

Diaz-Arnold et al.²⁴ evaluated the microhardness of the samples prepared with bis-acryl composite resin and PMMA resin material after they were kept in artificial saliva at 37°C for 14 days following the preparation. They found the microhardness of many materials decreases over time, and all samples prepared with bis-acryl composite resin had a higher microhardness than PMMA resin samples.

Another approach to fabricating temporary crowns is the use of prefabricated polycarbonate



forms which have a natural appearance.^{25,26} Polycarbonate crowns are practical and esthetic, but they have some disadvantages such as low resistance to corrosion and offer low retentive qualities.²⁶ A few studies have been done to examine the resistance of these crowns against pressure. Cetiner et al.²⁶ compared the fracture strengths of polycarbonate crowns and dual-cured temporary crowns fabricated with materials based on microfilled composite resin. They reported the strength of the polycarbonate crown was significantly higher. Yilmaz²⁷ observed polycarbonate crowns failed in a manner of plastic deformation rather than fracturing when a load was applied. He postulated this may be due to the structure of polycarbonate crown material.

The purpose of this study was to compare the fracture resistance of autopolymerizing and heat-polymerized acrylic resin, bis-acryl composite resin, and polycarbonate prefabricated temporary crowns using an *in vitro* test system. A load was applied using an angle similar to what occurs in a clinical situation using a typical interincisal angle between the upper and lower central incisors to simulate the natural stress on the restorations.

Methods and Materials

Four provisional crown types were selected for use in this study. One type was polycarbonate crown prefabricated by a manufacturer (3M, St. Paul, MN, USA), and the others were prepared with materials based on PMMA resin [BISICO Temp S (Bisico, Bielefeld, Germany) and Major C&B-V Dentine (Major Prodotti, Dentari, Mincelieri, Italy)] as well as bis-acryl composite resin [Protemp II (3M ESPE AG Dental Products, Seefeld, Germany)] in a laboratory environment. The materials used are shown in Table 1.

Wax specimens were prepared by pouring melted inlay wax (Cerin, Spofa Dental, Praha, Czech Republic) into polycarbonate crowns. Castings

Table 1. The forces (Newton (N)) needed to fracture of specimens and standard deviations.

Brand	Manufacturer	Material Type	Batch Number
3M Polycarbonate Crown	3M Dental Products, St. Paul, MN, USA	Preformed polycarbonate crown	C-300
BISICO Temp S	BISICO, Postfach, Bielefeld, Germany	Autopolymerizing acrylic resin	03110
Protemp II	3M ESPE AG Dental Products, Seefeld, Germany	Autopolymerizing bis-acryl composite resin	04600
Major C&B-V Dentine	Major Prodotti. Dentari, Mincelleri, Italy	Heat-polymerized acrylic resin	B3100

were made to simulate the prepared teeth by using a Cr-Co alloy (AZ Dental, Konstanz, Germany). The Cr-Co alloy dies were prepared by embedding them 1 mm lower than the shoulder level of the preparation forming a right angle to a autopolymerizing acrylic resin (Fortex, Self-Curing Orthodontic Resin 2000, Durham, England) retained in a copper band (Hahnenkratt, Königsbach-Stein, Germany).

Four groups of specimens were prepared with ten samples of each material in each group as follows:

- Group I specimens were composed of polycarbonate crowns directly adapted onto dies.
- Group II specimens were prepared with BISICO Temp S, an autopolymerizing acrylic resin, in accordance with the manufacturer's instructions. A special model was used as a matrix for the preparation of the samples in this group. The matrix was produced by taking an impression with elastomeric impression materials [(Speedex Putty ve Speedex Light Body (Coltene AG Altstatten, Switzerland)]. The polycarbonate crowns were positioned on three metal dies embedded into plasteron a level with the shoulder (Figure1).
- Group III specimens were prepared using Protemp-II temporary composite resin material polymerized chemically in a similar way to Group II and in accordance with the manufacturer's instructions.
- Group IV specimens were prepared using Major C&B-V Dentine heat-polymerized acrylic resin material. The crown samples were prepared with pink modeling wax on the cast-impresion complex employed in Groups II and III and then flasked. Major C&B-V Dentine acrylic resin dough was prepared in accor-

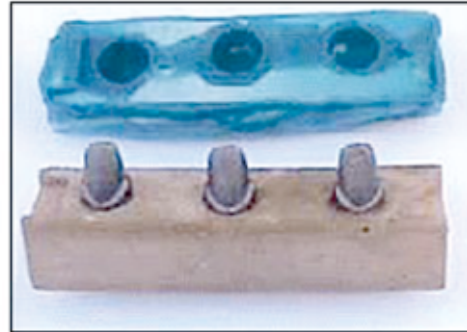


Figure 1. Model and impression used as matrix for preparation of specimens.

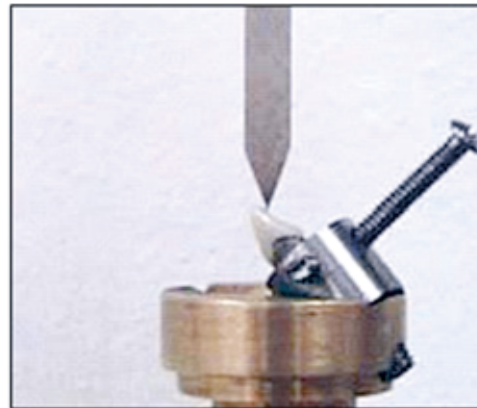


Figure 2. Sample adapted to the test machine.

dance with the manufacturer's instructions and was then processed and polymerized through boiling. The prepared crowns were adapted on metal dies for testing. The necessary surface corrections were made to simulate an adequate clinical fit.

All prepared crown specimens were kept in distilled water at room temperature for 24 hours. They were tested by being subjected to an increasing load applied at a position one-third of the way down the inciso-palatine surface by means of special tips placed on a Hounsfield

mechanical test machine (Hounsfield Tensometer, Hounsfield Test Equipment, Raydon, England). A cross-head speed of 0.5 inch/min was used at an angle of 135° to the palatal surface (Figure 2). The data obtained were recorded in Newtons (N).

The types of failures of the crown specimens due to loading were examined using a stereomicroscope (Nikon SMZ-U multi-point-sensor system, Yokohama, Kanagawa, Japan) and 10X magnification. The data obtained were analyzed with SPSS for Windows, V11 software (SPSS Inc., Chicago, IL, USA) using one-way analysis of variance (ANOVA) and the Tukey HSD multiple range test (P<.05).

Results

Specimens prepared with temporary restorative materials in various structures used to temporarily cover prepared teeth were tested for their fracture resistance using an arbitrary interincisal angle between the upper and lower incisors. The results of the fracture load test are shown in Table 2. The highest average fracture resistance value was found in the polycarbonate crown (585.0 N) group. The lowest average fracture resistance value observed was found in the Major C&B-V Dentine (253.3 N) group.

The ANOVA revealed a statistically significant difference (P<.000) between groups. The Tukey HSD multiple range test was used to test for

differences between groups, and results are shown in Table 3. The difference between the polycarbonate crown group and all other materials tested was significant at P<.05, but there was no significant difference between Bisico Temp S and Protemp II materials. Failure types of temporary crowns subjected to the fracture load test were photographed using a stereomicroscope, and representative specimens can be seen in Figures 3 to 6.

Failure occurred in the form of plastic deformation and cracks in all polycarbonate crowns, whereas fracture in the form of fragmentation occurred in the crowns prepared with other materials.

Discussion

In the present study an *in vitro* test method was employed to carry out a fracture failure test of groups of samples by applying a compressive load on the one-third inciso-palatal surface of crowns at an interincisal angle of 135°. Polycarbonate crowns demonstrated the highest values (585.0 ± 42.778 N), and they exhibited a statistically significant difference when they were compared to the other groups (P<.05).

Cetiner et al.²⁶ tested temporary crowns *in vitro* and found the brand “Interberg” (William’s Dental Service, Taby, Sweden) had a higher strength than the temporary crowns prepared with microfilled composite resin material. Furthermore,

Table 2. The forces in Newtons (N) needed to fracture of specimens and the standard deviations.

Materials	Values (N)	± SD
Polycarbonate Crown	585.0	42.778
BISICO Temp S	448.3	46.655
Protemp II	380.0	35.214
Major C&B-V Dentine	253.3	52.026

Table 3. Results of Tukey HSD multiple range test.

Materials	Number of samples (n)	Means (N)
Polycarbonate Crown	10	585.0 ^a
BISICO Temp S	10	448.3 ^b
Protemp II	10	380.0 ^b
Major C&B-V Dentine	10	253.3 ^c

Note: There is no difference between groups with the same letter exponents.



Figure 3. Fracture failure observed in a polycarbonate crown applied fracture load test. Both plastic deformation and cracks were seen in the crown (10X magnification).



Figure 4. Fracture failure observed in a sample prepared with BISICO Temp S (10X magnification).



Figure 5. Fracture failure observed in a sample prepared with Protemp II (10X magnification).

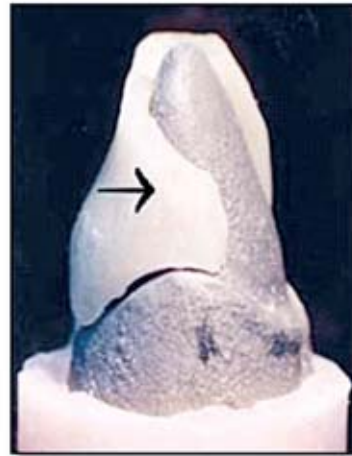


Figure 6. Fracture failure observed in a sample prepared with Major C&B-V Dentine (10X magnification).

Yilmaz²⁷ found the strength of 3M polycarbonate crowns cemented on extracted primary teeth against a load applied to the interincisal angle in primary dentition was 474.167 N. This value is lower than the results of the present study. Yilmaz²⁷ used cut primary teeth as a specimen and tested the sample crowns by applying the load at a different angle and at a different point as opposed to the die methods used in the present study. The lower values may have resulted from the different method used for testing. In the present study, failure in the manner of plastic deformation on all polycarbonate crowns was observed (Figure 3). Yilmaz²⁷ observed similar

failures to those of this study in polycarbonate crowns. It can postulated this type of failure on polycarbonate crowns may have resulted from the glass-fiber in the structure of these crowns.²⁷

The oldest and the most common material used for the fabrication of temporary crowns is PMMA resin. In this study, BISICO Temp S, an autopolymerizing acrylic resin, and Major C&B-V Dentine, a heat-polymerized PMMA resin, were used. The results showed the autopolymerizing acrylic resin BISICO Temp S had a lower strength value than polycarbonate crowns. However, it showed the highest strength value among

other materials (448.3 ± 46.655 N). The heat-polymerized Major C&B-V Dentine, in contrast to our expectations, demonstrated a lower strength value than autopolymerizing acrylic resin (253.3 ± 52.026 N), and a statistically significant difference between them was observed ($P < .05$). One of the possible reasons for this situation may be the addition of glycol dimethacrylate to this material which provides cross-linking of the autopolymerizing acrylic resin liquid which we used in our study. As a result, higher values may have been obtained. However, the types of molecular linking of acrylic resin materials used in this study were not specified by their manufacturers. Another reason may be the strong plasticizer effect of residual monomer within the autopolymerizing acrylic resin. As a result, fractures occurred after the load was applied to the heat-polymerized acrylic resins in which a rigid structure is formed. Plastic deformation might occur first in autopolymerizing acrylic resins, and immediately thereafter failures in the form of fractures might have occurred in this structure. Additionally, this situation might be explained by determining the failure moment and not the moment of conversion to plastic deformation by the test device (Figures 5 and 6).

Recently, bis-acryl composites called “temporary composites” have been made commercially available and used as temporary crown and bridge material. In this study, Protemp II was used as the bis-acryl composite material. The results obtained after the load was applied to the Protemp II samples revealed a strength value significantly lower than polycarbonate crowns ($P < .05$); while they were numerically lower than the autopolymerizing PMMA resins, there was no significant difference between them ($P > .05$).

In contrast to the results of the present study, Diaz-Arnold et al.²⁴ state bis-acryl composites are more dense, and as a result, they demonstrated high transverse strength. However, Gegauff and Pryor²² stated PMMA resins showed higher strength values than bis-acryl composites. These results are consistent with the results of the present study.

When the failure types of crowns prepared with bis-acryl composite resin were compared with autopolymerizing and heat-cured PMMA resins, fracture types were observed to be in fewer pieces (Figure 4). Garner and Kotwal²⁸ investigated the average bite force for incisor teeth in persons between the ages of 10 and 25 and determined the maximum bite force for incisor teeth was 249 N and the average bite force was 155 N. When these findings are considered, the materials used in the present study demonstrated higher fracture resistance values than the average bite force.



Conclusion

Four types of temporary crown materials were tested *in vitro* in this study in order to determine the forces needed to fracture them. Polycarbonate crowns demonstrated the highest values and exhibited a statistically significant difference when compared with the other materials. BISICO Temp S demonstrated a lower value than polycarbonate crown material. However, it showed the highest value among the other materials tested. It should be noted this *in vitro* model has not been correlated with the clinical performance of these materials. Further controlled clinical trials are necessary to establish the importance of these data in relationship to clinical decisions regarding selection of materials for temporary crowns.

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