EVALUATING THE FRACTURE STRENGTH OF THREE DIFFERENT PROVISIONAL CROWNS

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Abstract

With the advent of new provisional crown materials, it has become imperative to evaluate their strength in order to select the appropriate crown material. This study examined the fracture resistance of three different provisional materials. To simulate oral conditions, the specimens were fabricated in brass molds, ensuring their similarity to premolars. The 33 fabricated specimens were divided into three groups (n=11) and stored at 37°C in artificial saliva (1.6 g $NaHCO_3$, 0.4 g $NaH_2PO_4 \cdot H_2O$, and 0.1 g $CaCl_2 \cdot H_2O$ per L H_2O). After conditioning, the fracture resistance was assessed using a universal testing machine (Testometric). Analysis of variance and Student's t-test were used for statistical analysis. The study concluded that the mechanical properties of provisional restorative materials are strongly influenced by their proportions of methyl methacrylate and bisphenol A glycidyl methacrylate.

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Introduction

Today, provisional crowns represent an important stage in fixed prosthesis treatment. Provisional prostheses are intended to protect the support teeth and restore function, phonation, esthetic appearance, and tissue compatibility during preparations for permanent restoration[1,2]. Provisional crown and bridge materials must be esthetically acceptable, must resist functional loads, and must possess adequate stability and biocompatibility. The resistance of a material assumes greater importance in the presence of parafunctional habits or if a long-term prosthesis is planned, especially if the patient needs to wear a provisional crown for a long time[1-3].

Various resins are used to fabricate provisional restorations; these include ethyl methacrylate, methyl methacrylate, and bis-acryl composites. Ethyl methacrylate has poor esthetics, despite being resistant to abrasion. Methyl methacrylate and bis-acryl composites are superior to ethyl methacrylate in both respects[4].

Provisional crown materials have been evaluated in terms of marginal aperture, polymerization shrinkage, color stability, temperature increase, and fracture resistance. The specimens used for resistance tests were generally prepared as disks, rods, or bars, which were subjected to three-point bending tests[5]. However, researchers have reported the need to test specimens with close resemblance to crown morphology, emphasizing that data obtained otherwise might be unrealistic[6,7].

This study analyzed the fracture resistance of different provisional crown materials *in vitro* using specimens prepared in premolar form.

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Material and Methods

Three provisional crown materials were selected for use (Table 1). Thirty brass dies with the dimensions of premolars were prepared for crown fabrication. The conic specimens had a crown height of 7 mm, a crown width of 8 mm, and a planned shoulder width of 1.5 mm in all directions. The labial, palatinal, and axial surfaces were inclined at a 6°-angle of approach.

Brand Name	Manufacturing Company	Material	Lot no.
Temdent Classic	Schütz Dental Group, Germany	Methylmethacrylate	2004002716
Tempofit Duomix	Detax, Etlingen, Germany	Bis-acrylic composite	F65617
Protemp III	3M-ESPE, Seefeld, Germany	Bis-acrylic composite	239246

Table 1. Provisional crown materials tested.

To obtain provisional crowns with the same dimensions and shape, a brass mold was used (Figure 2). A socket to hold the die was prepared in the brass mold. With the die inserted in the mold, a negative space, 9.5 mm in diameter and 8.5 mm deep, resulted.

The 30 dies were divided into three separate (totally 33 samples) groups, and three different provisional crown materials were used (Figure 1). The provisional crown materials were prepared according to the manufacturers' recommendations and were poured into the space formed inside the mold. The mold was vibrated to eliminate air, and excess material was removed. Polymerization proceeded to completion under a fixed pressure of 2.5 kg. Subsequently, excess material was removed using stone grinders. The specimens were matched to a crucible, and abraded surfaces were rubbed with 600-grit sandpaper to obtain smooth surfaces. The crown-shaped provisional crown specimens were cemented (Proviscell; Septodont, France) onto the brass molds following the manufacturer's instructions. Before fracture testing, the specimens were kept for 14 days at 37°C in artificial saliva (1 L double-distilled H_2O, 1.6 g $NaHCO_3$, 0.4 g $NaH_2PO_4{\cdot}H_2O$, and 0.1 g $CaCl_2$).

The prepared specimens were placed in a measurement device (Testometric; Testometric, UK) for fracture testing. The ends of the fracturing apparatus were hemispherical, and the base of the crown was marked so that the fracture test could be performed at the same point on each crown. During the test, the force was loaded at an approach speed of 0.5 mm/min. The data were recorded digitally (Figure 3) and were analyzed using the SPSS 10 statistical program. As the groups were independent and each contained fewer than 30 specimens, Student's *t*-test was used for statistical analysis.

Figure 1. Brass dies with premolar dimensions were prepared with the aim of crown fabrication.

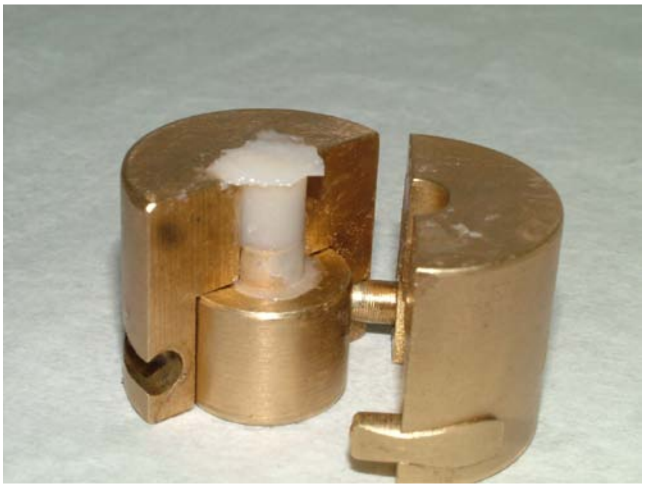

Figure 1. The use of brass mold, in order to obtain provisional crowns with all the same dimensions and shape.

Results

The fracture resistances of the three different provisional crown materials are presented in Figure 4. The provisional crown material Temdent had the highest fracture resistance (581.9 N), followed by Tempofit duomix (403.7 N), and Protemp III (304 N). The difference between groups was significant ($p < 0.05$) based on one-way analysis of variance (ANOVA). The results of two-way Student's *t*-tests are presented in (Table 2).

Figure3. The specimens prepared were consecutively placed in a test measurement device (Testometric, Testometric Co., UK) for fracture testing.

Group	N	Mean (N)	Std. Deviation	Std. Error Mean
Temdent Classic	11	581,9091	136,7388	41,2283
Tempofit duomix	11	403,7273	46,9534	14,1570
Protemp III	11	304,0000	51,1859	15,4331

Table 2. Statistical results (p<0.005).

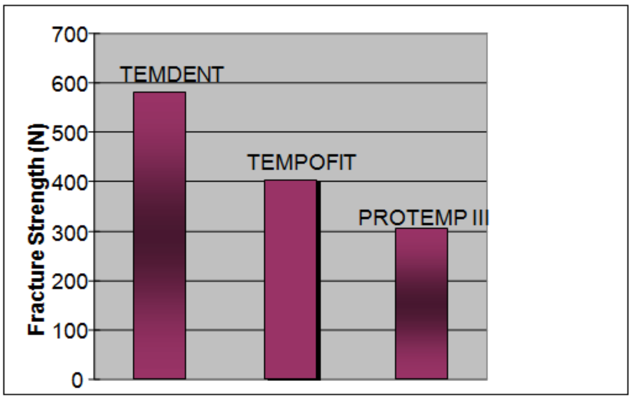

Figure 4. Fracture resistances among the groups.

Discussion

The fracture resistances of three different provisional crown materials were examined in the laboratory[8,9]. We used brass molds to produce standard specimens of provisional prostheses prepared in a crown shape.

In addition to the preparation of standard specimens and the establishment of appropriate storage conditions, the loading speed selected during testing is also thought to influence fracture resistance. A variety of loading speeds have been used in studies of the fracture resistance of provisional restorations. Resistance has been shown to increase with increased loading speed, owing to the lack of time for cracks to grow. Thus, fast loading speeds can produce faulty data, and the loading speed should be relatively slow[10-12]. In light of these studies, we used a loading speed of 0.5 mm/min and applied axial (vertical) loading, considering the intraoral forces on the premolar crown-shaped specimens.

The average values for resistance to fracture obtained in our study were 581.9 N for Temdent (methyl methacrylate), 403.7 N for Tempofit (bis-acryl composite), and 304 N for Protemp (bis-acryl composite). The differences between groups were significant ($p < 0.05$), and we believe that these differences arise from differences in the chemical structures of the materials[9,13-15].

Provisional crowns are fabricated from materials containing bisphenol A glycidyl methacrylate (BIS-GMA) and methyl methacrylate, with each material exhibiting unique physical and chemical properties. When combined in different provisional materials, the monomers display differences in properties such as exothermic heat of polymerization and shrinkage resistance[4,9].

Haselton *et al*. examined the shrinkage resistance of various provisional crown materials, obtaining the lowest shrinkage resistance with methyl methacrylate and the highest with bis-acryl[13]. Osman *et al*. reported that provisional crown material containing methyl methacrylate had higher resistance to shrinkage compared with composite-based provisional crown material[8].

In contrast, after testing methyl methacrylate and composite-based provisional crown materials, Wang *et al*. reported no significant difference between them[11]. Ireland *et al*. investigated the shrinkage resistance of four provisional restoration materials and reported that bis-acryl had the highest shrinkage resistance[14].

In contrast to our study, those studies applied flexural testing. It is thought that methyl methacrylate is not resistant to flexural stress because it consists of linear, mono-functional, low-molecular-weight molecules, whereas materials containing BIS-GMA comprise multi-directional, flexible chains that provide high flexural resistance[8,12,13].

With advanced monomer systems using bis-acryl, it is necessary to establish a balance between high mechanical resistance and limited elasticity. Methyl methacrylate increases fracture resistance, while BIS-GMA provides flexural resistance. Studies have shown that materials containing both are able tolerate brief deformation and resist high stress13,14,16.

In our study of provisional crown materials with different structural properties, Temdent, which contains only methyl methacrylate, was the most resistant to pressure-induced fracture. Protemp, which contains BIS-GMA, was the least resistant, probably because BIS-GMA, although resistant to flexural forces, is not resistant to pressure forces. Researchers obtained similar findings in a study of three different resins and bis-acryl materials[9,12,13].

Materials containing methyl methacrylate have serious disadvantages such as high heat emission during polymerization, shrinkage, and high residual monomer levels. Compared with the mono-functional acrylate, bis-acryl materials have the advantage of relatively low heat emission during polymerization[8,9,12,13,16].

Conclusions

We found only a few studies of provisional crown restorations in our review of the literature. Our study evaluated the resistance properties of three materials. However, a material with good mechanical properties may have other less desirable features (*e.g.*, polishing, difficult manipulation, and esthetic appearance). As no provisional crown material can meet all requirements under all circumstances, clinicians must evaluate several characteristics such as esthetic appearance, ease of application, and cost when selecting products. The requirements will differ for a single provisional crown implanted in the anterior region, emphasizing the importance of selecting a provisional crown material appropriate to each patient based on the particular features the material.

Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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