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Original article

Flexural Strength of Composite Based Provisional Crown Materials

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Abstract

Introduction: One of the important aspects of provisional restorations, especially in case of long-span edentulous situations, short-height pontics, extended treatment time and in patients with para-functional habits is their flexural strength. Maintaining the integrity of the provisional restorations throughout the course of treatments is highly valuable and important to have a predictable outcome. ***Objectives:*** To evaluate and compare the flexural strength of composite based provisional materials. ***Materials and Methods: Materials:*** Group 1, conventional bisacryl composite material (Protemp 4, 3M). Group 2, Computer Assisted Designing - Computer Assisted Milling (CAD-CAM) composite provisional material (CAD Temp). ***Method:*** Twenty identical specimens sized 25×2×2-mm were prepared from each material.
A standard three-point bending test was conducted on the specimens with a universal testing machine at a 0.5 mm/min crosshead speed, and the flexural strength values were calculated (MPa) for each specimen. The flexural strength data were statistically analyzed using T-Test. ***Results:*** The measured mean flexural strength values (MPa) were as follow: group1 = 99.38 in comparison to group 2 = 92.06. There were statistically significant differences among the flexural strengths of tested materials ($P < 0.05$), The conventional group had significantly higher flexural strength than the CAD/CAM group ($p < 0.05$). ***Conclusion:*** Within the limitation of this study, the bisacryl composite resin (Protemp 4) provisional material has superior flexural strength than CAD/CAM composite material. Although many authors recommended the use of CAD/CAM provisional materials, this study prove that the material composition is as important as the material method of fabrication.

Keywords: ***CAD/CAM, Flexural Strength, Provisional Composite***

Introduction

Provisional restorations should process many criterion such as protecting vital pulpal tissues, maintaining positional stability, occlusal function, provide esthetics and color stability for the prepared teeth and most importantly having a high strength and hardness properties [1]. They can also be used in correcting irregular occlusal planes, restoring vertical dimensions. In many instances, provisional restorations are used for a long period to assess the results of periodontal and endodontic therapies [3]. Provisional restoration is providing an important tool for the psychological management of patients until the final restorations are cemented [2].

The provisional prosthesis is subjected to compressive, tensile and shear forces during mastication in the oral cavity, understanding the mechanical properties of the provisional restorative materials is helpful to determine whether the restoration will be able to survive repeated functional forces over prolonged periods of time [4].

One of the important aspects of provisional restorations, especially in case of long-span edentulous situations, short-height pontics, extended treatment time and in patients with para-functional habits is their flexural strength [5].

Materials used to fabricate provisional restorations can be classified as acrylics or resin composites. Provisional crows can be either prefabricated or custom made [6].

In accordance to their composition, the provisional restorative materials are categorized to 4 groups; Polymethyl Methacrylate, Polyethyl Methacrylate, microfilled bisphenol A-glycidyl dimethacrylate (Bis-GMA) composite resin, and urethane dimethacrylate (light-polymerizing resins) [7].

Auto polymerizing polymethyl methacrylate (PMMA) have been used to fabricate provisional restorations since the 1930s and usually available as powder (polymer) and liquid (monomer) [6]. Regardless its cost-effectiveness in dentistry, PMMA has clinical drawbacks like low color stability and mechanical properties that depend on handling conditions, which lead to inclusion of voids within restorations [8].

In the 1990's, bis-acryl composite resins were first introduced into the dental market [9], containing inorganic fillers have been used extensively as provisional materials [10]. The color stability of bis-acryl composite resins is improved, and the polymerization shrinkage are reduced compared with PMMA. In addition, bis-acryl composite resins are commercially available with automix syringe, increasing costs but with easy handling and reducing air entrapment [11]. Bis-acryl composite resins can maintain long-term stability in the oral environment because of enhanced mechanical properties [10] compared with PPMA, such as higher wear resistance and esthetics, lower marginal misfit, and improved repair potential [11].

Although digital dentistry, including Computer-Assisted Designing and Computer-Assisted Milling (CAD-CAM) was first introduced in dentistry in the 1970s. CAD-CAM now become a well-accepted technology in most modern dental laboratories . Subtractive technologies have emerged during the recent years for provisional restorations fabricated by milling the resin-based blanks which are cured under optimal conditions. Not only they do exhibit increased mechanical strength and prevent porosity within the restorations but also have reduced the chairside time [12].

An example of CAD/CAM technology applied in dentistry is crowns made of composite resins. CAD/CAM composite resin crowns are produced by compressing and heat-curing composite resins into blocks, and then fabricating these into crowns using the CAD/CAM technology [13]. The CAD/CAM technology enables the reproduction of crowns with complex morphologies even from different materials [14].

The purpose of the current study is to compare the flexural strength between conventional bisacryl composite resin and CAD/CAM composite resin provisional materials.

Material & method

Materials: Group 1, conventional bisacryl composite material (Protemp 4, 3M) (**figure 1**). Group 2, Computer Assisted Designing-Computer Assisted Milling (CADCAM) composite provisional material(CAD Temp) (**figure 2**).

Method: Twenty identical specimens sized 25×2×2-mm (ADA-ANSI specification #27) [16], were prepared from each material.A teflon mold [25 × 2× 2mm] was used to fabricate bis-acrylate composite resin blocks (**figure 3**).

Figure 1: CAD Temp

Figure 2: Protemp 4

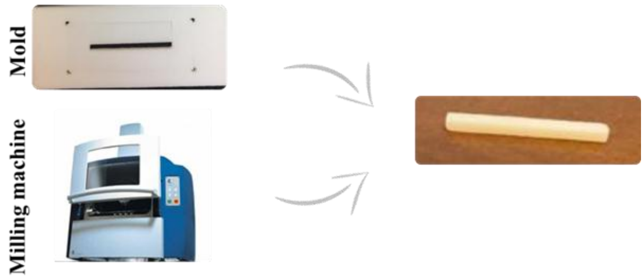

Figure 3

Bis-acrylate composite resin was directly injected into teflon molds from a cartridge After the composite resin blocks had been polymerized for 15 minutes at room temperature, and then the specimens was removed from the mold. Bis-acrylate composite resin specimens were stored in a room temprature for 24 hours to complete their polymerization. VITA CAD-Temp products was prefabricated from composite resin blocks.

The specimens were polished by a 400-grit silicon carbide abrasive paper with running water. After polishing, all specimens were evaluated for their dimensions with a digital caliper. All specimens were examined for air bubbles. Defective specimens were excluded from the study. Each group consisted of 10 specimens.

A standard three-point bending test was conducted on the specimens with a universal testing machine at a 0.5 mm/min crosshead speed (**figure 4**), The universal testing machine was calibrated annually. Specimens were inserted on the sample holder apparatus (**figure 5**), after inserting, the load was applied at the middle of the specimens. The loading was continued till fracture occurred and the breaking load was noted. These breaking load values were converted to flexural strength (σ) using the following formula:

$\sigma = 3Fd/2wh2$, where, F is the maximum load exerted on the specimen (N), d is the distance between support spans (mm), w is the width at the center of the specimen (mm), and h is the height at the center of the specimen (mm). The flexural strength data were statistically analyzed using T-Test.

Figure 4: Instron Machine

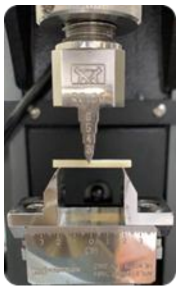

Figure 5: 3-Point bending Test

Results

The flexural strength were recorded for each specimen. This raw data of the values were compiled on MS-Excel sheet to get the mean and SD. Then the data were statistically analyzed. The mean and SDs were determined for the two groups: conventional bisacryl composite material and (CAD-CAM) composite.

Flexural strength values ranged between 92 ± 6 and 99.3 ± 7.2 MPa. According to T-Test, material type affects the FS. (**Table 1**) There were significant differences among the FS of tested materials ($P < 0.05$), The conventional group had significantly higher flexural strength than the CAD/CAM group ($p < 0.05$). (**Figure 6**) T-Test revealed that both material influenced the flexural strength ($p < 0.05$) and that interaction occurred between the 2 variables ($p < 0.05$).

Table 1: Flexural strength mean values (MPa) and standard deviations for each group are presented in the table below:

Group	N	Mean (MPa)	Standard Deviation
Group 1: CAD/CAM	10	92.06700	6.003040
Group 2: Conventional	10	99.38316	7.286590

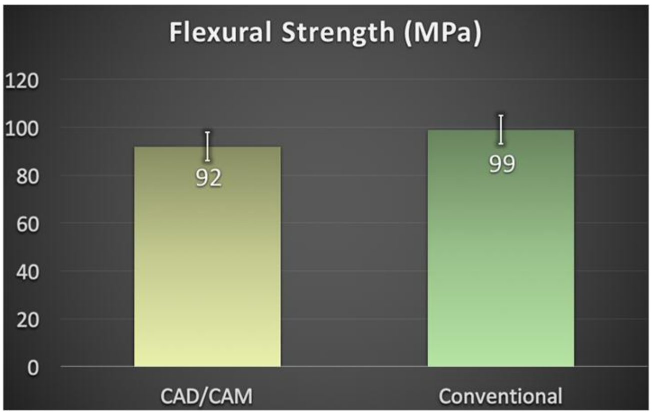

Figure 6: Flexural strength mean values (MPa) and standard deviations for each group are presented in the figure

Discussion

Provisional FDPs are essential components of fixed prosthodontic treatment. Provisional restorations must satisfy biologic, esthetic, and mechanical requirements such as resistance to functional loads, resistance to removal forces, and maintenance of abutment alignment [17].

There are a number of materials available for provisional FDPs. The majority of these materials can fit into two main categories based on their composition: (1) Methyl methacrylate resins and (2) composite resins [18]. There is not a single material or method that has been found to be useful in all clinical situations, so it is important to know the properties of the material in order to know the limitations and indications/contraindications for their clinical use for extended periods of time. One such property is flexural strength [16]. Higher FS is essential for achieving clinical success with interim prostheses.

If the provisional FDPs are expected to function for extended periods of time or when additional therapy is required before completion of definitive treatment. during the prosthetic phase of dental implants, while evaluation of a change in vertical dimension, for orthodontic stabilization, in case of assessing the results of periodontal and endodontic therapies and in cases of bruxism, the improved mechanical properties play an important role [19].

In case of prosthetic phase of dental implants, longer treatment times and the necessity for addressing tissue contour issues before definitive treatment dictate techniques that would provide more durability [20]. reviewed the CAD\CAM systems used in dentistry and proposed its use for provisionalization. Manufacturing under industrial conditions permits high-density polymer-based restorations which offer favorable mechanical behavior and biocompatibility [21]. In addition, according to Rocca et al. it is over the last two decades that the CAD\CAM technique has evolved. Hardware has become less expensive, software is easier to use, fabrication is faster, and the milled restorations are more accurate in terms of anatomic form, marginal fit, and occlusal/interproximal contacts. Thus, the CC approach is becoming more popular for the fabrication of tooth-colored indirect restorations [23].

VITA CAD-Temp is an acrylate polymer that contains vinyl groups, that is, 2 carbon atoms double bonded to each other and attached to the carbonyl carbon. Acrylates easily form polymers because the double bonds are very reactive and exhibit lower strengths. In the present study, VITA-CAD Temp demonstrated the lower flexural strength.

The shape of the restoration can be simulated for the fabrication of the definitive prosthesis. The customized provisional restoration could be scanned after a prolonged clinical acceptance and digitally transferred into a definitive restoration. This facilitates the precise transfer of the contour of the provisional into a definitive restoration and in turn will result in higher predictability for the definitive restorations [22].

Thus, keeping in mind the long-term FDPs, this study was done to evaluate the effect of manufacturing technique and material of provisional FDPs on mechanical properties like flexural strength, which were fabricated using: Conventional method using bisacryl composite material (Protemp 4), (CAD-CAM) composite provisional material. Aside from the different chemical composition of the materials, the filler is a significant contributor to flexural strength.

Ireland et al18 found that bis- acryl composite resins exhibit significantly higher mechanical strength within 24 hours of fabrication and that these values decrease greatly over time [20].

The results of this study indicated that the mean flexural strength values of Conventional method using bisacryl composite material group (99.38 MPa) were higher FS than the (CAD-CAM) composite provisional material (92.06 MPa), the results of this study demonstrated significant differences in the flexural strength of the tested materials ($P < 0.05$), According to the results of the present study, higher FS for bisacryl composite material might be due to Bis-acrylate composite resins have an organic matrix and inorganic filler particles in addition to multifunctional monomers (Bis-GMA and TEGDMA), and have cross-linked polymer structure between monomer chains, [33,34] This cross-linked polymer structure and inorganic fillers of bis-acrylate composite resin have been shown to increase the strength and durability of the material [22,33]. The null hypothesis of the study was rejected because tested materials had different FS values.

One of the limitations of the present study was that the in vitro nature of the experiments limited the simulation of different intraoral conditions. The specimens were also tested under consistent static load. Although FS test has been reported as a useful predictor of clinical performance,1 long-term clinical studies are required for the selection of optimal interim resin material [27].

Conclusion

Within the limitation of this study, the Bisacryl composite resin has superior flexural strength than CAD/CAM provisional composite material.

Although many manufacturers recommended the use of CAD/CAM provisional materials for their higher strength properties, this study suggested that the composition of the material is important as the method of fabrication.

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