Original Article

In Vitro Comparison of Flexural Strength of Temporary Restorative Materials

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Abstract

Background: *Strength parameter greatly influences the selection of the temporary dental crown materials. Strength is the stress that is necessary to cause fracture or a specified amount of plastic deformation. One method to evaluate the ability to withstand the functional loads is to evaluate the material's flexural strength, which is the strength of a material under a static load. A provisional restoration should be well fabricated in order to withstand stresses produced during mastication, prevent displacement and be removable so that it may be reused prior to delivery of the definitive prosthesis. A provisional material should be dimensionally stable, easy to contour and polish, adequate strength and abrasion resistance to be maintained the entire time required. When strength is of primary concern, it should be known which material provide more resilient restoration.*

Objectives: *The objective of the study was to compare the flexural strength among the commonly used temporary dental crown materials.*

Materials and methods: *In this study 22 samples were taken from light polymerized composite resin and heat polymerized acrylic resin temporary dental crown materials. From each material 11 samples were made as bar specimens which were prepared according to ADA specification no. 12 (65mm×10mm×3mm).The specimens were stored in artificial saliva for 10 days. The specimens were subjected for testing under universal testing machine which uses 3 point bending test for flexural strength. Then data was analyzed using paired-t test and one-way analysis of variance (ANOVA).*

Results: *The flexural strength of group A was 94.25±17.67 MPa, group B was 90.99±12.97MPa.This differences of flexural strength was statistically significant (P value 1.0).*

Conclusion: *It is concluded that light polymerized composite resin has the highest flexural strength compared to heat polymerized acrylic resin temporary dental crown materials.*

Key Words: *Flexural strength, Temporary restorative materials.*

Introduction

Temporary dental crowns on prepared abutment for fixed partial dentures (FPDs) areessential prerequisite in the field of fixed prosthodontics treatment. Temporary restorations must satisfy biologic and esthetic needs as well as mechanical requirements such as resistance to functional loads, resistance to removal forces and maintenance of abutment alignment.[1]

The purpose of the temporary restorations is to protect the dentin-pulp complex in the prepared teeth; to evaluate and preserve the periodontal tissues; prevent movement of the abutment teeth; help to stabilize the teeth with mobility; provide the patient with adequate esthetics and phonetics, and promote comfort during masticatory function.[2] The longer the period of time of using these temporary teeth, the greater the durability required. Temporary restorations with inadequate mechanical resistance and marginal adaptation may lead to caries, tooth sensitivity, gingival inflammation, movement of the prepared tooth, in addition to constant fractures under occlusal loads. Failure of temporary restorations resulting from fractures or loss of marginal integrity, leads to great clinical inconvenience, capable of compromising the success of the definitive prosthesis.[3]

Temporary restorations must protect the prepared tooth surface from various thermal and chemical stimuli present in the oral environment to prevent sensitivity and further irritation to the pulp. It must have good marginal fit, proper contour, a smooth surface for good periodontal health and easy to manipulate. To serve these functions a temporary restorative material must be strong enough to resist masticatory forces, especially in long span restorations or areas of heavy occlusal stress.[1]

Mechanically, Interim restorations must be able to withstand the functional forces of mastication without fracture or displacement. This becomes especially important in long term provisional restorations, long span fixed dental prosthesis and also during the restorative phase of implant reconstructive procedures. These cases require provisional materials and techniques that provide greater flexural strength and extended durability. Flexural strength is a measurement of the strength of a bar (supported at each end) under a static load. The flexural strength test is a combination of tensile and compressive strength tests and includes elements of proportional limit and elastic modulus measurements. The flexural strengths of interim restorative materials vary within material, chemical classes and between chemical classes of materials.[4]

Provisional materials have been divided into the following categories based on how they are converted from plastic to solid-elastic masses: (1) chemically activated autopolymerising acrylic resins; (2) heat activated acrylic resins; (3) light-activated acrylic resins; (4) "dual" light and chemically

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activated acrylic resins; and others (alloys).
One of the main applications of polymeric biomaterials in dentistry is the fabrication of provisional restorations. The oldest group of polymer-based direct temporary materials is PMMA resins. The popularity of this material increased so fast that, by 1946, 95% of the denture bases were fabricated with it.[5]

The biggest improvement of polymer base restorative materials came in the late 1950s and early 1960s. First, Dr. Rafael Bowen started fundamental work on the use of high molecular weight epoxy and methacrylate derivates that incorporated inorganic filler loading. The introduction of a high molecular weight, difunctional monomer (known as bis-GMA or Bowen's Resin) greatly facilitated the commercial development of materials containing inorganic fillers: composites.[6]

Heat-polymerized PMMA is supplied as a powder and liquid. The powder contains a copolymer of PMMA in the form of spheres or beads to which the benzoyl peroxide initiator is added. Coloring pigments and fibers often are added for improved esthetics. The liquid is methyl methacrylate (MMA) monomer with a cross-linking agent usually ethylene glycol dimethacrylate to provide craze resistance (Hill, 1981). A small amount of inhibitor (hydroquinone) is added to avoid premature polymerization and enhance shelf life.

Light-activated resin in dentistry is not new. Over 25 years ago ultraviolet light-activated fissure sealants and composite tooth-filling materials were introduced. The two main components of composite filling materials are the resin phase and the reinforcing filler. The filler is bonded chemically to the matrix by a third minor phase, an interfacial coupling agent. The resin matrix in the majority of composites is typically based on bisphenol a diglycidyl dimethacrylate (Bis-GMA) or urethane dimethacrylate (UDMA) (Virendra, 2004). These are high molecular weight liquid monomers of high viscosity. Blending of filler particles with a material of this consistency is difficult and manufacturers normally have to use a fluid diluent monomer such as triethylene glycol dimethacrylate (TEGDMA) to reduce the viscosity (Me Cabe, 1998).
Tanoue et al. (2005) described the use of a light-polymerized composite for a patient hypersensitive to PMMA, polysulfone, and polycarbonate. A urethane-dimethacrylate composite (Axis; GC Corp, Tokyo, Japan) was used as an alternative to fabricate the denture and the custom artificial teeth (Newmetacolor Infis; Sun Medical Co Ltd, Moriyama, Japan). They reported that the allergic symptoms disappeared from the patient's mucous membrane immediately after placing the new prosthesis and without recurrence of the hypersensitivity after two and a half years.Strength is the stress that is necessary to cause fracture or a specific amount of plastic deformation. One method to evaluate the ability to withstand the functional loads is to evaluate the material's flexural strength, also known as transverse strength, which is the strength of a material under a static load. This measurement is a combination of tensile and compressive strength tests with elements of proportional limit and elastic measurements.[7]

Presently, there is no provisional material that meets optimal requirements for all situations.[8] Clinicians typically choose a product based on ease of manipulation, cost, and esthetics. When strength is of primary concern, it would be useful to know which materials provide a more resilient provisional restoration.[9] The purpose of this investigation was to measure the flexural strength of contemporary provisional crown and FPD materials.

Researchers have been directed towards developing techniques and materials that improve the quality and that allow the fabrication of provisional restorations of greater durability, quality and resistance. Thus, the aim of this study was to evaluate the flexural strength of heat activated acrylic resin and light activated composite resin.

Materials and Methods
This prospective comparative experimental in vitro study was carried out in the Department of Prosthodontics, faculty of dentistry, BSMMU, Dhaka, Bangladesh, and Department of Pilot Plant & Process Development Centre (PP & PDC), BCSIR, Dhaka-1205, Bangladesh.

Sample of the study
Custom made bar specimens measured in Length- 65mm, Width- 10mm, Thickness- 3mm made from Light polymerized composite resin, and Heat polymerized acrylic resin were used as the sample of the study. Total 22 bar-specimens were taken as the sample of the study.Sample was prepared as per required standard for the study, according to ADA specification no.12 (65mm x 10mm x 3mm).The specimens were divided into 2 groups: Group A Eleven (11)bar specimensmade using light polymerized composite resin and Group B Eleven (11) bar specimensmade using heat polymerized acrylic resin.
The specimens were immersed in artificial saliva, and stored for 10 days. After 10 days the specimens were taken out, washed and air dried. The specimens were subjected for testing under universal testing machine which uses 3 point bending test for flexural strength.

Flexural strength measurement procedure
Total 22 samples of two different type of temporary dental crown materials were tested by 3 point flexural strength test machine in the laboratory of the Department of Pilot Plant and Process Development Centre (PP & PDC). BCSIR, Dhaka, Bangladesh.The samples were mounted on the designated part of Hounsfield Universal Testing MachineBrand: Hounsfield, Model no: H10KS, Made in : England. The load was applied on the center of the samples. The maximum load before

fracture was measured. Then the flexural strength of the samples were calculated using the standard formula.

FLEXURAL STRENGTH = 3FL / 2BH2
Where F = force / load required to break the samples, L = distance between the supports, B = width of the specimen, H= thickness of specimen.

The flexural strength were measured by QMAT software in computer by giving width and thickness of the samples.Where Test speed-2mm/minute, Load-500Newton, Supports span-40 mm.

Data was collected from P.C operated universal testing machine, and recorded in predesigned data collection sheet on the basis of specific parameter of the study. All collected data were analyzed by using the statistical program of social science, version 20 (SPSS Inc, Chicago, USA). Statistical analysis was carried out using unpaired-t test and one-way analysis of variance (ANOVA). Level of statistical significance was taken as P value <0.05.

Results

The mean flexural strength was 94.25±17.67 MPa with ranged from 49.47 to 107.30 MPa in group A. In group B, the mean flexural strength was 90.99±12.97 MPa with ranged from 74.0 to 112.90 MPa.
The mean difference of flexural strength between Group A and Group B was not statistically significant (p = 1.0) by ANOVA test.

Table-1: Comparison of flexural strength (MPa) among two groups (Group A and Group B)

Groups	N	Flexural strength (MPa) Mean±SD	P value
Group A	11	94.25±17.67 (49.47 – 107.30)	1.0^{ns}
Group B	11	90.99±12.97 (74.0 – 112.90)	

Data were expressed as Mean ± SD. Figures in parentheses indicate ranges. Statistical analysis were done by ANOVA and Bonferroni test. The test of significance was calculated and p values < 0.05 was accepted as level of significance.
Group A: Light polymerized composite resin
Group B: Heat polymerized acrylic resin
ns = Not significant

Figure 1 shows mean flexural strength of group A was 94.25 MPa. Box denoted that the maximum samples were within this range.

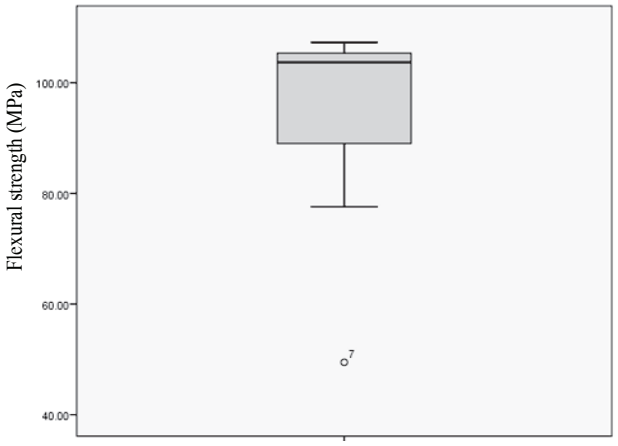

Figure -1: Shows mean flexural strength of group A was 94.25 MPa. Box denoted that the maximum samples were within this range.

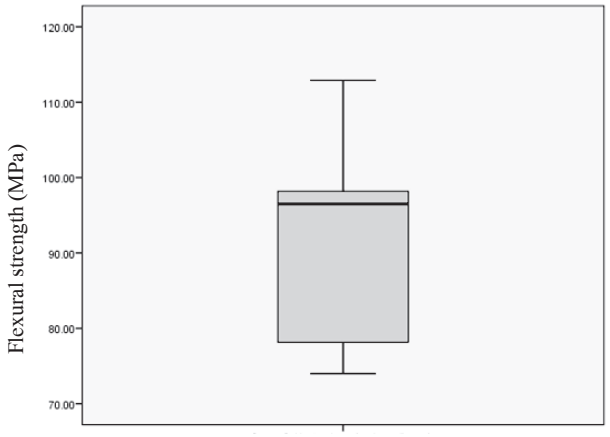

Figure 2 shows mean flexural strength of group B was 90.99 MPa.

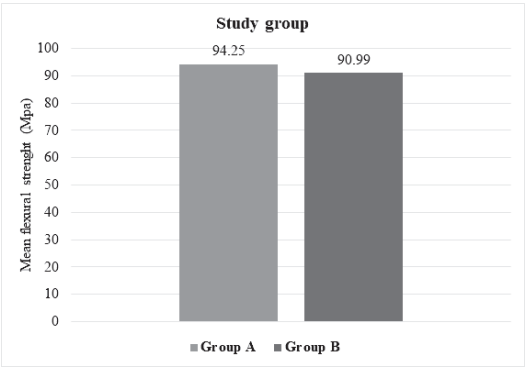

Figure-3: Mean flexural strength (MPa) in different groups.

Group A: Light polymerized composite resin
Group B: Heat polymerized acrylic resin

Figure 3 shows the flexural strength among two groups. In group A mean flexural strength was 94.25 MPa, in Group B mean flexural strength was 90.99 MPa.

Discussion

This study found that flexural strength of Light polymerized composite resin is (mean±sd) 94.25±17.67 and flexural strength of Heat polymerized acrylic resin is (mean±sd) 90.99±1.97 MPa. This difference of flexural strength is statistically non significant (P value1.0). The flexural strength of Light polymerized composite resin ranges from 49.47 to 107.30 MPa and Heat polymerized acrylic resin has flexural strength in between 74 and 112.90 MPa.The mean flexural strength of light polymerized composite resin is higher than heat polymerized acrylic resin but statistically nonsignificant. It is expected to construct provisional crowns with acceptable strength, occlusion, contour, marginal adaptation, and finish. The materials selected for this study have substantial advantages and disadvantages. In this study, two most commonly used provisional crown materials were evaluated for flexural strength. While flexural strength values obtained in a laboratory under static load may not reflect the conditions found in the oral environment, it is helpful to compare provisional materials tested in a controlled situation. Strength values may be a useful predictor of clinical performance. To simulate the oral condition the specimens fabricated from the two materials were immersed in artificial saliva for 10 days.

A study conducted on direct and indirect provisional materials and found that heat cure polymethyl methacrylate had higher flexural strength as compared to composite resin (Protemp II).[10] another study tested the modulus of rupture (flexural strength) of 4 provisional materials and found a light polymerized composite resin to have the highest flexural strength.[11] he findings of these study differ from the present study. Differences in flexural strength can be partly attributed to differences in chemical composition. Also, water storage may affect the mechanical properties of some resin.S. Dagar et al stored the specimen at room temperature for 24 hours and then to simulate the oral environment incubated the specimens in normal saline at 37°C for 5 days in an environmental machine. Ireland et al placed the specimens in deionized distilled water at 37°C. In the present study the specimens were stored in artificial saliva for 10 days to simulate the oral environment.

Research by Osman & Owen,[9] showed that 2 methyl methacrylate provisional materials had higher flexural strength than a composite material but the difference was non significant. No significant differences were found between methyl methacrylate and composite provisional materials tested by Wang et al in 1989.[8] The finding is similar to present study. In a study by Koumjian and Nimmo (1990),[12] who tested methyl methacrylate resins and bis-acryl resin, demonstrated statistically similar strength and resistance to fracture. In 7days dry storage group and 7 days of storage in water at 37°C group composite resin Triad showed higher strength than methyl methacrylate but the difference was non significant.This result is similar to present study.

It is important to note that 3-point flexural strength is only one of many behaviors in response to a particular stress and that strength is just one property of provisional crown materials. A strong material may possess other, less desirable characteristics such as tendency to stain, lack of polishability, difficult manipulation, or poor esthetics. A provisional crown placed on a single anterior tooth will have different clinical requirements than a long-span provisional fixed partial denture (FPD). The clinician must be aware of all attributes of various materials and choose the provisional material appropriate for each patient.

Conclusion

After completion of the study, it was found that there is no significant differences of flexural strength exists between Light polymerized composite resin and heat polymerized acrylic resin temporary dental crown materials used.

Recommendations

In the present study it was found that Light Polymerized Composite resin and heat activated acrylic resin had the similar flexural strength. Therefore, it can be recommended that this temporary dental crown materials may be advocated in clinical practice successfully.

Besides the flexural strength other mechanical properties like compressive strength, diametral tensile strength, shear strength and film thickness also play a vital role in evaluation the mechanical properties of temporary dental crown materials. To overcome the limitations of the present study further studies are recommended about the above mentioned parameters.

Illustrations

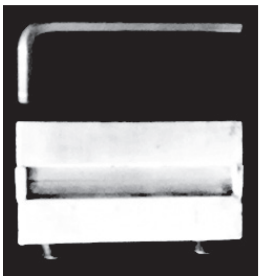

Fig 1. Metal mold with opener

Fig 2. Samples of Light polymerized composite resin

Fig 3.Samples of Heat polymerized acrylic resin

Fig 4. Light curing chamber (POLYLUX-P)

Fig 5. Artificial saliva

Fig 6. Digital Vernier Caliper

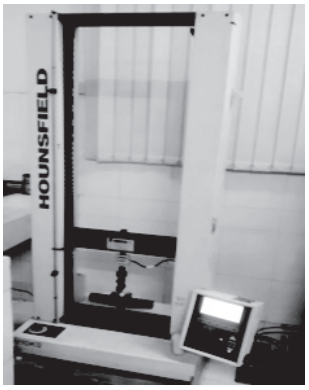

Fig 7. Universal Testing Machine

Fig 8. Computer Part of Universal Testing Machine

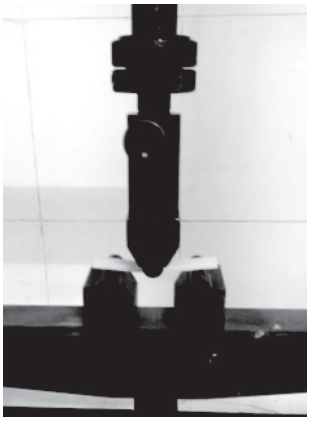

Fig 9. Sample placed on support of Universal Testing Machine

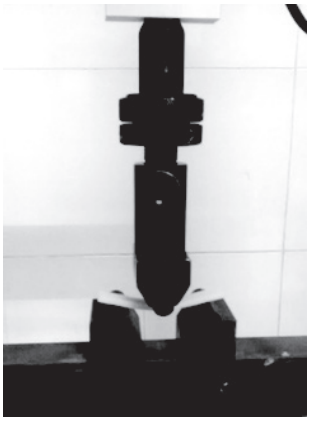

Fig 10. Flexibility of sample under load

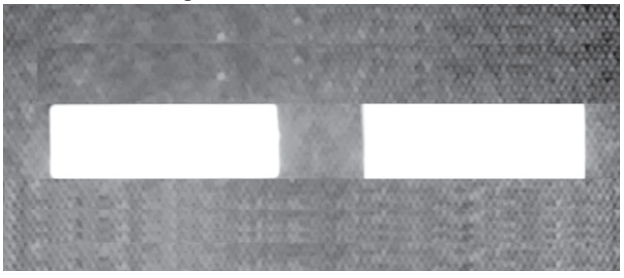

Fig. 11. Fractured part of sample

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