A Comparative Evaluation of Transverse Strength of Two Provisional Restorative Materials

Medical Science

KEYWORDS : Provisional restoration, acrylic resin, autopolymerizing, transverse strength, fracture toughness.

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ABSTRACT

Autopolymerizing acrylic resins have traditionally been selected for fabrication of provisional restoration. Heat polymerization of acrylic resin materials can be used when provisional restorative treatment will be required for extended periods of time or when additional strength is required. This investigation compared the transverse strength of two provisional restorative materials (Polymethylmethacrylate,Tempron and Bis-acryl composite resin, Protemp II) at different curing temperatures. Significant differences in transverse strength were found between groups as the curing temperatures increased.

Introduction

Provisional restorations must maintain their integrity throughout diagnostic and restorative phases, which in turn depends upon important physical properties of resins including polymerization shrinkage, wear resistance and strength. Strength of provisional materials is important, particularly when the patient must use provisional restoration for an extended period, or when a long span prosthesis is planned.

Several techniques have been proposed to increase the strength and the life of the provisional restorations and avoid fracture[1,2,3,4,5,6,]. Heat polymerization of acrylic resin results in materials that are denser, stronger, more wear resistant, more colour stable, and more resistant to fracture than the autopolymerizing acrylic resins. Both heat polymerized provisional restorations should last longer than autopolymerized restoration, but the expense and time required for indirect fabrication can make them less cost effective for routine use. Hence, autopolymerized provisional restorative materials are more commonly used. Three types of chemically polymerized materials are commercially available for provisional coverage of single and multiple units. These include ethyl methacrylates, methyl methacrylates, and bis - acryl composites. Historically, ethyl methacrylates have shown poor wear resistance and poor esthetics [7] .Thus the methyl methacrylates and bis -acryl resin composite materials possess a larger market share.

Previous studies have shown that heat enhances the chemical reaction between monomer and polymer components of the resin and produces more complete polymerization[8]. Heat activation is known to increase strength and fracture resistance of autopolymerizing resin. So placing the provisional resin restoration in hot water is an accepted procedure and is often recommended in the manufacturer's directions.

The present investigation compared the effects of curing environments and different water temperatures during polymerization on the transverse strength of two most commonly used autopolymerizing resins i.e. Polymethylmethacrylate and Bis-acryl composite resin.

Materials and method

A detachable brass mould was prepared with a base, a top, and a central part with a groove of specific dimension i.e. 65mm in length, 4mm in width and 4mm in thickness for standardization of the specimens (fig. 1). A total of 150 specimens were prepared and divided into two groups: - Group I (Protemp II) and Group II (Tempron). Each group was divided into five subgroups of 15 specimens each depending upon the curing temperatures i.e. IA and IIA- at 23^0 C (air), IB and IIB-at 30^0 C (water), IC and IIC-at 40^0 C (water), ID and IID -at 60^0 C (water), IE and IIE -at 80^0 C (water). Materials were proportioned and mixed according to manufacturer's instructions. The time schedule was designed to simulate the direct technique commonly used in fabricating provisional crowns, i.e. test specimens were left at room temperature for one minute after 10 seconds of mixing, assuming working time on the abutment tooth or teeth. It was then placed in air at 23° C or kept in water bath at 30° C, 40^0 C, 60^0 C, and 80^0C. Six minutes after commencement of mixing, i.e. approximately the time taken for completion of polymerization, the mould was removed from the water bath. The specimens were retrieved carefully from the mould and excess material was trimmed using a micromotor. The specimens were finished using a 400 grit abrasive paper held on a flat surface i.e. glass slab.

Mechanical properties of the test resins were assessed by 3 point flexural test with a Universal Testing Machine (Lloyds UK, LR 100K) (fig. 2.) at room temperature with a cross head speed of 0.05 inch/minute. Load values at the time of fracture were recorded.

Results

Transverse strength of each sample was calculated using the following equation:

$$Fs = 3.PI / 2bd^2$$

Where F_S - Transverse strength/Flexural strength; P - Peak load (maximum load in Newton); I - Span length (Effective length of specimen in meters, 0.05m); b - Width of specimen in meters, 0.004m; d-thickness of the test specimens in meters (0.004m).

The mean value of the transverse strength was maximum for group IIE & minimum for group IA. In order to collectively compare the means of the study groups in a single stroke, one way ANOVA (analysis of variance) test was used (tables 1 and 2). This indicated a highly significant difference in the transverse strength values for Protemp II and Tempron in all the study groups ($p< 0.01$).

Finally in order to make all possible valid comparisons to test the difference of any two means, the Student's t- test with Bonferroni's procedure was applied. Results from this test indicated a highly significant difference between group means and between Tempron and Protemp II at all the temperatures.

Discussion

The samples cured at 23^0C air showed the least transverse strength of both Tempron and Protemp II (37.78 Mpa and 45.85 Mpa respectively). This may be due to incomplete resin polymerization. Specimens cured in water at temperatures above the room temperature showed increase in the transverse strength with the highest transverse strength at 60^0C and 80^0C. The transverse strength of Tempron at 60^0 C in water (50.82 Mpa) was approximately 1.35 times more than the transverse strength of the specimens cured at room temperature in air (37.78 Mpa). Similarly the transverse strength of Protemp II at 60^0 C in water (66.03 Mpa) was approximately 1.44 times more than the transverse strength of the specimens cured at room temperature in air (45.85 Mpa). Increasing the temperature above 60^0 C of water showed further increase in the transverse strength. Samples cured at 80^0C water showed the greatest transverse strength of both Tempron(61.09 Mpa) and Protemp II (69.89 Mpa) which is 1.67 and 1.55 times more than the transverse strength of the specimens cured at room temperature in air respectively. This is because heat activates the chemical reaction between monomer and the polymer components and between 60^0 C to 80^0 C, it allows maximum utilization of monomer and nearly complete polymerization.

Studies by Ogawa T, Tanaka M, and Koyano K showed that the transverse strength increased with increase in water temperature[8]. Results of the present study were almost similar to the results obtained in their study.

After statistical analysis, it was also concluded that the transverse strength of Protemp II was greater than that of Tempron at different curing temperatures. The transverse strength of Protemp II at 23^0 C air (45.85 Mpa) is approximately 1.21 times more than the transverse strength of Tempron(37.78 Mpa) cured at same temperature in air. This can be explained by the fact that bis-acryl composite materials contain bifunctional acrylates which cross link to provide increased mechanical strength. In contrast the methylmethacrylate based materials do not have the benefit of cross linked bifunctional acrylates, consequently have a reduced mechanical strength.

Ireland et al (1998) tested the modulus of rupture (flexural strength) of four provisional materials- one bis-acryl and three PMMA based resins and found a bis-acryl (Providont DC) to have the highest flexural strength[9]. A similar study by Young HM et al (2001) compared the quality of crowns made from PMMA and bis-acryl composite based resins and found the latter to be superior in all respects . Similarly research by Haselton DR et al (2002) evaluated the flexural strength of eight bis -acryl composite based provisional materials and five PMMA based provisional resins[10]. They found that composite based provisional materials had higher flexural strength (123.6 Mpa) than PMMA based resins (56.2Mpa). Lang R et al (2003) tested the fracture toughness of two PMMA and four bis-acryl based provisional materials after thermocycling and occlusal loading and found that composite based Protemp 3 Garant had fracture resistance (1015 Newton) which was approximately twice as compared to PMMA based materials (484 Newton) . Similar results were found by Rosentritt M et al (2004) after testing flexural properties of four bis-acryl based and one PMMA based provisional materials after repair[11]. The highest values of flexural strength were shown by bis-acryl based resins (58.9 Mpa). The results of these studies are comparable to results of the present study which shows that the strength of Protemp II is approximately twice as compared to Tempron.

Bis-acryl composite materials are more expensive and more colour stable than PMMA, show low exothermic reaction on setting, good fit, and strength. They have a convenient cartridge based dispensing system which results in a more accurately proportioned and consistent mix. So composite resins are gaining popularity. But some clinicians find bis- acryl materials difficult to manipulate before setting because of difficult handling properties.

By using hot water during polymerization, the stiffness of the provisional restorations will be increased and the discrepancy between provisional and the final restorations felt by the patients during biting and chewing may be reduced.

Use of temperature above room temperature may result in poor marginal adaptation. This may be the limitation of this technique. From this point of view, some clinicians may be hesitant to place the resin in hot water during polymerization. In clinical situations, because polymerization shrinkage of the resin is unavoidable to some extent, it is usual to readjust and reline a provisional restoration a few times until an acceptable marginal fit is obtained.

Regardless of direct or indirect technique used in fabricating provisional restorations, use of hot water provides more economical method to obtain improved mechanical properties of provisional restorations, reduces the discrepancy between provisional and the final restoration felt by the patient during biting, reduces chair side time and also extends the clinical performance.

Legends

Fig. 1 Detachable brass mould for fabrication of specimens.

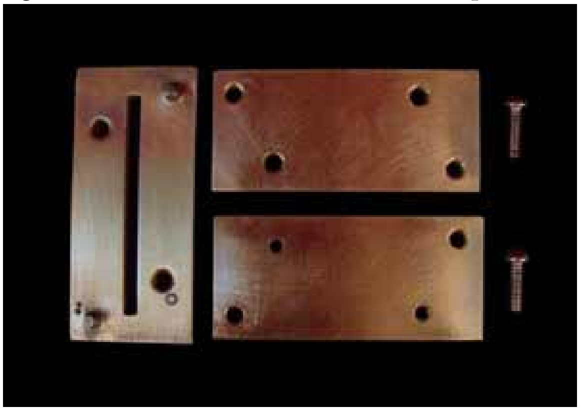

Fig. 2 Universal Testing Machine (Lloyds UK, LR 100K) with testing sample placed.

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Table 1

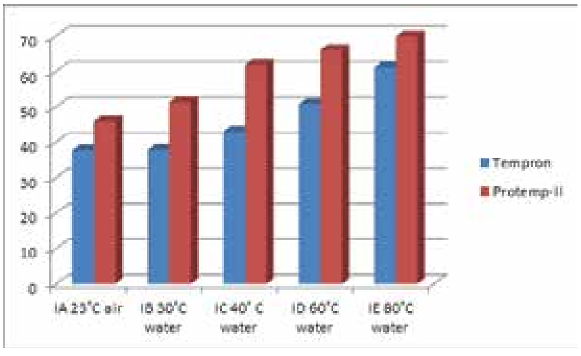
ONE WAY ANOVA TABLE FOR TRANSVERSE SRENGTH OF TEMPRON

Source of variation	Degrees of Freedom	Sum of squares	Mean squares	Variance Ratio(F)		
				Computed	Critical	
					At 5% level of significance	At 1% level of significance
Between Groups	4	5889.45	1472.36	390.63	2.502	3.66
Within Groups	70	263.84	3.76			
Total	74	6153.295				

Table 2

ONE WAY ANOVA TABLE FOR TRANSVERSE SRENGTH OF PROTEMP II

Source of variation	Degrees of Freedom	Sum of squares	Mean squares	Variance Ratio(F)		
				Computed	Critical	
					At 5% level of significance	At 1% level of significance
Between Groups	4	6117.79	1529.44	371.85	2.502	3.66
Within Groups	70	287.91	4.11			
Total	74	6405.70				



REFERENCE

1. Galindo D, Soltys JL, and Graser GN. Long term reinforced fixed provisional restorations. J Prosthet Dent 1998; 79 : 698-701. | 2. Larson WR, Dixon DL, Aquilino SA, and Clancy JMS. The effect of carbon graphite fiber reinforcement on the strength of provisional crown and fixed partial denture resins. J Prosthet Dent 1991; 66 : 816¬820. | 3. Ramos V, Runyon DA, and Christensen LC. The effect of plasma - treated polyethylene fiber on the fracture strength of polymethyl methacrylate. J Prosthet Dent 1996; 76 : 94-96. | 4. Youdelis RA and Faucher R. Provisional restorations: an integrated approach to periodontics and restorative dentistry. Dent Clin North Am 1980 ; 24 : 285-303. | 5. Binkley CJ and Irvin PT. Reinforced heat processed acrylic resin provisional restorations. J Prosthet Dent 1987 ; 57 : 689- 693. | 6. Hazelton LR and Brudvik JS. A new procedure to reinforce fixed provisional restorations. J Prosthet Dent 1995 ; 74 : 110-113. | 7. Gough M. A review of temporary crowns and bridges. Dent Update 1994 ; 21 : 203-7 | 8. Ogawa T, Tanaka M, and Koyano K. Effect of water temperature during polymerization on strength of autopolymerizing resin. J Prosthet Dent 2000; 84 : 222-224. | 9. Ireland MF, Dixon DL, Breeding LC and Ramp MH. In vitro mechanical property comparison of four resins used for fabrication of provisional fixed restorations. J Prosthet Dent 1998 Aug ; 80(2) : 158¬62. | 10. Haselton DR, Diaz-Arnold AM, and Vargas MA. Flexural strength of provisional crown and fixed partial denture resins. J Prosthet Dent 2002; 87 :225-228. | 11. Rosentritt M, Behr M, Lang R, and Handel G. Flexural properties of prosthetic provisional polymers. Eur J Prosthodont Restor Dent 2004; 12(2) : 75-79. |