Original Article

Effect of Curing Time on the Flexural Strength of Heat Cured Acrylic Resin

Dr. Kazi Ziaul Islam
BDS, MS
Asst. Professor
Dept. of Prosthodontics
University Dental College, Dhaka

Prof. Dr. Md. Ali Asgor Moral
BDS, DDS, PhD
Professor, Conservative Dentistry & Endodontics
Course Director, Faculty of Dentistry
Bangabandhu Sheikh Mujib Medical University, Dhaka

Dr. Md. Mahbubur Rahman
BDS, DDS, PhD
Assoc. Professor and Chairman
Dept. of Prosthodontics
Bangabandhu Sheikh Mujib Medical University, Dhaka

Correspondence to:
Dr. Kazi Ziaul Islam
BDS, MS
Asst. Professor
Dept. of Prosthodontics
University Dental College, Dhaka

Abstract :

Objectives: The aim of this study was to find out the proper curing time and flexural strength of heat cured acrylic resin cured in boiling water at 100°c with time difference and to compare the maximum flexural strength in optimum time.

Methods: In this study, 60 heat cured acrylic resin samples were processed with compression moulding technique at 100°c among which each of 20 samples were cured for 20, 40 and 60 minutes separately. Flexural strength of samples was determined by using 3 point bending test by universal testing machine. Data was analyzed using ANOVA test and unpaired t-test.

Results: The ANOVA result showed that there was no significant differences among the groups with respect to the mean flexural strength (P□0.05) and unpaired t-test also showed no significant differences among the groups. The mean flexural strength of acrylic resin cured at 100°c with compression moulding technique at 100°c at 20 minutes was 80.09±14.58 MPa, at 40 minutes was 79.71±13.1 MPa and at 60 minutes was 80.76±15.75 MPa.

Conclusion: The flexural strength of heat cured acrylic denture base resin cured at 100°c for different period of time (at 20, 40 & 60 minutes) have given no significant differences.

Key words: Curing time, flexural strength, heat cured acrylic resin.

Introduction :

Heat cured denture base materials are widely used in construction of a denture.[1-6] Various factors can affect the physical properties of acrylic resins.[1,2,9,] 11-13 Various methods to strengthen acrylic resin have been suggested.[1,2,5,7,8,10] The processing is usually done by conventional water bath technique.[3,7] So, to get the maximum strength of the material it is necessary to know the flexural strength of the material. In Bangladesh, almost all dental laboratories cure the acrylic resin denture base by the method of boiling water at the temperature of 100°c. But there is no study about the flexural strength of acrylic resin denture base cured at different period of time. This study was designed to evaluate and compare the flexural strength of heat cured acrylic denture base material cured in boiling water at 100°c for 20 minutes, 40 minutes and 60 minutes, respectively.

Methods:
On the basis of experimental design, metal specimens of dimension 65 × 12.7 × 2.5 mm were prepared by tool manufacturer.

Laboratory Technique of Sample for Preparations- 60 test samples of heat-cured acrylic resin were prepared in the 65 × 12.7×2.5 mm size by the help of experimental design among which 20 test samples were cured in boiling water at 100°c for 20 minutes, 20 test samples for 40 minutes, 20 test samples for 60 minutes.

Study procedures:
Preparation of Molds for Fabrication of intact Acrylic Patterns to prepare experimental sample- Dental stone was used to invest metal die. Before investing, the metal die was coated with a thin layer of petroleum jelly for easy removal of the die once the dental stone had been set. For easy removal of the metal die and to avoid fracture on the model, space was created on one side of the metal die in the first pour of dental stone. It is allowed easy retrieval of the metal die once the 2nd pour had set completely.[10]

Packing- The mix of polymethyl methacrylate and mono methyl methacrylate was taken in a mixing jar for polymerization according to the manufacturer's instruction. Each mold space was packed with acrylic resin once it reached the dough stage. Excess material was removed during trial of closure.

Processing- Flask was immersed in water where thermometer was set with the help of a clamp in the water bath with compression molding technique to measure the temperature of the water. Gradually the temperature raises and when reached at 100°c then the time was recorded accordingly by the help of stop watch. The flask was allowed to bench-cool before deflasking.

Retrievals of intact Acrylic Pattern- Following the bench cooling procedure, the flask was opened and acrylic pattern was carefully retrieved and the sample was stored in water containing bottle.

Trimming, Finishing and Polishing of the samples- Excess flash of the sample was trimmed by laboratory micro motor with burs, finished by sandpaper on the flat surface and polished with pumice powder. Last of all the finished and polished samples were measured with Vernier caliper to ensure that the samples were 65 × 12.7×2.5 mm.

Flexural Strength Measuring Procedure- Total 60 samples were fabricated and to evaluate the flexural strength of all the specimen of this study were tested by 3 point flexural strength test machine in the laboratory of the Department of Development Materials for Tools and Bio-Metallic Implant, BCSIR, Dhaka, Bangladesh. The samples were mounted on the designated part of Hounsfield Universal Testing Machine .The load was applied on the center of the samples. The maximum load before fracture was measured.

Results:
The in vitro study was intended to compare the flexural strength of heat cured denture base material cured in boiling water at 100oc for different period of time.

Table-1: Flexural strength (MPa) of different groups.

Groups sub groups (n=20)	Flexural strength (MPa) of different groups (Mean ± SD) Range(max.– min.)
Group A	80.1±14.6 (111.4-52.3)
Group B	79.7±13.1 (111.9-60.9)
Group C	80.8±15.7 (108.4-54.5)

Table-2: Statistical analysis of the results:

	P value
Group A vs Group B	0.932^{ns}
Group A vs Group C	0.889^{ns}
Group B vs Group C	0.820^{ns}

Group A- samples cured at 1000C for 20 minutes, Group B- samples cured at 1000C for 40 minutes, Group C- samples cured at 1000C for 60 minutes.
n- number of sample. Ns- not significant.

Results are shown in table-3 and figure-1 where the mean flexural strengths were 80.09±14.58 MPa that ranged from 52.3 to 114.4 MPa in group A. The mean flexural strength in group B was 79.71±13.1 MPa that ranged from 60.9 to 111.9 MPa. In group C, the mean flexural strength was 80.76±15.75 ranging from 54.5 from 108.4 MPa. The mean difference of flexural strength was not statistically significant (P>0.05, P=0.974) among three groups in ANOVA test.

Table-3: The flexural strength (MPa) among Group-A, Group-B and Group-C.

Groups	Mean SD	(Min-Max)	P value
Group-A	80.09±14.58	(52.3-114.4)	0.974^{ns}
Group-B	79.71±13.1	(60.9-111.9)	
Group-C	80.76±15.75	(54.5-108.4)	

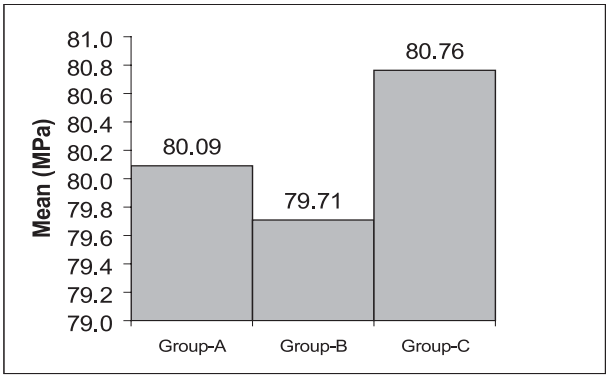
N.B.: Statistical analysis was done by ANOVA test.

Group A- Consist of 20 samples of heat cured acrylic resin cured in boiling water at 100^0c for 20 minutes.

Group B- Consist of 20 samples of heat cured acrylic resin cured in boiling water at 100^0C for 40 minutes.

Group C- Consist of 20 samples of heat cured acrylic resin cured in boiling water at 100^0c for 60 minutes.

Figure 1: Bar diagram showing the flexural strength among Group-A, Group-B and Group-C.



Discussion:

This study was designed to compare the flexural strength of heat cured acrylic resin cured in boiling water at 100^oc for different period of time to assess the maximum strength. Among which, 20 samples of heat cured acrylic resin were selected from the samples that were cured for 20 minutes, 40 minutes, 60 minutes respectively. Total 60 samples were selected. Samples were divided into three groups, each consists of 20 samples, which were placed in 3 point bending testing machine (HOUNSFIELD Universal Testing Machine) to get the flexural strength with the help of QMAT software in computer.

In table-1 & 3, results revealed that there was no significant difference in respect to the mean flexural strength of heat cured acrylic resin. The PMMA was not reinforced with other materials because reinforcement could increase the cost. PMMA itself has the advantage of low cost, ease of processing, easy repair and light weight which has an important socio-economic impact on patient satisfaction of underdeveloped and developing countries like Bangladesh.

Though different authors recommended various curing cycles for heat cured acrylic resins, the most common is to cure the packed resin at 74°C for 9 hours (longer cycle) than the shorter (74° for 2 hours followed by further 2 hours at 100° C).5-8 In fact, sometimes time constraint both in part of the dentist and the patient, the technician prefers even shorter curing time of curing cycles. In Bangladesh, most of the laboratories use the curing time of 20-40 mins at 100°C. With the advances Fernanda Faot et al. (2009)[4], found QC 20 and Impact 1500 acrylics cured for 20 minutes at 100°C had adequate flexural strengths tested by universal testing machine with a loading rate of 5mm/min. This justifies our selection observed in the proposed polymerization cycles to improve the laboratorial techniques. Vasconcellos et al.(2003)[14] conducted a study in which they compared an alternative polymerization cycle with that recommended by the manufacturer that includes a pause period.14 Their results showed that the transverse strength and surface microhardness were not affected by this alternative cycle and is in agreement with this study.

Conclusion:

With some limitations of the study, it can be concluded that there was no significant difference of flexural strength of heat cured acrylic resin cured in boiling water at 100^oc among the groups (cured for 20, 40 and 60 minutes). It may also suggest that increase time of curing at 100^oc might have very minor effect on the flexural strength of heat cured acrylic resin.

References :

1. Aydin C, Yilmaz H. Caglar A. Effect of glass fiber reinforcement on the flexural strength of different denture base resins. Quint Int 2002; 33(6):457-463.
2. Ellakwa AE, Morsy MA, El-Sheikh AM. Effect of aluminum oxide addition on the flexural strength and thermal diffusivity of heat-polymerized acrylic resin. J Prosthodont 2008;17(6):439-444.
3. Diaz ANM–Vargas AM, Kenneth LS, John EL, et al. Flexural and fatigue strengths of denture base resin. J Prosthet Dent 2008;100:47-51.
4. Fernandes AUR, Portugal A, Veloso LR, et al. Assessment of the flexural strength of two heat curing acrylic resins for artificial eyes. Braz Oral Res 2009;23(3):263-7.
5. Chitchumnog PBSC, Stafford GD. Comparison of three and four point flexural strength testing of denture base polymers. Dent Mater 1989;5(1):2.
6. Golbidi F, Jalali O. An Evaluation of the flexural properties of meliodeut and acropars heat polymerized acrylic resins. J Dent 2007;4(2):68.

7. Faot F, Panza LHV, Garcia RCMR, et al. Impact and flexural strength and fracture morphology of acrylic resins with impact modifiers. The Open Dent J 2009;3:137-143.
8. MCLinDent ILA, Yunus N, Abu-Hassan MI. (2008), Hardness, flexural strength and flexural modulus comparisons of three differently cured denture base systems. J Prosthodont 2008;17:545-549.
9. John Gangadhar SA, Shah I. Flexural strength of heat-polymerized polymethyl methacrylate denture resin reinforced with glass, aramid or nylon fibers, J Prosthet Dent. 2001;86(4):424-427.
10. Yadav NS, Elkawash H. Flexural strength of denture base resin reinforced with aluminum oxide and processed by different processing techniques. J Adv Dent Res 2011;2(1):33-36.
11. Vallittu PK. Flexural properties of acrylic resin polymers reinforced with unidirectional and woven glass fibers. J Prosthetic Dent 1999;81(3):318-326.
12. Kanie T, Fuji K, Arikawa H, et al. Flexural properties and impact strength of denture base polymer reinforced with woven glass fibers. Acad Dent Mat 2000;16:150-158.
13. Vallittu PK. Flexural properties of acrylic resin polymers reinforced with unidirectional and woven glass fibers. J Prosthet Dent 1999;81(3):318-326.
14. Vasconcelos L, Feitosa MAL, Del BelCury AA, et al. Avaliação de um cicloalternativo de polimerizaçãopara a resinaacrílica de microondas. RPG Rev Pós Grad 2003;10:108-11.