MDJ

Effect of Temperature on Surface Hardness of …. Vol. 19: No.1: 6 / 2023
DOI: https://doi.org/ 10.32828/mdj.v19i1.996

Effect of Temperature on Surface Hardness of Different Acrylic Materials utilized for space maintainer

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Abstract

Aim of the study: surface hardness is essential to avoid the indentation or scratch of space maintainer. Efforts have been made to improve the flexible and cold-cured acrylic's strength, by raising the processing temperature, unless the temperature has a chemical impact on the acrylic's qualities. The aim of this study was to study the effect of elevated temperature on the surface hardness of flexible and cold cured acrylic utilized as space maintainer appliance.

Methods: Sixty specimens were divided into three groups: flexible acrylic (Lingchen dental) , cold-cured acrylic (vertex) and (Paladur). Each group was subdivided into two subgroups,10 control and10 experimental . The control group for flexible acrylic was injected at 270 °C ,while for the two types of cold -cure, control groups, the specimens were processed at 37°C . The experimental group for flexible acrylic was injected at 290°C and for the two cold -cure types were processed at 70°C. Hardness was tested by Shore A device for flexible acrylic while for cold -cure specimens, shore D device was used.

Results : results showed no significant increase in the hardness of flexible acrylic the mean value of control group is 66.44±0.47 while for experimental group is 66.50±0.48. For vertex and Paladur cold- cured acrylic the surface hardness was increased significantly with increasing processing temperature. The mean values of vertex and Paladur control groups are around 86.14±0.39 and 88.33±0.39 respectively, while for experimental groups are 88.39±0.40 and 88.70±0.25

Conclusion : elevated processing temperature increased the surface hardness of both types of cold acrylic however; the hardness of flexible acrylic was not affected by temperature elevation.

Keywords: acrylic resin materials, hardness , processing temperature.

Introduction

Dental space maintainer is essential in cases of premature loss of primary dentition to prevent malposition, supra-eruption , impaction , or crowding of the developing permanent teeth (1). The space maintainer is subjected to force exerted on them when performing various function , therefore , it is important to have good mechanical properties (2).

Flexible acrylic is considered one of the most commonly used material for construction of appliance because due to its ideal properties. Moreover, cold acrylic is widely used for temporary crowns, space maintainers, relining procedures, and maxillofacial removable appliances (3-6) .

During World War II, chemically polymerizing acrylics were first employed in Germany for dental uses in order to differentiate from heat-polymerized acrylic resin, the "self polymerizing " or cold polymerizing or " auto polymerized " is called(7).

Due to greater residual monomer acting as a plasticizer and reducing acrylic resin hardness, cold-cured acrylic resin has less hardness than heat-cured acrylic resin (8, 9) . The high water absorption of flexible acrylic can decrease the surface hardness(10) When acrylic materials are cured at higher temperatures, the polymer network becomes harder, improving the materials' hardness (11, 12) .There are few studies that concerned the curing temperature and hardness of cold-cured acrylic. They (13, 14) concluded that increasing the processing temperature improved the hardness of cold-cured acrylic .Moreover limited studies are concerned with the increased injection temperature of flexible acrylic. They showed that there is no significant effect on hardness with increasing injection temperature. (15).Hardness was used to assess the degree of resin polymer conversion and was considered as an indirect method for assessing resin material polymerization (8, 13, 16, 17) .

Therefore the purpose of this study was to investigate the hardness of cold – cured resin and flexible acrylic that cured by elevated processing temperature.

Materials and Methods

Totally 60 rectangular shaped specimens with dimension (65mm x 10mm x 2.5mm) length, width, and thickness respectively were fabricated according to ADA Specification NO.12(1999) Figure (1). The specimens were distributed into three groups, according to the type of acrylic material ,used; flexible acrylic (Lingchen dental , china),cold -cured acrylic vertex (Dental bv, Netherland) and cold- cured acrylic Paladur (kulzer,GmbH, German). Each group was subdivided into two subgroups according to the processing temperature (10 specimens for control group and 10 specimens for experimental group)

Metal models with previously mentioned dimensions were embedded in stainless steel flask filled with dental stone to create a mold for packing of acrylic resin Figure(2). The control groups of cold-cured acrylic material , vertex and Paladur were cured by an ivomate curing device containing water under air pressure of 30 Pascal for 15 min at 37 ˚C (18). The experimental groups were processed at a higher temperature of 70̊C.

After processing ,figure (3A) , the specimens were finished with a tungsten carbide bur to remove all the irregularities, followed by polishing with pumice and wool brush finished with polishing soap on the dental lathe (England). Then all specimens were stored in distilled water at room temperature until used.

For flexible acrylic, the control group was fabricated according to the conventional method. The flexible material was injected into an electric furnace (thermo press injection machine,China) at 270˚ C according to the manufacturer's instructions. The experimental group was cured at a higher temperature of 290̊C. After cooling at room temperature ,the flask was opened Figure (3-B), and the prepared specimens were separated from the flasking mold carefully. The glossy surface was achieved by conventional finishing and polishing procedure.

The final measurements of all prepared specimens were obtained using vernier with an accuracy of 0.01mm (Louisware, China).

Measurement of surface hardness

The Shore D hardness tester with accuracy 0-100HD (Time group Inc ,China) was used to measure the surface hardness of the cold cure specimens according to ISO7619(ASTMD 2240) . The device was vertically placed over flat specimen which was supported by flat, rigid base Figure (4) . The distance between the specimen surface and the indenter of hardness tester is around 5to 12mm. The period of contact between the specimen and the indenter was 6 seconds. For each specimen, five hardness measurements were obtained from the scale reading and the mean of these values was computed (17).

The shore A device tester with accuracy of 0-100HA (Time group Inc ,China) was used to measure Lingchen flexible specimens hardnessFigure (5) . Each specimen was marked with three points then the Shore A durometer was utilized to measure the hardness. The reading was obtained from the scale reading representing hardness value. The three readings from each specimen were collected and the mean was calculated (19).

Statistical Methods: Data were analyzed using SPSS software version 21. The t- test was applied to determine whether there are any statistically significant differences between the means of two testing groups (control and experimental).

Results

The descriptive data of the hardness test mean, minimum, maximum, and standard deviation of cold cured acrylic groups are shown in Table (1) and Figure (6). At normal temperature, the Shore D surface hardness mean value of Vertex cold cure acrylic was (86.14±0.39) while Paladur cold cure acrylic was (88.33±0.39). At higher temperature, the mean hardness values were increased to (88.39±0.40) and (88.70±0.25) for Vertex and Paladur cold cure acrylic resin respectively. Table (2) shows that there were highly significant differences between (Vertex and Paladur) control and experimental groups.

For flexible acrylic tested groups, the descriptive data of the hardness test mean, minimum, maximum, and standard deviation are shown in Table (3) and Figure (7).The results demonstrated that the mean Shore A surface hardness was increased from (66.44±0.47) to (66.50±0.48) when the curing temperature raised from 270°C to 290°C.

However, there were no significant differences between the control and experimental groups of Lingchen flexible resin as shown in Table 4

Discussion

Since acrylic has excellent mechanical and physical qualities, it is a superior material for use in dentistry (20, 21). Cold cured acrylic exposes more volumetric alteration (due to water absorption) as well as porosity, residual monomer, and low impact strength over time. In comparison, flexible denture material was introduced in 1971 and has better mechanical properties in addition to a good aesthetic appearance when used in clinics(22) .

The hardness feature is a crucial characteristic and it mostly indicates the mechanical characteristics of the acrylic material (23, 24) . When residual monomer was decreased, the hardness property increased, and mechanical characteristics are influenced by residual monomer because of its plasticizing effect, Therefore, raising the processing temperature can remove any remaining monomer.(25).

The polymerization of paladur type cold-cured acrylic at elevated temperature of 70˚C showed maximum value of surface hardness. This indicates that, hardness can be improved as the processing temperatures increased. The high hardness value may be due to a higher complete polymerization reaction and more monomer to polymer conversion resulting in the creation of a harder polymer network with a high molecular weight and long polymer chain length (26, 27). Additionally, the low amount of water sorption is another likely explanation for the highly significant increase in hardness in groups polymerized at high temperatures, and vice versa. The high amount of water sorption may be responsible for the highly significant reduction in hardness in control groups. The hardness resistance decreases more quickly in materials with high water sorption. The results of the cold cure acrylic are agreed with Al- Naimi (28) who evaluated the surface hardness of cold cure acrylic that polymerized in water at different temperature from 20˚C up to 100˚C. The study reported that the high values of surface hardness are showed in specimens that polymerized in water at 60 ˚C, 70˚C and 80˚C

Moreover, the results agreed with Rashid AA(13) who concluded that increase polymerization temperature of cold cure acrylic lead to improvement of surface hardness. . The hardness of cold cure acrylic that polymerized at elevated processing temperature of 40 ˚C, 60 ˚C and 80 ˚C higher than that polymerized at conventional temperature.

For flexible acrylic, there was no significant difference between the control and experimental groups. The results may be attributed to the injection process because the time will decrease when the temperature increases. In the control group, the time and temperature of the device should be adjusted according to the manufacturer's instructions to ensure a sufficient curing process. Increasing the injection temperature allows for more crystallization of acrylic material; the greater crystallization of flexible material results in the hardest material also due to the integrated polymerization reactions that take place at higher temperatures.

This result agrees with Latif Rashid AA(15), who evaluates the surface hardness of flexible denture base material at different temperatures and different injection times (300˚C in 9 min and 250˚C in 24 min). The results showed there were no significant differences with the control group that injected according to the manufacturer's instructions at 270˚C.

Conclusions: increasing the temperature of polymerization improved the surface hardness of cold-cured acrylic material while having no effect on the flexible acrylic.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Table (1) :Descriptive statistics of surface hardness for cold cure acrylic (vertex and Paladur) groups

Type of acrylic materials	Tested Groups	No.	Mean(Shore D)	S.D	Min.	Max.
Cold- cured (vertex)	control	10	86.14	0.39	85.66	86.66
	experiment	10	88.39	0.40	87.33	88.66
Cold- cure (Paladur)	control	10	88.33	0.39	88.00	89.00
	experiment	10	88.70	0.25	88.00	89.00

Table (2): T-test between cold cure acrylic (Vertex and Paladur) groups

Type of acrylic	Tested Groups	Mean differences	P-value	Sig.
Cold -cured (vertex)	control	-2.25	P<0.01	H.S
	experiment			
Cold- cure (Paladur)	control	- 0.37	P<0.05	S
	experiment			

Table (3) :Descriptive statistics of surface hardness for flexible acrylic (Linghen) groups

Type of acrylic materials	Tested Groups	No.	Mean(Shore A)	S.D	Min.	Max.
Flexible(Lingchen)	control	10	66. 44	0.47	65.00	67.20
	experiment	10	66.50	0.48	65.20	68.00

Table (4): T-test between flexible acrylic (Linghen) groups

Type of acrylic	Tested Groups	Mean differences	P-value	Sig.
Flexible (Lingchen)	control	-0.06	P> 0.05	N.S
	Experiment			

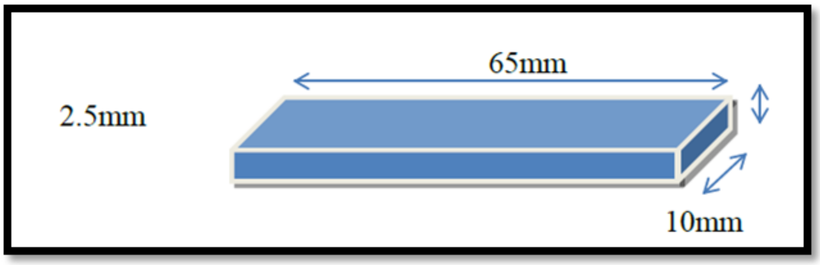
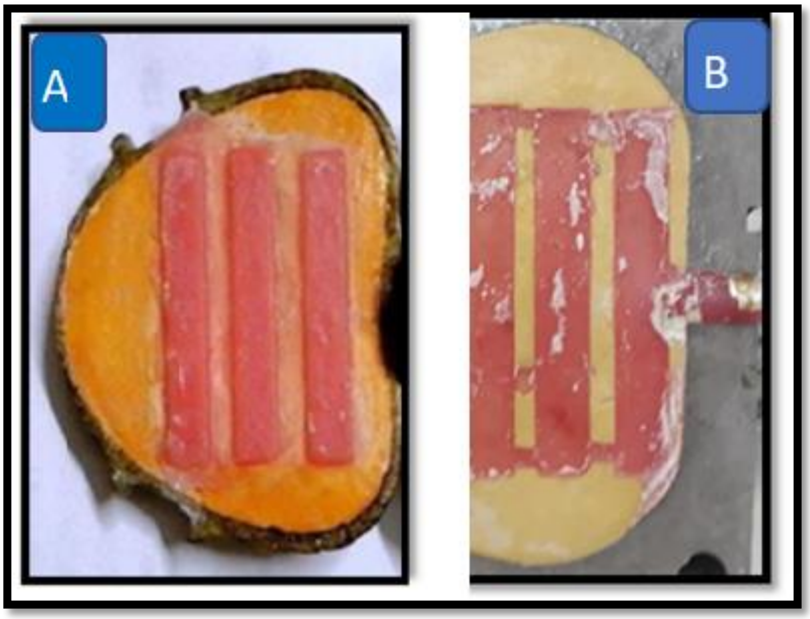


Figure (1) : Measurements of specimen used for surface hardness test.

Figure (2) : Flasking of metal pattern.



Figure(3):A: Cold cure acrylic specimens after processing, B:Flexible acrylic specimens after injection process.

Figure (4) : Shore D hardness tester for cold cure acrylic specimens

Figure(5): Shore A hardness tester for flexible acrylic specimens

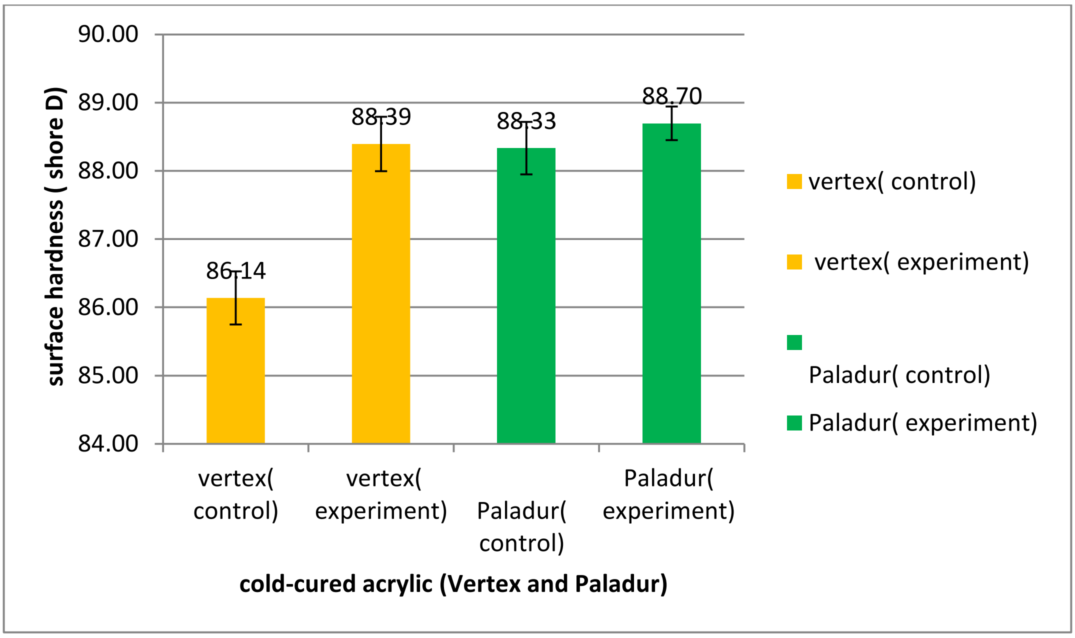


Figure (6) : Bar- Chart shows the mean value of surface hardness for cold cure acrylic (vertex and Paladur)

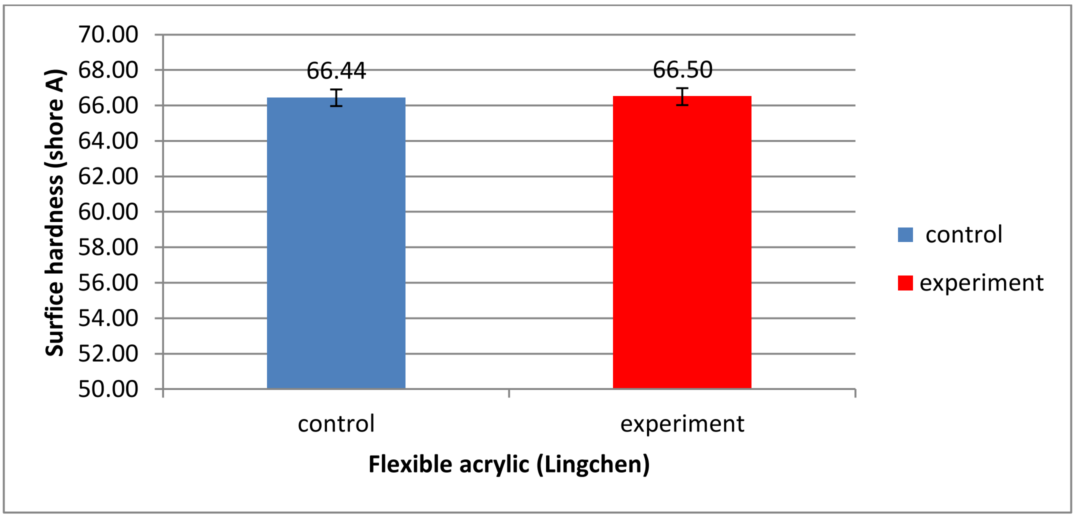


Figure (7) : Bar- Chart shows the mean value of surface hardness for flexible acrylic (Lingchen)