Impact strength and superficial hardness in relation to diferent types of acrylic resin

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ABSTRACT

This paper evaluates the impact strength and surface hardness in the following thermo-cured acrylic resins: Classico, QC-20, and Onda-Cryl. The wax patterns (65x10x3mm) were put into metal and fiberglass flasks. The proportion powder-liquid, the manipulation, and the pressing of the acrylic resin followed strictly the instructions from the manufacturers. They were cured in hot water bath at 74ºC for 9 hours, boiling water during 20 minutes, and microwave energy. After the flasks had cooled in room temperature, the specimens were removed from their flasks and underwent a process of conventional polishing. They were tested for impact strength by Charpy system in a Wolpert machine with load of 40 kg/cm, and for superficial hardness by Shimadzu microdurometer with load of 25 grams for 10 seconds. The ANOVA test and Tukey's test (5%) showed that the acrylic resins could not influence the impact strength, whereas the hardeness determined statistically significant differences.

Key Words: impact strength, superf icial hardness, acrylic resin.

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INTRODUCTION

Many materials and processing methods have been introduced in the dental practice aiming the production of remo vable total or par tial prosthesis with better mechanical proper ties, resistant and polished to promote comfort and attain the requisites of retention, stability and aesthetics to the patient (Phillips, 1993).

However, despite the advantages of easy manipulation and repair, improved thermal conductibility, less permeability to bucal fluids and considerable stability of color, the hypothesis that acrylic resins could be considered as the ideal material (Spencer & Gariaeff, 1949) is not fully accepted although showing interesting properties, such as dimensional fidelity and resistance to fracture while polymerized by effective cycle of cure (Harman, 1949).

Thus, since the introduction of acrylic resins, researchers are seeking better and safer variations in the technical procedures (Peyton, 1950; Peyton & Anthony, 1963) attempting to improve mechanical characteristics when polymerized by conventional bath (Woelfel et al., 1962), microwave energy (Nishii, 1958), dry heat (Gay & King, 1979), visible light and boiling water (Phillips, 1993).

The process of quick cure was made possible by mixing chemical and thermal polymerizing agents into the material (Craig, 1996) without increasing porosity and distortion (Al Doori et al., 1988; Dixon et al., 1992).

In the same way, the use of acrylic resin polymerized by microwave energy made possible the cure in just 3 minutes, using the phenomenon of molecular vibration of the monomer to generate heat (Clerck, 1987), producing baseplates of total prosthesis similar to those by the traditional method (Salim et al., 1992).

However, the type of material did not influenced the impact strength of acrylic resins under polishing, although hardness has showed statistical superiority when the specimen was polished conventionally (Mesquita et al., 1999). On the other hand, there are differences in the impact strength among acrylic resins formulated for different cycles of cure (Smith et al., 1992; Cury, 1994) and a recent study showed that the hardness of the QC-20 resin was influenced by the polymerization cycle (Borges, 1999).

Based on these considerations it would be convenient to verify the influence of different types of acrylic resin regarding the impact strength and surface hardness in order to obtain relevant data to the study of the resistance to fractures of the baseplate of total prosthesis.

PROPOSAL

Taking into account that different types of acrylic resins may not show similar mechanical properties, the objective of this study was to verify the level of strength to impact and the surface hardness of thermocured acrylic resins Classic (conventional cycle), QC-20 (quick cycle) and Onda-Cryl (microwave energy).

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MATERIAL AND METHOD

The materials used for specimen were thermo-cured acrylic resins Classic (Artigos Odontológicos Clássico Ltda.), QC-20 (Dentsplay/De Tray) and Onda-Cryl (Clássico). Three rectangular aluminum molds were used (superior surface with 65x10mm and inferior surface with 64x9mm, 3-mm tick) (Stolf et al., 1985) which were molded with silicon by condensation (Zetalabor) and than the molds were included in metallic and fiberglass flasks by routine technique. Afterwards, the flasks were opened and the conditions of the silicon molds examined to assess the quality of inclusion. After removing the aluminum molds the specimens were made in acrylic resin according to the manufacturer recommendations and polymerized according to the groups: (1) polymerization in warm water bath to 74°C for 9 hours. After pressing of the Classic resin, flasks were thermally polymerized (Termotron) for conventional cycle processing; (2) quick cycle polymerization. After pressing, flasks were put into thermostatic cans containing boiling water for 20 minutes; (3) microwave energy polymerization. After pressing, flasks were put into domestic oven (Sanyo) for 3 minutes in 1400 watts.

Specimens were removed from flasks after cooling in room temperature according to routine laboratory procedure, and finished with abrasive point and sandpaper of decreasing abrasion degrees. Polishing was made in a bench lathe with black and white brush adding water paste of pome-stone and Spanish white-water and felt point with universal paste (Kota).

Impact strength

The specimens were submitted to impact strength test in a Wolpert-Werke device using the Charpy system with impact load of 40Kg/cm. The value for strength obtained at the moment of fracture was read in strength resistance (kgf/cm^2), according to the formula:

Ri = Ci/b x h being:

Ri – impact strength; Ci – strength load (Kg/cm); b, specimen width (cm) and h, specimen height (cm).

Surface hardness

The surface hardness of the specimen was measured in a Shimadzu device calibrated at 25g load for 10 seconds through 5 penetration in each 3 areas of the surface (one central and two lateral).

Results of both tests were statistically treated for variance and the Test of Tukey in 5% of significance level.

RESULTS

Averages of v alues for impact strength under Tukey test (5%) revealed no statisticall y signif icant difference among the acr ylic resins (TABLE 1).

The highest a verage for surf ace hardness w as obtained b y the resin polymerized by microwave energy with statistical signif icant difference when compared to the other products. The lowest average was that of the resin polymerized by quick cycle while the resin for mulated by conventional c ycle sho wed inter mediate results, all of them with statisticall y significant differences (TABLE 2).

TABLE 1- Average values for impact strenght (kgf/cm^2) according to the type of acrylic resin.

RESIN	AVERAGE	5%
Quick cicle	8.12 (0,66)	a
Microwave	8.06 (1,19)	a
Conventional	7.15 (1,41)	a

Averages followes by the same letter do not dif fer at a level of 5%
Minial significative difference: 1.26
Odds ratio in parenthesis

TABLE 2- Average values for surface hardness (Knoop) according to the type of resin.

RESIN	AVERAGE	5%
Quick cicle	11.11 (0,96)	a
Microwave	18.43 (1,12)	b
Conventional	14.64 (1,05)	c

Averages followes by the same letter do not dif fer at a level of 5%
Minial significative difference: 1.26
Odds ratio in parenthesis

DISCUSSION

Tests for impact strength and surf ace hardness may furnish relevant data for the study of the fracture of the baseplate in total prosthesis

In this study, TABLE 1 shows that there was no statistically significant difference for v alues of impact strength among the 3 tested resins. These results could indicate the presence of similar elements in the chemical composition of the products in which the rate of conversion for transformation of monomers into polymers were, most probably, similar for all materials.

Additionally, the basic constitution of the 3 products is polymethylmethacrylate, formulated with some monomer enhancer to allow the formation of copolymers with cross-links (Anusavise, 1998) that, in resins such as Classic, QC-20 and Onda-Cryl, were not sufficient to establish different levels of energy absorption at the moment of impact. As a result, the energy absorbed by these products was similar, leading to fracture values without statistically significant differences.

Thus, under these conditions, it was not possible to confirm the hypothesis that resins polymerized by long cycle present better characteristics regarding absorption of energy due to the formation of long chains of polymers with high molecular weight when compared to those polymerized by microwave energy with short chain of low molecular weight (Hayden, 1986). It was also not possible to confirm that there are differences among the values for the impact strength in resins formulated for microwave, thermally activated cured in long cycles of hot water and chemically activated (Cury, 1994).

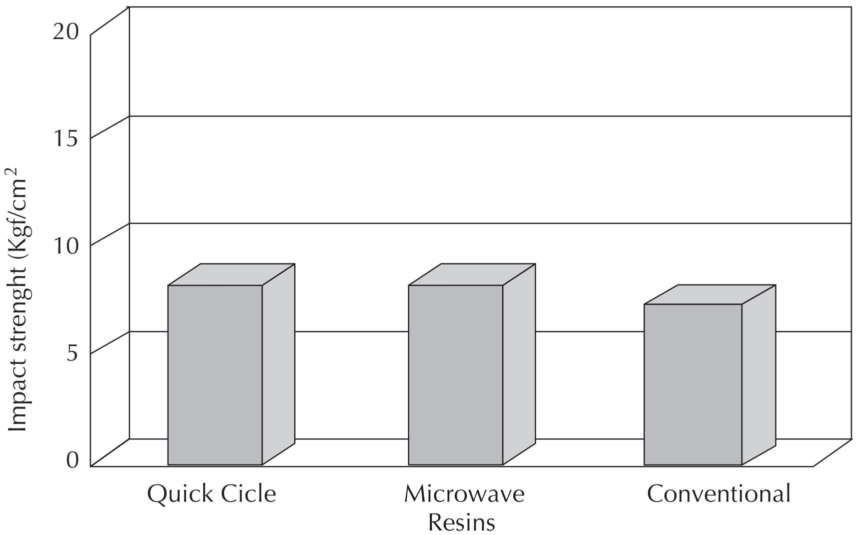

FIGURE 1 – Illustration of the average values for impact strenght (Kgf/cm ^{2}) according to the type of resin.

Furthermore, results of this study do not endorse results from the literature that shows decrease of values for impact strength in resins processed by microwave energy when compared to activation by water bath cycle (Smith et al., 1992).

On the other hand, when surface hardness was analyzed it was possible to conclude (TABLE 2) that the values suffered influence on the type of acrylic resin with statistically significant differences among materials. The resin activated by microwave energy showed the highest surface hardness value and the resin for quick cycle, the lowest. The resin used in the conventional cycle presented intermediate values.

Although all resins can be easily scratched due to their low Knoop hardness value (Crag, 1996), resins polymerized by microwave energy show higher hardness value when compared to those formulated to quick cycle and conventional cycle (Smith et al, 1962; Borges, 1998) what is in accordance with our finding.

In spite of the fact that increase in hardness, due to the cross-link agents, may be partially neutralized by the plastic effect of the non activated interstitial material (Jagger & Huggett, 1975), we believe that the variation in values of surface hardness in these materials may be based in differences among the residual levels of monomers resulting from the polymerization cycles, once the hardness has a proportional relation with the residual amount of monomers (Jagger, 1978).

It is known that the longest polymerization cycle promotes lower levels of residual monomers (McCabe & Basker, 1976; Austin & Baxter, 1980) In spite of that, the values for Knoop hardness obtained with the conventional resin did not show statistically significant difference when compared to those obtained in resins cured by micro wave energy (Troung & Thomaz, 1988).

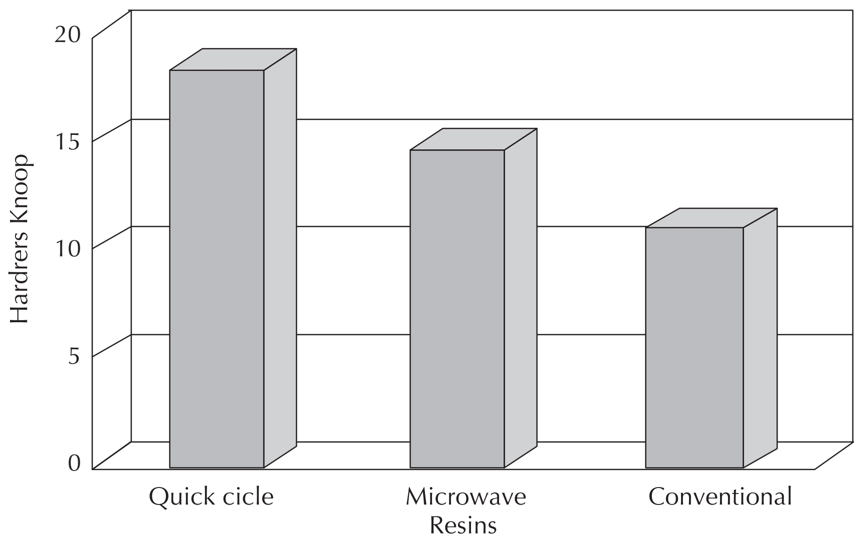

FIGURE 2 – Average values for surface hardness (Knoop) according to the type of resin.

On the other hand, in a recent study, the QC-20 acrylic resin formulated for quick cycle cure showed less value for hardness despite being processed for conventional cycle of 9 hours (Borges, 1998). In this case, the components for the reaction of chemical activation in addition to the thermal activation, which are present in the resin for quick cycle, could be blamed for the average lesser results of hardness, since the chemically activated resins are significantly less hard than those thermally activated (Von Fraunhofer & Suchatlampong, 1975).

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CONCLUSION

Impact strength has shown values without statistical differences among the acrylic resins. However, surface hardness was influenced by the material, being the greatest value found in the acrylic resin polymerized by microwave energy and the lowest by resin for quick cycle. The conventional resin showed intermediate value. All of them presented a significant statistical difference.

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