Original Article

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Assessment of flexural strength of two self-curing acrylic resins containing pigment

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Abstract

Aim: To assess the flexural strength of orthodontic acrylic resins from two different manufacturers (VIPI, OrtoCril versus Clássico, OrtoClas) by comparing pigmented resins to colorless ones. **Methods:** Resins of blue, yellow and green colors were studied. A total of 120 specimens were made and then divided into groups of 15 elements each, all having the same dimensions. Next, they were kept in aqueous medium until being subjected to mechanical testing. The flexural strength was tested in a universal test machine (EMIC DL 10000) in which the specimens were subjected to a gradual load until fracture occurred. **Results:** Pigmented resins had flexural strength values compatible with clinical use, being similar to those from colorless ones, except for OrtoClas green-colored and yellow-colored resins, which showed greater flexural strength. The OrtoClas green-colored resin was the most resistant to fracture (482.2 N), whereas the OrtoCril colorless resin was the least resistant (368.4 N). All OrtoClas resins showed higher strength values compared to OrtoCril resins of same color, except for the OrtoCril's blue-colored resin, which presented higher flexural strength than that of the other trademark. **Conclusions:** The use of pigments seems to have no effect on decreasing the flexural strength of self-curing acrylic resins. Therefore, pigmented resins are compatible with clinical use.

Keywords: acrylic resins, flexural strength, orthodontic appliances.

Introduction

Self-curing acrylic resins have been widely used in orthodontics for making plates for small tooth movements and space maintenance, palatal disjunction appliances, retention plates, and fixed inclined planes[1]. Either orthodontists or even general practitioners can make some of these more simple appliances in order to prevent progression of malocclusions, which can potentially require a more complex and prolonged treatment in the future[2]. Therefore, despite being inefficient in some orthodontic treatments, these appliances still play an important role in correcting malocclusions during deciduous and mixed dentition within each stage of the craniofacial development[3-4]. Because of their limitations, these orthodontic appliances are used only in the treatment of children and teenagers as the practitioner can rely on both bone growth and eruptive tooth movement.

Esthetics is so valued today that the demand for orthodontic baseplates that are colored, decorated or inscribed with designs has increased. Because these appliances can be fixed or removable, it is extremely important that the patient is satisfied and accepts them so that he or she can co-operate with the orthodontic treatment. In order to fulfill such a demand, pigmented acrylic resins has been increasingly accepted in the dental market as their preparation is the same as that regarding colorless resins and there is no need to add pigment during the laboratorial phase to obtain a colored resin. However, no study assessing the resistance of these materials after pigmentation is available in the literature.

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Although acrylic resin is widely used, this material can easily fracture due to its low resistance to impact, low flexural strength or low fatigue strength[5-6]. Flexural strength is a physical property that determines the material's resistance to bending. When a flexural force is applied, the material suffers an elastic deformation followed by plastic deformation and eventually fractures[7]. Another great disadvantage of acrylic resins is the rapid loss of esthetic, physical and mechanical properties within the oral medium because this material absorbs and releases water[8].

Orthodontic appliances tend to fracture due to both occlusive forces and presence of metallic wires which promote dental movement because it suffers some deformation during placement and removal, thus leading to fatigue over the insertion areas of these wires[9-10].

Because the pigments added to resins can bring impurities that might react with free radicals, the polymerization reaction could be compromised and consequently the physical properties of the material changed. Therefore, the aim of the present study was to assess the flexural strength of pigmented resins compared to colorless resins.

Material and methods

A total of 120 acrylic resin specimens (20.5 x 5.5 x 4.0 mm) distributed into 8 groups (n = 15) were fabricated using in a powder/liquid mixing ratio of 3:1, according to recommendations of the two manufacturers, namely, OrtoCril® (VIPI, Pirassununga, SP, Brazil) and OrtoClas® (Artigos Odontológicos Clássico Ltda., São Paulo, SP, Brazil). The specimens were made within a silicone condenzation mold (Perfil, Vigodent, Rio de Janeiro, RJ, Brazil) with internal dimensions of 21 x 6.2 x 4.0 mm that served as a negative control. Polymerization occurred inside a VH Softline pressure container (Midas Dental Products Ltda.) at constant pressure of 17 pounds/in^2 or 87.93 cm/Hg for 20 min. The excess material was removed from the specimens by using progressively 150, 400 600-grit sandpapers until obtaining the desired dimensions, which were measured with a Starrett caliper (Figure 1).

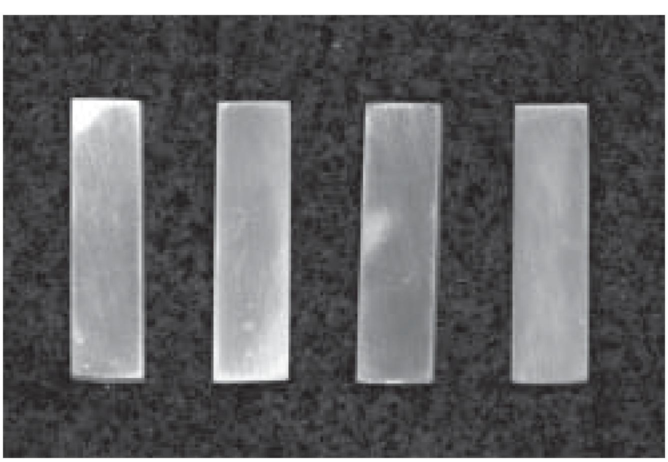

Figure 1 – Samples after polishing.

After polishing the specimens were stored in containers with water for 24 h so that residual monomers could be released. After this period, water was replaced and the specimens remained immersed until being subjected to mechanical testing.

OrtoClas specimens were indicated by the abbreviation Cl, whereas OrtoCril specimens were indicated by Cr. These groups were also identified in terms of color as follows: colorless (L), yellow (Y), blue (B) and green (G).

The test consisted of gradually applying a force to each sepcimen by using a universal test machine (EMIC DL 1000; São José dos Pinhais, PR, Brazil) at a crosshead speed of 5 mm/min until fracture occurred. The machine has three shafts in which the two inferior ones serves to hold the sample and the superior one serve to apply force to the centre of the sample. The three shafts have the same ray of 2.5 mm in order to avoid differences in the results. The center of the specimen was determined by using a millimeter rule and the resulting central point was marked with an OHP marker pen. The machine recorded the force that resulted in fracture (Figure 2).

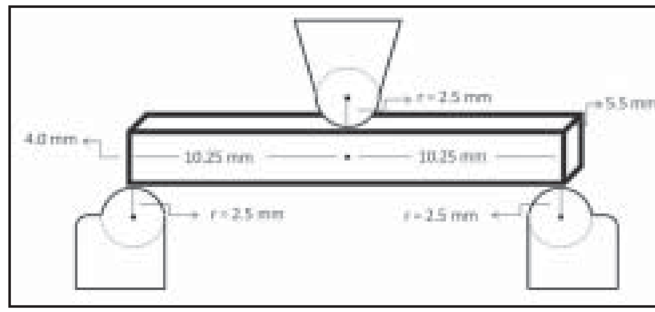

Figure 2 – Flexural strength test schematic's representation.

Statistical analysis was performed with the SPSS software for Windows (v. 13.0) and using two-way ANOVA and Tukey's test in order to determine the mean flexural strength of each group and to compare them regarding the trademarks. The control group consisted of colorless self-curing acrylic resins because of the absence of pigments. Means and standard deviations were obtained for a significant level of 5% (Table 1).

Results

In the control group containing OrtoCril specimens, the fracture force was not significantly higher than that of other specimens of same trademark (Table 1 and Figure 3). With regard to OrtoClas resins, containing yellow-colored and green-colored resin specimens had a significantly higher flexural strength than the blue-colored resin and colorless resin specimens (Table 1 and Figure 3).

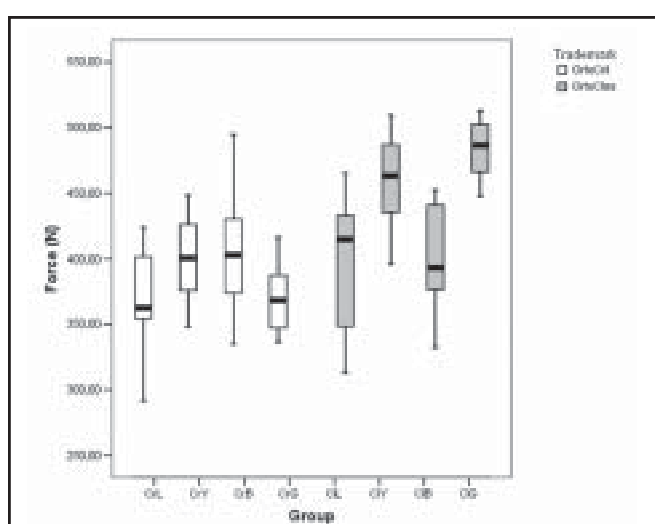

Figure 3 – Box Plot comparing trademarks and colours of acrylic resins. Mean, SD, max, min.

Table 1 – Descriptive statistical analysis of the mean flexural strength values (N).

	n	Mean	SD	Minimum	Maximum	Statistics
OrtoCril Colorless	15	368.38	40.73	291.59	423.98	A
OrtoCril Yellow	15	401.37	32.03	348.01	448.56	A
OrtoCril Blue	15	406.17	46.29	334.60	494.92	A
OrtoCril Green	15	369.50	24.14	336.28	416.16	A
OrtoClas Colorless	15	397.42	52.04	312.82	465.31	A
OrtoClas Yellow	15	461.77	34.80	396.05	509.44	B
OrtoClas Blue	15	402.49	39.97	332.37	452.47	A
OrtoClas Green	15	482.17	20.81	448.00	512.79	B

Different letters mean statistically significant difference ($p \leq 0.05$).

By comparing the trademarks, OrtoClas yellow-colored and green-colored resins were significantly more resistant than the OrtoCril resins of same colors. With regard to blue-colored and colorless resins, no statistically significant differences were found between the trademarks (Table 1 and Figure 3).

Discussion

Acrylic resins are composed of polymeric chains of polymethylacrylate and monomers of methylmethacrylate with a small amount of ligant agents[1,10]. Polymerization occurs by mixing polymer (powder) with monomer (liquid). A macromolecule is formed through a series of chemical reactions[11-12]. Any impurity existing in the monomer may inhibit or delay polymerization if free radicals are involved, thus impeding the stage called propagation. Chemically polymerized resins have 3-5% free monomers. A greater amount of these residual monomers implies a decrease in resistance and hardness of the material[1,11-13].

According to Rocha Filho et al.[12], there is an amount of residual monomer following resin polymerization that is released mainly during the first 24 h. Orthodontic resins have higher levels of residual monomers compared to the conventional ones. In order to avoid any influence from the residual monomer released, which might interfere with the final physical properties of the resin, the aqueous medium in which the specimens were stored was replaced following that period of time. Residual monomers, if in contact with oral mucosa, can cause local or systemic tissue reactions due to their cytotoxic activity[14-15]. Pressure during polymerization raises the amount of residual monomer as well as compromise the powder-liquid mixing ratio, mainly in orthodontics as the salt-and-pepper technique is widely used to saturate the polymer with monomer[1,15-16].

According to Rantala et al.[10] and Keyf and Etikan[8], acrylic resins undergo a water-absorbing process depending on the medium in which they are. The greater the amount of residual monomer, the greater is the water absorption. Water absorption decreases the mechanical properties of the material in the oral cavity, since water acts as a plastifying agent penetrating into the spaces between the polymeric chains and decreasing the secondary chemical bonds such as the Van der Waals forces[1,14]. With the aim of meeting the reality, we decided to store the specimens in aqueous medium before submitting them to mechanical test.

It has been reported that the addition of acrylic fibers or acrylic stain to the polymerized resin through microwaves did not affect the transverse strength, and that both methods were found to be esthetically and mechanically acceptable for clinical use[17]. The present study also shows that addition of pigments to acrylic resins does not reduce their physical properties.

Although the flexural strength values are compatible with masticatory forces, Price[18] emphasizes that the majority of fractures in acrylic resin are not the result of fatigue because such fractures generally occur outside the oral cavity due to accidental impacts (e.g.: falls). Despite the fact that these accidental impacts are not classified as a functional stress, many manufactures have considered the impact strength as being relevant factor to classify a given resin as being "virtually unbreakable" under impact[18]. In order to increase the fracture strength of acrylic resin, several types of fibers have been used such as aramid fibers, glass fibers, nylon fibers, and carbon fibers, all showing favorable results[9,19-20]. Nevertheless, because such techniques are not frequently used for making orthodontic baseplates, they were not assessed in the present study.

The use of a pressure container is indicated because the resin cannot come in contact with oxygen during polymerization. Therefore, the reaction speed and degree of polymerization are higher than those in polymerization under air atmosphere because oxygen reacts with free radicals, which results in less porosities[12-13,20]. The presence of porosity not only reduces the mechanical properties of the resin, but also interferes with the cleaning of orthodontic baseplates by allowing adhesion of substances and deposition of calculus, which may promote inflammatory processes in the surrounding mucosa[11,16,21]. Due to this factor, finishing and polishing procedures using sandpapers as well as the use of a pressure device were shown to be extremely important. However, further studies are needed, as the pressure was used on an arbitrary basis.

In addition, it was raised the question on why the OrtoClas self-curing acrylic resins of yellow and green colors had higher flexural strength. Although no further investigation was carried out in the present study, it is possible that the polymer might be accounted because the specimens were made using the same monomer. Therefore, the reasons why OrtoClas acrylic resins of yellow and green colors have higher flexural strength compared to colorless resins could not be fully understood. The differences in the flexural strengths obtained in various studies may be explained by the different methods of polymerization and storage of the specimens before test.

It may be concluded that the use of pigments seems to have no significant effect on decreasing the flexural strength of self-curing acrylic resins. Although two pigmented resins had higher flexural strength, other colors had mean values compatible with clinical use and can be used according to the patient's needs. In addition, the use of pigmented resins does not interfere with the construction of the orthodontic appliance.

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