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Influence of Investment, Disinfection, and Storage on the Microhardness of Ocular Resins

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Abstract

Purpose: The longevity of an ocular prosthesis is directly related to the resistance to erosion of its material. The purpose of this study was to evaluate the effects of chemical disinfection and the method of investment on the microhardness of ocular prosthesis acrylic resin.
Materials and Methods: Thirty-two test specimen investments were obtained in two silicones. A segment was cut in each test specimen, and each specimen was fixed in an acrylic disk. The specimens were then polished and submitted to the first microhardness test before immersion in distilled water and incubation for 2 months. During this 2-month period, the specimens were immersed in a water bath at 37°C and were disinfected daily; half were disinfected with neutral soap and the other half were disinfected with 4% chlorhexidine gluconate. After the storage phase and disinfection, a second microhardness test was performed. The surface microhardness values for the acrylic resins were submitted to ANOVA, followed by the Tukey test.
Results: The disinfection and the period of storage did not statistically influence the surface microhardness of the acrylic resin, independent of the method of investment of the specimens (Zetalabor or Vipi Sil). The investment of specimens with Zetalabor silicone presented a greater surface hardness, independent of the type of disinfection and the period of storage.
Conclusions: Based on these results, we suggest that the microhardness of the resin evaluated was not influenced by the method of disinfection or the time of storage used and was affected only by the investment material.

Maxillofacial prostheses were introduced as a consequence of individuals' needs to disguise, repair, and hide their maxillofacial defects. The rehabilitation treatment of patients with facial defects helps them to improve their appearance and personal well-being.

Among the several kinds of maxillofacial prostheses used, use of the ocular prothesis is common, since it satisfactorily restores the patient's facial esthetics even though it does not restore vision. Therefore, it is of the utmost importance to analyze the physical properties, such as hardness, of the materials that are used for manufacturing these prostheses to assess their longevity.

The microhardness of a material is characterized by its resistance to permanent penetration and can predict the performance of this material in relation to other properties, including resistance to wear and tear.[1] Microhardness is directly linked to the lifespan of the prosthesis; the greater the prothesis' microhardness, the greater its resistance to abrasive wear and tear.

Although no statistically significant relationship has been observed between Gram-negative microbes and the quantity of secretion present in anophthalmic cavities, the development of unhygienic habits by patients during the cleaning of anophthalmic cavities and prostheses appears to favor the colonization of Gram-negative microorganisms.[2]

Dental practitioner auxiliaries and laboratory personnel have become more aware of the various routes of cross-contamination, as prostheses have been identified as a source of cross-contamination between patients and dental personnel.[3-5] To avoid possible infections, the ocular prosthesis should be removed and disinfected periodically with neutral pH soap and water[6] and then re-inserted in the patient's ophthalmic cavity. Thus, the disinfectant must not have any influence on the physical properties of the acrylic resins used in ocular manufacturing.[7]

In view of these considerations, the aim of this study was to assess the microhardness of acrylic resins used for ocular

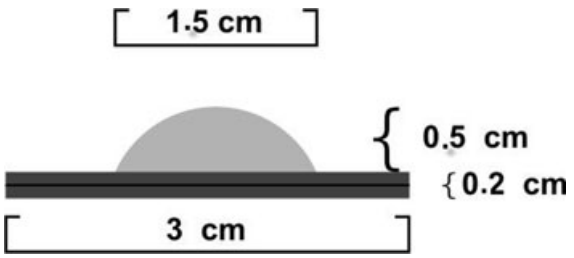

Figure 1 Illustration representative of the specimens (1.5 cm diameter, 0.5 cm height) and blades (3 cm wide, 0.2 cm thick).

prostheses. The effects of chemical disinfection were observed, as was the use of two silicones for investment in a flask.

Materials and methods

To conduct this study, 32 test specimens were acquired to simulate ocular prostheses. These specimens were manufactured in curved metal disks standardized to 1.5 cm in diameter and 0.5 cm in height. Each curved disk was placed on two blades, linked by wax (Wilson, Polidental, São Paulo, Brazil); these blades were rectangular shaped and measured 3 cm long, 2 cm wide, and 0.2 cm thick (Fig 1).

After obtaining the 32 test specimens in wax, the specimens were divided into groups of eight in flasks suitable for polymerization in a microwave oven. During the investment process, using plaster Type IV (Vel-Mix Die Stone, KerrLab, Orange, CA), the curved disks were coated with two types of silicone: Vipi Sil (VIPI, Pirassununga, Brazil) and Zetalabor (Zhermack, Rovigo, Italy). Sixteen molds were made in the wax investment with Vipi Sil, and 16 were made with with Zetalabor silicone.

The flasks were then opened, and thermopolymerizable acrylic resin No. 1 (Classico, São Paulo, Brazil) was condensed. Before placing the flask in a hydraulic press with a force of 1.5 kgf, the curved metal disk was simultaneously positioned and isolated with Vaseline. The whole set underwent a procedure for polymerization in a microwave (840 W) using 60% of the maximum microwave capacity for 3 minutes. After resin polymerization, the flask was opened again, and the curved metal disk was taken out, so the artificial irises could be positioned.

The artificial irises were manufactured on disks made of black card, each measuring 11 mm in diameter. The 32 disks were painted with hydrosoluble watercolor paint (Faber-Castell, Cleveland, OH). To dry the paint, direct infrared light was used for 2 hours. When the painted disks were dry, they were glued in the center of the No. 1 resin plaque. Colorless thermopolymerizable resin (Classico), polymerized by microwave, was placed over the irises.

After the test specimens were manufactured, the microhardness of the acrylic resin was evaluated, and acrylic disks were manufactured. Chemically activated colorless acrylic resin (Classico) was used to manufacture 32 acrylic disks, on which were fixed segments obtained by the following sectioning procedure: a part of the acrylic resin of each simulated ocular prosthesis test specimen was sectioned with a monophasic disk to obtain 32 segments in total, each measuring 0.5×0.5 cm^2, with thickness corresponding to the test specimen base thickness.

These specimens were polished in sequence with four water abrasive papers (Nos. 220, 320, 600, and 1200) in a polishing machine (APL-4, Arotec, Cotia, Brazil), using each abrasive paper for 1 minute. The specimens were then submitted to the microhardness test in two stages, totaling 10 penetrations for each specimen, measured with a microdurometer (Shimadzu HMV-2000, Shimadzu Corp., Kyoto, Japan) and observed on a monitor attached to the microdurometer.

The first microhardness test (before disinfecting) was performed with five penetrations in each specimen. After the first microhardness test, these same specimens, which would later be used for the second microhardness tests, were immersed in a water bath at 37°C for a period of 60 days, during which time they were disinfected daily with neutral pH soap and water (control group) or with 4% chlorhexidine. Test specimens were disinfected with a 4% chlorhexidine gluconate solution by sprinkling for 1 minute, after which they were washed under running water. Using this method, one can assume that no disinfecting solution absorption occurred, and that the physical properties of the polymer were not altered.

The specimens were randomly divided into four groups with eight specimens each, treated as follows:

Group 1: Eight test specimens invested with Vipi Sil silicone and disinfected with neutral soap.
Group 2: Eight test specimens invested with Zetalabor silicone and disinfected with neutral soap.
Group 3: Eight test specimens invested with Vipi Sil silicone and disinfected with chlorhexidine at 4%.
Group 4: Eight test specimens invested with Zetalabor silicone and disinfected with chlorhexidine at 4%.

At the end of the 60-day storage and disinfection period, a second microhardness test was performed, employing five penetrations at the bottom margin of each specimen. The microhardness values of the acrylic resins were submitted to analysis of variance (ANOVA). Means were compared by the Tukey multiple comparison method. All statistical tests were performed at the 95% level of confidence.

Results

The disinfection and the period of storage did not statistically influence the surface microhardness of the acrylic resin, independent of the method of investment of the specimens (Zetalabor or Vipi Sil) (Tables 1 and 2). The investment of samples with Zetalabor silicone presented a greater surface hardness, independent of the type of disinfection and the period of storage (Tables 3 and 4).

Discussion

Physical and mechanical properties in laboratory tests intend to simulate clinical conditions of use of dental materials. In the case of acrylic resin, these properties will characterize the durability of the prosthesis and will contribute to the clinical success of the treatment. Fractures occur mainly due to the

Table 1 Effect of disinfection and storage on the microhardness of test specimens invested with Zetalabor silicone (kg/mm)

	Period of storage				
Disinfection	Initial	SD	60 days	SD	
Neutral soap	17.32	0.482	16.88	0.522	Ns
4% chlorhexidine	17.52	0.460	17.20	0.566	Ns

Ns: values in row are not significant.

Table 2 Effect of disinfection and storage on the microhardness of test specimens invested with Vipi Sil silicone (kg/mm)

	Period of storage				
Disinfection	Initial	SD	60 days	SD	
Neutral soap	16.28	0.672	15.84	0.654	Ns
4% chlorhexidine	16.48	0.460	16.32	0.434	Ns

Ns: values in row are not significant.

Table 3 Effect of disinfection and storage on the microhardness of test specimens before the incubation period (kg/mm)

	Material of inclusion				
Disinfection	Zetalabor	SD	Vipi Sil	SD	
Neutral soap	17.32	±0.482	16.28	±0.672	S
4% chlorhexidine	17.52	±0.460	16.48	±0.460	S

S: values in row are significant.

Table 4 Effect of disinfection and storage on the microhardness of test specimens after 60 days (kg/mm)

	Material of inclusion				
Disinfection	Zetalabor	SD	Vipi Sil	SD	
Neutral soap	16.88	±0.522	15.84	±0.654	S
4% chlorhexidine	17.20	±0.566	16.36	±0.434	S

S: values in row are significant.

diminished hardness of the material and can be considered one of the most important practical deficiencies of acrylic resin for prosthesis manufacture.

According to the results obtained, it was observed that the microhardness of No. 1 acrylic resin test specimens embedded in Zetalabor or Vipi Sil silicones is not statistically significantly altered during the storage time, or after daily chemical disinfection (Tables 1 and 2). This result conflicts with the findings of Neppelenbroek et al,[8] who confirmed the hypothesis that the microhardness of acrylic resin is affected by the type of disinfecting solution and by the storage time in water. The explanation for this could be that the specimens in the Neppelenbroek et al[8] study were immersed in disinfecting solutions, and according to Asad et al,[9] when acrylic resin specimens are immersed in a 0.5% chlorhexidine gluconate solution, the resin can slowly absorb the disinfectant, altering the structure of the polymer.

In the present study, the disinfection method used was different: test specimens were disinfected with a 4% chlorhexidine gluconate solution by sprinkling for 1 minute, and after that they were washed under running water. Using this method, one can assume that no disinfecting solution absorption occurred, and that the physical properties of the polymer were not altered. Upon review of the relevant literature, no study was found that used the same experimental disinfection protocol as was used in this study. As such, only indirect comparisons can be made.

Although the storage time values were not statistically different, a numerically lower test specimen microhardness was observed after the 60-day storage in all the groups analyzed (Tables 1 and 2). According to Von Fraunhofer and Suchatlampong,[10] storage in water causes a decrease in microhardness, indicating that water penetrates the superficial amorphous layer of the acrylic resin, thus having a laminating or softening effect.

In relation to the investment material, the microhardness values of the test specimens invested with Zetalabor or Vipi Sil were statistically significantly different (Tables 3 and 4). This might have occurred as consequence of the intrinsic characteristics of the investment material. The acrylic resin absorbs a small quantity of water by diffusion when placed in an aqueous environment.[1,11-13] These water molecules penetrate the acrylic resin paste and then position themselves among the polymeric chains, separating these chains, causing a slight expansion of the polymerized resin paste and, at the same time, interfering in the entwining of the polymeric chain. This will alter the physical characteristics of the final polymer. Thus, since it is known that the condensation of silicone releases byproducts, such as alcohol, during polymerization (as reported by McCabe and Storer,[14] Braden,[15] and Fano et al[16]), it may be suggested that these byproducts were incorporated in the polymer in the same manner as the water. Therefore, a greater release of byproducts may have occurred in the test specimens that were invested with Vipi Sil silicone, as the test specimens invested with this silicone presented lower microhardness values.

The American Dental Association[17] does not specify values for acrylic resin microhardness; on the other hand, it gives values for artificial teeth made of acrylic resin, which cannot be inferior to 15 kg/mm. Therefore, if a value of 15 kg/mm microhardness for acrylic resin artificial teeth is considered ideal, even though these teeth are submitted to strong chewing forces, then the values found in this study are adequate, since the lowest value found was 15.84 kg/mm.

Conclusions

On analyzing the results obtained herein, it may be concluded that:

- The test specimens disinfected with neutral soap or with 4% chlorhexidine gluconate did not show statistically significant differences in the microhardness properties of their acrylic resin, irrespective of the inclusion method used for these test specimens (Zetalabor or Vipi Sil).
- The test specimens invested with Zetalabor silicone demonstrated greater surface microhardness compared with the

test specimens invested with Vipi Sil silicone, irrespective of the disinfection and storage period.

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