

EVALUATION OF SURFACE ROUGHNESS AND COLOR CHANGE OF A LIGHT-CURED AND A HEAT-CURED ACRYLIC RESIN EMPLOYED FOR FABRICATION OF PROSTHETIC BASES AFTER EXPOSURE TO DIFFERENT TYPES OF DISINFECTANTS

ABSTRACT

This study evaluated the changes in surface roughness and color of materials employed in the fabrication of prosthetic bases after immersion in disinfectants. Sixty specimens were fabricated using a round matrix; half of the specimens were fabricated with a heat-cured composite resin, and the other half with a light-cured composite resin. After polishing, the specimens were stored in distilled water at 37°C from 48 to 52 hours, and then submitted to initial tests of surface roughness and color. The specimens were randomly divided into three groups and immersed in the following chemicals: G1 (1% sodium hypochlorite for 10 minutes), G2 (5.25% sodium hypochlorite for 5 minutes) and G3 (2% acidic glutaraldehyde for 10 minutes). The surface roughness and color tests were once again performed and the specimens were then stored in deionized water at 37°C for 6 days. On the seventh day, the immersion was repeated; this procedure was performed at every 7 days during 1 month and the tests were repeated after the fourth week. The results were submitted to three-way analysis of variance (ANOVA) and to the Tukey test. Within the same groups of specimens, statistically significant differences were only observed for the light-cured resin, which presented slight changes after exposure to 5.25% sodium hypochlorite and 2% glutaraldehyde for the interval ΔE_2 , which indicates differences in reading values between immersion after 30-day storage and the first immersion in the disinfectants.

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KEYWORDS

Color stability. Acrylics. Disinfection. Cross infection.

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INTRODUCTION

Complete dentures are usually fabricated with artificial teeth retained to a heat-cured acrylic base (polymethylmethacrylate) in laboratory; however, light-cured resins are currently available for this purpose. This acrylic resin is injectable and thus allows curing in increments, which avoids the waste of material; moreover, it does not contain methyl methacrylate¹ and then it does not trigger allergic reactions, when compared to chemically cured acrylic resins.

Light-cured acrylic resins may be employed for several purposes, including fixed and removable dentures, implant-supported prostheses, orthodontics, and also for denture relining². The advent of light-cured acrylic materials has simplified the fabrication of removable dentures. These materials have also been employed in maxillofacial prostheses and palatal prostheses for patients with cleft lip and palate, or submitted to large surgeries³.

The materials employed for fabrication of prosthetic bases should necessarily allow a smooth and shiny surface, since an esthetic prosthesis should reproduce the natural appearance of oral tissues.

The occurrence of surface roughness is unavoidable during the laboratory steps for fabrication of complete dentures, even after polishing; what favors the formation of biofilm on the acrylic resin base, which should be

constantly controlled to avoid the establishment of diseases. This microbial biofilm may be associated with denture stomatitis and is able to degrade the tooth structures⁴. Its presence may be related with oral, gastrointestinal and pulmonary infections, especially in immunodepressed or elderly patients, who continuously swallow and inhale microorganisms from the biofilm on the prosthesis⁵.

Several clinical steps during prosthetic oral rehabilitation impair the prevention of cross contamination⁶. Prostheses sent from the clinic to the laboratory for adjustment and repair contain bacteria, viruses and fungi, which jeopardize the health of dental technicians, if not properly disinfected. Many oral and non-oral microorganisms associated with local and systemic diseases have been found in contaminated prostheses and laboratory materials and instruments, such as polishing brushes, felt discs, burs and stones, revealing the importance of disinfection of materials sent to the laboratory, and also of prostheses coming from there, especially immediate complete dentures, which have direct contact with the patient's blood.

The most common method for denture cleansing is brushing with tap water and soap or toothpaste. Denture cleansing is usually poor and seems to be neglected by both patients and professionals, since both are frequently unaware of a well-defined

disinfection protocol. This is worrisome, since the prosthetic surface usually has microporosities, which allow the accumulation of microorganisms hardly removed by mechanical methods and may lead to the occurrence of infections, including oral candidosis⁷.

Based on these aspects, professionals working with dental prostheses should attempt to eliminate the pathways of cross contamination. Due to the impossibility of dry- or moist-heat sterilization of complete dentures, the utilization of chemicals is an effective option for disinfection⁸. There are several controversies, as about the type of disinfectant, period of disinfection of prostheses and concentration of these agents⁹. Some authors advocate immersion of complete dentures in 5.25% sodium hypochlorite diluted at 1:10 for 10 minutes¹⁰, whereas others recommend utilization of the same agent diluted at 1:5 to 1:100 for 10 to 30 minutes¹¹. Comparative studies evaluating the efficacy of disinfectants for complete dentures revealed that, besides sodium hypochlorite, two concentrations of glutaraldehyde solution (2% concentrated and 2% diluted at 1:16) may also be employed with significant reduction in the number of bacteria on the surfaces of complete dentures¹.

Considering the several evidences highlighting the importance of utilization of chemicals for disinfection of complete

dentures and prevention of cross contamination, this practice has been routinely followed; however, besides knowing the type of solution, it is important to know if the chemical, concentration and time of immersion adopted are compatible with the material employed for fabrication of complete dentures, to avoid adverse effects on the acrylic resins.

On the other hand, the material should not present color changes after disinfection, since the discoloration of acrylic resins would pose an esthetic problem. With regard to the effect of disinfectants on the surface roughness and color of denture base resins, only a phenol-based disinfectant (Multicide) cannot be used. Utilization of other disinfectants for a period of up to 30 minutes does not yield changes in surface roughness and color¹².

The color stability of denture base resins and relining materials is requested by ADA (American Dental Association, 1996), which also indicates utilization of the CIELab system, discovered in 1978 by the "Commission Internationale d'Eclairage", to investigate this stability. In the CIELab system, the colors are obtained by the combination of three basic colors, including red, blue and green. Spectrocolorimeters are currently being employed to measure the color changes of dental materials, instead of subjective visual interpretation¹³.

This study aimed to evaluate the changes in surface roughness and color of two

types of acrylic resins after immersion in three types of disinfectants, at different concentrations and for different periods.

MATERIAL AND METHODS

Sixty specimens were fabricated with aid of a round polyethylene matrix with 30-mm diameter and 6-mm height. Four positive indents were fabricated inside the matrix, which involved the entire lateral portion of the matrix equidistantly, and were transferred in a negative manner to the resin, dividing the circumference into 4 equal quadrants, which aided the division of specimens for reading during the tests.

The matrix was filled with laboratory condensation silicone Zetalabor (Hard 85 shore-A, laboratory high precision condensation silicone, Zhermack, Italy) and pressed between two glass slabs. Thereafter, the silicone specimen was removed from the matrix and embedded in a metallic muffle DCL n. 6. The lower part of the metallic muffle was isolated with the separating agent Cel Lac (SS White, Rio de Janeiro, Brazil) and poured with type III stone (Gesso Pedra Herodent – Vigodent, Brazil) under vibration; the stone was prepared and mixed following the manufacturer's instructions. After setting, the stone was isolated with Cel Lac (SS White, Brazil) and the silicone matrix was positioned on the stone. The upper part of the muffle was then adapted and poured with type III stone, according to the aforementioned technical conditions.

The muffles were placed in a hydraulic press under 1-ton load for one hour and then opened for removal of the silicone matrices; the stone was then checked as to the presence of

bubbles. Two types of acrylic resin were then employed: a pink heat-cured resin (Lucitone 550 – Dentsply International INC., Chicago, IL, USA) and a light-cured resin (Versyo – Heraeus Kulzer South America Ltda., São Paulo, Brazil), adding up to thirty specimens for each type of resin.

After placement of the heat-cured acrylic resin, the muffles were placed in the hydraulic press until it reached 1,250 Kgf for 30 minutes, and then placed in a thermopneumatic polymerizer at 60-pound pressure, heated for 90 minutes at 73°C and then kept at 100°C for 30 minutes. After removal from the muffle, the excess acrylic resin was removed with aid of tungsten burs.

For fabrication of specimens with light-cured resin, the matrices were isolated with the separating agent supplied with the Versyo resin system (Versyo sep) on the glass slab, on which they were placed. The resin was inserted in the round matrix in two increments (Figure 1). The first one was previously cured for 30s with a halogen light unit (Heralight); after injection of the second increment on the first, the assembly was once again placed in the appliance for further 60s. The specimens were removed from the matrices and placed in the UniXS unit (Kulzer) for further 180s, for final curing (Figure 2).

Polishing for both types of resin was performed on both aspects of the specimen with aid of a metallographic polishing machine (Arotec, model APL 4 – Cotia, Brazil), with a device for multiple polishing, using silicon sandpaper (US Industrial Mesh, Extex) grit 180, 320, 600, 1,200 and 2,000, applied for 4 minutes under maximum load (215 grams) under cooling. The specimens were cleaned by ultrasound (Ultra sonic cleaner,

100W energy – Arotec – Cotia, Brazil) for 2 minutes, between grits and after polishing.

Figure 1: Insertion of light-cured resin.

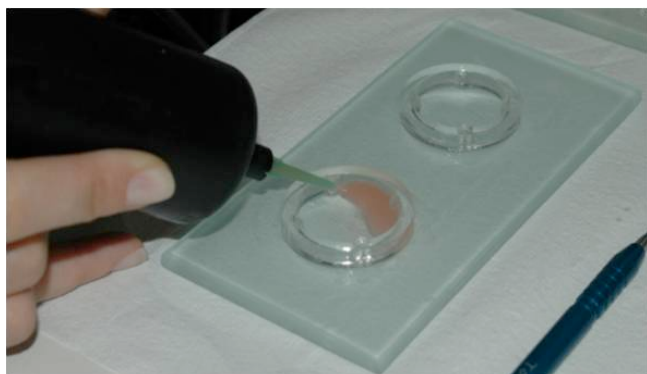
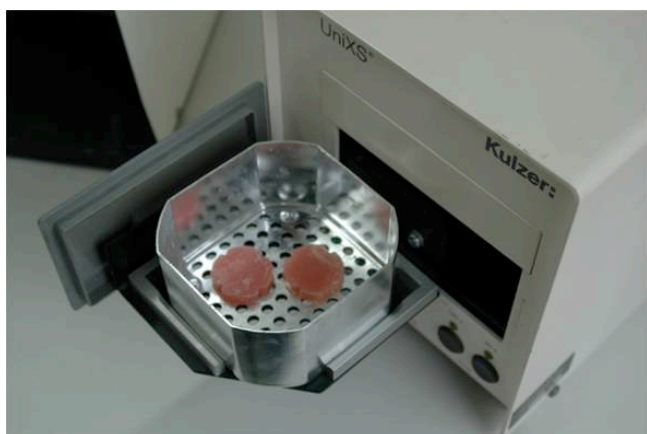


Figure 2: Final curing.



The specimens were stored in deionized water at 37°C for 48 to 52 hours, following the guidelines of the American Dental Association, 1975 (International Organization for Standardization Specification 1567, 1988) and randomly divided into three groups of solutions that effectively promote disinfection of dental materials, as reported in the literature: Group 1: immersion in 1% sodium hypochlorite for 10 minutes (Miyako do Brasil Ind. e Com. Ltd, São

Paulo, Brazil)¹⁴. Group 2: immersion in 5.25% sodium hypochlorite for 5 minutes (Miyako do Brasil Ind. e Com. Ltd, São Paulo, Brazil)¹⁵. Group 3: immersion in 2% acidic glutaraldehyde for 10 minutes (Anti-G Plus – Dentsply)¹².

Each group was composed of twenty specimens, ten of each type of resin. The specimens were identified by numbers on their lateral aspect to enhance the control after disinfections. After immersion in each solution, the specimens were washed in tap water for 3 minutes, and then submitted to the first step of color and surface roughness tests.

After testing, the specimens were stored in a sterile covered plastic flask containing deionized water at 37°C, in a culture oven (Fanem- model 520C, São Paulo, Brazil) for 6 days. On the seventh day, they were once again immersed in the disinfectants and washed in tap water as previously described, and stored in distilled water. This procedure was performed at every seven days for one month; the surface roughness and color tests were repeated at completion of the fourth week.

Color evaluation (color stability):

The specimens were investigated with aid of a portable spectrophotometer at Ribeirão Preto Dental School (FORP-USP), model color guide 45/0 (Figure 3), with spectral variation of measurement from 400 to 700 nm, 11-mm focal diameter and color measurement geometry 45° circular/0 (manufactured at Geretsried, Germany – manufacturer: BYK Gardner GmbH 07/2002). The functioning of this visible light equipment, which employs the CIELab system, is based on color positioning in space. Space is defined as a combination of cylindrical and Cartesian

coordinates, in which a point is associated with a single color. Each specimen was positioned among four wax points, which prevented its movement; a standard white background was employed to avoid reading errors. Individual analysis was performed by the three variables inherent to the device, in which "L" represents the coordinate of shine, "a" corresponds to the intensity of red and green colors, and "b" corresponds to blue and yellow. The ΔE value was automatically obtained by the following formula: $\Delta E = \{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2\}^{1/2}$, in which ΔL , Δa and Δb are differences between the respective values of L, a and b⁷. Only the ΔE result was employed for comparison. After collection, the data were transmitted to a microcomputer connected to the spectrophotometer.

Figure 3: Portable spectrophotometer.



Evaluation of surface roughness:

The specimens were submitted to the mean surface roughness test (Ra) in a roughness meter Mitutoyo SJ 201P (Figure 4) at Ribeirão Preto Dental School (FORP-USP). This device allows high-sensitive evaluation for quantitative establishment of

surface roughness. Two readings were obtained from each aspect of the specimen, based on the indents reproduced on the lateral aspect of specimens; the mean was then calculated.

Figure 4: Roughness reading.



Readings were performed before and after the first immersion and after 30-day immersion. Calculation of these means allowed observation of possible changes in surface roughness by the following formula: surface roughness = RF - RI.

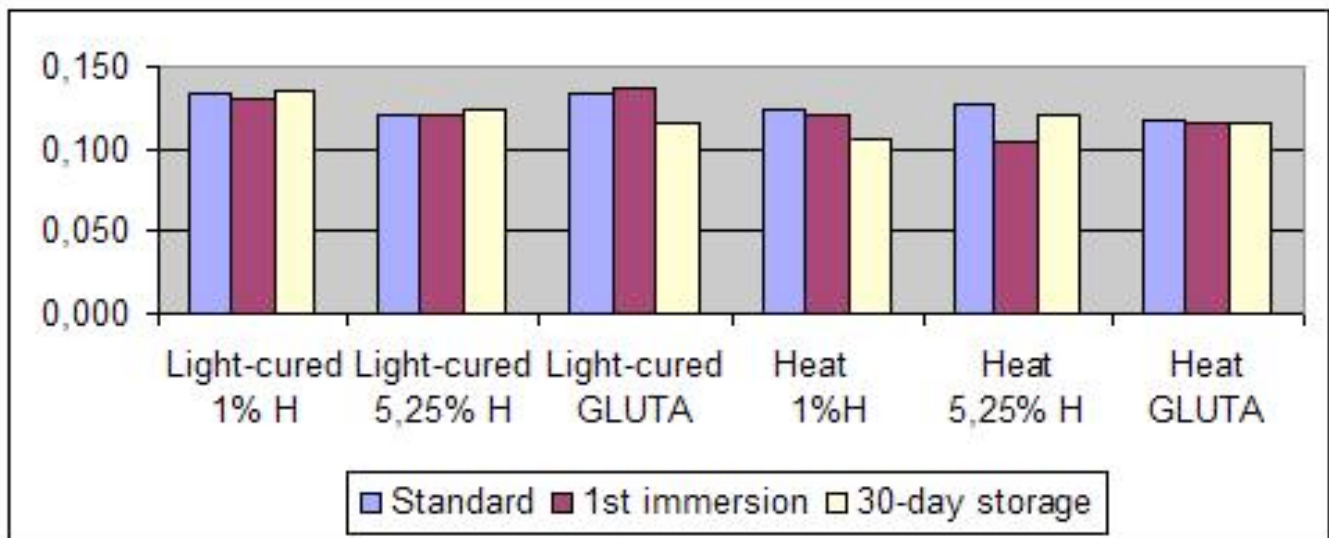
RESULTS

The changes in surface roughness and color were compared by three-way analysis of variance, namely the type of resin, disinfectant and time of immersion. Since this test indicated statistically significant difference, the Tukey test was then applied. A significance level of 5% was adopted for all the tests. Analysis of color change, considering $\Delta E1$ = first immersion - standard; $\Delta E2$ = 30 days - first immersion; and $\Delta E3$ = 30 days - standard, there was statistical difference for $\Delta E1$ for groups G1 (1% hypochlorite) in the comparison between

light-cured resin specimens (P1 to P10) and heat-cured resin specimens (P31 to P40). The same was observed for group G2 (5.25% hypochlorite), in which the specimens P11 to P20 were statistically different from specimens P41 to P50 for the interval $\Delta E1$. For the interval $\Delta E2$, there was statistical difference within the light-cured resin specimens for groups G2 and G3 (2% glutaraldehyde). Statistically significant differences were also observed in the comparison between light-cured and heat-cured resin specimens for groups G1 (P1 to P10 with P31 to P40), and G3 (P21 to P30 with P51 to P60). For the $\Delta E3$ interval, there were only differences in the comparison between light-cured and heat-cured specimens for

the three groups: G1 (specimens P1 to P10 with P31 to P40), G2 (specimens P11 to P20 with P41 to P50) and G3 (P21 to P30 with P51 to P60). It could be concluded that, within the same group of specimens, significant differences were only observed for the light-cured resin, which presented slight change after exposure to 5.25% hypochlorite and 2% glutaraldehyde for the $\Delta E2$ interval, which means the difference in reading values between immersion after 30-day storage and the first immersion in the disinfectant. Analysis of surface roughness did not indicate statistically significant difference among the study groups (Graph 1).

Graph 1: Mean surface roughness values for both resins.



DISCUSSION

Many materials employed for prosthetic treatment are subject to the occurrence of liquid absorption and adsorption^{7,18}, depending on the medium in which they are inserted; this may lead to discoloration of these materials. The polymers of denture bases tend to present discoloration during utilization in the oral cavity, which would be the

result of both extrinsic and intrinsic factors¹⁹. The intrinsic factors involve chemical changes of the material assigned to oxidation of catalyst amine after exposure to different energy sources, and immersion in water for long periods. The extrinsic factors comprise penetration of pigments from exogenous sources. One of these factors may contribute to visible detection or esthetically unacceptable color change of prostheses.

The color change may be visibly noticed or may be assessed by spectrophotometer¹⁵. These appliances provide a reproducible method of color determination, eliminating the subjective interpretation of visual comparison, because the sensitivity of human eye to observe color changes is limited.

The CIELab system is recommended by the International Lighting Commission (Commission Internationale de l'Éclairage) and quantitative evaluation of color changes (ΔE) with aid of the spectrophotometer, which offers advantages such as reproducibility, objectivity and sensitivity. If a material presents stable color, it will not reproduce differences when exposed to the spectrophotometer test ($\Delta E=0$); however, a ΔE value equal to or smaller than 3.7 is still considered as clinically acceptable²⁰. The highest value of color change of provisional restorative materials has been observed when specimens were polished with sandpaper²¹, compared to other polishing techniques, as diamond paste and pumice²².

In the present study, a slight color change on the light-cured resin was observed in the comparison between different disinfectants. The reason may be associated with the concentration of solutions, period of disinfection²³, but mainly due to incomplete curing of the denture base material. The effects of color changes after long-term immersion of denture base resins in disinfectants should be evaluated.

The color evaluation of each resin also provided information on the color stability of materials processed by different manner. When processed following the manufacturer's instructions, heat-cured denture base resins presented proper color stability, which is not

observed for self-curing materials, whose color stability is relatively poor²⁴.

Light-cured materials have been employed for direct relining of removable partial dentures and complete dentures²⁵, and present advantages, such as elimination of chemical or thermal irritation, longer working time, shorter curing time, better handling properties, and easy correction procedures; however, the superiority of these materials depend on their complete curing. The light-cured relining materials are a good option for patients sensitive to the MMA monomer because they do not contain allergens; and these materials are also well accepted by patients.

Limitations related to effective curing in depth have been reported^{10,7}. The degree of curing significantly affects the mechanical properties of light-cured resins and depends both on the exposure to light and on the material hardness. The extended exposure to light is an option to reduce the component of residual monomer; however, the temperature in the curing chamber will be increased due to the heat from the light source. A high temperature will be disadvantageous for the dimensional stability of these materials.

The exogenous discoloration may be reduced by polishing the material surface, which is a fundamental treatment for reduction of staining²⁵. The results of studies on the roughness value of acrylic resins are not clear, since they depend on the type of surface polishing. Ideally, the roughness value (Ra) should be lower than $0.2\mu\text{m}$ to prevent bacterial adhesion²⁶. In the present study, each specimen was submitted to a strict process of finishing and polishing; this was confirmed by roughness evaluation of specimens, which was ideal, i.e. equal to or lower than $0.2\mu\text{m}$.

The utilization of chemicals for denture cleaning has been highlighted because of their effectiveness, acting as complements or substitutes to tooth brushing, both for dental plaque reduction and prevention of denture stomatitis associated with colonization by *Candida*²⁷. Depending on their composition, these cleaning agents may cause harmful effects, damaging the physical properties. Thus, selection of chemicals to be employed for denture cleaning should take into account not only their antimicrobial properties, but also the compatibility among them, so the physical properties of these materials may be preserved as much as possible.

A variety of the so-called intermediate disinfectants are approved by the ADA¹⁶; however, disinfection of acrylic resin dentures with iodine-free solutions is recommended in order to avoid esthetic changes. There are several controversies, as to the type of disinfectant, period of disinfection of dentures and concentration of solution. Some authors advocate immersion of complete dentures in 5.25% sodium hypochlorite diluted at 1:10 for 10 minutes²⁷, whereas others suggest utilization of the same concentration diluted at 1:5 to 1:100 for 10 to 30 minutes²¹. The occurrence of color changes in four of five resins submitted to utilization of 1% sodium hypochlorite has been reported; this indicates the bleaching action of this disinfectant²⁸.

CONCLUSION

The color and surface roughness changes of different types of denture base resins after immersion in disinfectants must be evaluated in the long term. The present cross-sectional study demonstrated a slight change in light-cured resin

after exposure to 5.25% hypochlorite and 2% glutaraldehyde, which demonstrates that this material should be further investigated, as to its physical properties.

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