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Influence of a Peracetic Acid-Based Immersion on Indirect Composite Resin

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Abstract - *The aim of this study was to evaluate the influence of immersion in a 0.2% peracetic acid-based disinfectant on the three-point flexural strength, water sorption and water solubility of an indirect composite resin. Specimens were produced according to ISO 4049:2000 specifications and were divided in two groups: Control group, with no disinfection and Disinfected group, with three 10min immersions in the peracetic acid intercalated with 10min immersions in sterile distilled water. All evaluations were conducted in compliance with ISO specifications. Three-point flexural strength, water sorption and solubility of indirect composite resin before and after immersion showed no statistical significant differences (p>0.05) and met ISO standard requirements. Immersion in peracetic acid solution showed no influence in indirect composite resin tested properties.*

KEY WORDS: peracetic acid, flexural strength, water sorption, solubility, indirect composite resin.

INTRODUCTION

Resin-based composite (RBC) materials use has become widespread since their introduction to dentistry and more recent formulations have improved technically for placement for a range of dental indications. Direct RBCs are indicated for small, and medium sized cavities, however, for more extensive restorations, indirect composite resin restorations constitute a viable treatment option[1].

Indirect restorations are fabricated in the laboratory, then adjusted clinically at chair side, returned to the laboratory for finishing and polishing and finally returned to the clinic for cementation. The restoration is therefore handled by several different people before final placement in the patient's mouth. During handling of the indirect restorations and materials involved in their fabrication, some type of disinfection procedure is required to prevent cross-contamination. Impression materials are invariably contaminated by saliva, dental plaque and occasionally blood. Likewise, cast models constructed on non-disinfected impressions become contaminated and contaminate the prosthetic pieces constructed on them[2-4].

The indirect RBC is a thermosensitive material precluding thermal disinfection or sterilization. Disinfection of indirect RBC could be achieved using chemical disinfectants. Glutaraldehyde is widely used as a disinfectant, however it is a toxic substance causing severe tissue irritation and allergic responses. Sodium hypochlorite is an intermediate-level disinfectant, an unstable solution, eye and skin irritant, has a whitening effect in addition to a corrosive effect on metal structures[5,6]. The search for the ideal disinfectant has led to investigation of new substances as alternatives to the available disinfecting solutions, among which is peracetic acid. The peracetic acid is a biodegradable substance, not inactivated by organic matter, which presents a high microbicidal effect, and has a low occupational exposure hazard[7-9]. Peracetic acid-based disinfectants are used as a disinfecting or sterilizing agent by food industry, water and sewerage treatment companies, decontamination of plastic insulating materials and medical and dental equipment, devices and materials[10-11]. It is composed of hydrogen peroxide and peracetic acid and its mechanism of action involves release of free oxygen and hydroxyl radicals decomposing in oxygen, water and acetic acid[12].

Composites polymerized extra orally are materials that takes contact with the intact mucosa and should therefore undergo a disinfecting process. However, the effect of 0.2% peracetic acid disinfectant on the properties of indirect RBC is unclear. For viable and broaden application in dental practice, disinfectants should not only be effective but also not alter properties of the dental materials. The purpose of this study was to evaluate the influence of immersion in a 0.2% peracetic acid-based disinfectant on the three-point flexural strength, water sorption and water solubility of an indirect resin-based composite.

MATERIAL AND METHODS

Specimen Polymerization

The specimens were fabricated from BelleGlass HP indirect resin-based composite (Kerr Co., Orange, CA, USA; shade: opaceous dentin A_2), using the matrices specified for each assay according to ISO specifications. Initial polymerization was performed with a light-curing unit (Demetron LC; Kerr) with 600 mW/cm^2 output as measured by a curing radiometer (Demetron; Demetron Research Corporation, Danbury, CT, USA), for 20 seconds each curing cycle. As the

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initial polymerization was completed, the specimens were submitted to an additional 20-min polymerization in the previously heated BelleGlass HP Curing Unit (Belle de Saint Claire Products Line, Kerr, Orange, CT, USA), in a process that combines heat and nitrogen-pressured environment.

Immersion in Peracetic Acid-Based Disinfectant

The flexural strength, water sorption and solubility of BelleGlass HP indirect RBC were evaluated after immersion in a 0.2% acid peracetic-based disinfectant (STERILIFE[a]; Lifemed Produtos Médicos Comércio Ltda, São Paulo, SP, Brazil). The experimental specimens were soaked in the disinfecting solution for a total of 30 min, divided in three 10-min immersions intercalated with 10-min immersions in sterile distilled water. This study design intended to simulate the maximum challenge to which an indirect resin restoration would be submitted during the period comprising laboratory processing and clinical adjustments. According to the manufacturer's specifications, a 10-min immersion in the tested peracetic acid-based disinfectant is the appropriate and sufficient time to provide adequate disinfection. Specimens of the Control Group were not immersed in disinfection solution.

Three-point Flexural Strength Testing

The specimens were fabricated in compliance with ISO 4049:2000 standard specifications and the material was prepared according to the manufacturer's instructions. A split metal matrix was used to produce tetragonal slabs with the following dimensions: 25 ± 2 mm long, 2 ± 0.1 mm wide and 2 ± 0.1 mm thick. Five control and 5 experimental specimens (immersion in 0.2% acid peracetic-based disinfectant intercalated with immersion in sterile distilled water) were obtained. The specimens were stored for additional 24 hours in water bath at 37°C until three-point flexural strength testing. Specimen dimensions were measured using a metric micrometer with digital counter calibrated to 0.01 mm accuracy (Tesamaster; Tesa, Renens, Switzerland). The specimens were taken to a universal testing machine (DL 2000; EMIC, São José dos Pinhais, PR, Brazil) calibrated to provide a crosshead speed of 0.75 mm/min with 50 N load cell. The load applied at the point of fracture was recorded. Flexural strength (MPa) was calculated using equation 1:

$$\sigma = \frac{3.F.L}{2.b.h^2} \qquad (1)$$

where: F= maximum load, in N, exerted on the specimen; L= distance, in mm, between the supports, accurate to ±0.01 mm; b= width, in mm, of the specimen measured immediately prior to testing; h: height, in mm, of the specimen measured immediately prior to testing;

Water Sorption and Solubility

Water sorption and solubility assays were also performed according to ISO 4049:2000 standard specifications. Disc-shaped specimens (15 mm in diameter and 1 mm thick) were fabricated using a steel matrix and the material was prepared following the manufacturer's instructions. Five control and five experimental specimens were obtained.

The specimens were stored in a desiccator at 37°C containing silica gel freshly dried for 5 hours at 130°C, replaced with freshly dried gel after each weighing sequence. After 22 hours, the specimens were transferred to a second desiccator at 23°C for 2 hours and then weighed in an analytical balance (Sartorius, Goettingen, Germany) to an accuracy of 0.01 mg, constituting a weighing cycle every 24 hours.

The complete cycle was repeated until a constant mass (m_1) was obtained, i.e., until the mass loss of each specimen was not more than 0.1 mg *per* 24-hour cycle. A digital pachymeter (Vonder, Curitiba, PR, Brazil) accurate to 0.01 mm was used to measure the mean diameter and the mean thickness of each specimen. The area was calculated, in square millimeters, from the mean diameter and the volume was calculated, in cubic millimeters from the mean thickness.

Thereafter, the specimens were stored in water at 37°C for 7 days, the volume of water for immersion being at least 10 mL *per* specimen. After 7 days, the specimens were rinsed in water, waved in the air for 15 seconds to blot away surface water and weighed 1 min after removal from water. A second mass record was performed (m_2), i.e., the mass of the hydrated specimens. After this weighing, the specimens were returned to the first desiccator and the entire mass reconditioning cycle was repeated and the constant mass was recorded as m_3.

The values for water sorption and solubility, in micrograms *per* cubic millimeter, were calculated according equations 2 and 3, respectively:

$$Wsp = m2\text{-}m3/V \qquad (2)$$

$$Wsl = m1\text{-}m3/V \qquad (3)$$

where: m_1= mass of the specimen prior to immersion in water (µg); m_2= mass of the specimen, after immersion in water for 7 days (µg); m_3= mass of the reconditioned specimen (µg); V= volume of the specimen (mm^3)

STATISTICAL ANALYSIS

Flexural Strength, water sorption and solubility values were analyzed with independent *student t-test* at a significance level of 5% and compared with ISO 4049:2000 standard guidelines.

RESULTS

Flexural strength, water sorption and solubility values of the control group and experimental group (immersion in 0.2% peracetic acid-based disinfectant) are shown in Table 1. The results show that all specimens in both groups met ISO standard guidelines regarding the tested properties: minimum of 100 MPa for flexural strength; maximum of 40 µg/mm^3; maximum of 7,5 µg/mm^3. Statistical analysis with independent student *t-test* showed no significant differences between control and experimental group ($p>0,05$).

Table 1. *Flexural strength, Water Sorption and Solubility means and standard deviation of the control and experimental (immersion in 0.2% peracetic acid-based disinfectant) groups, and reference values required by ISO 4049:2000 standard.*

Groups	*Flexural strength (MPa)*	*Water Sorption (μg/mm³)*	*Solubility (μg/mm³)*
Control	158,6 (±10,3)[a]	11,5(±0,3)[b]	0,16 (±0,20)[c]
Experimental	159,7 (±6,9)[a]	10,9(±0,8)[b]	0,19 (±0,23)[c]
ISO Reference	Min 100	Max 40	Max 7,5

*Same letters in column shows no significant differences (p>0,05)

DISCUSSION

Indirect restorations are laboratory-processed and fabricated on stone casts. Leung and Schonfeld[2] have shown the contamination of stone casts and have assumed that they are sources of cross-contamination. If stone casts are poured from non-disinfected impressions, they might become contaminated and contaminate prosthetic appliances constructed on them[3,5].

Disinfection should ideally be a practical, accessible and rapid process. Ten-minute immersion in peracetic acid, as recommended by the manufacturer of the peracetic acid-based disinfectant, has been showed effective for high-level disinfection[7,10]. Taking into account that indirect restorations have to return to the prosthetic laboratory for fitting adjustments, a protocol simulating three 10-min immersions was used in this study, totalizing 30 min of disinfection, which would comprise a disinfection prior to clinical adjustments, another before sending the indirect restoration back to the laboratory and a final disinfection before cementation. This 30-min immersion period would be the maximum challenge to which an indirect RBC restoration would be submitted before final cementation into the patient's mouth.

The option for acid peracetic was based on the need for disinfecting laboratory-processed restorations allied to the advantages of this disinfectant like its biodegradability and easy disposal. In addition, the great disadvantages and limitations of the currently available disinfectants for dental use, such as glutaraldehyde and sodium hypochlorite, have also been taken into account for this choice[6,8,9]. According to the report of working party of the British Society of Gastroenterology Endoscopy Committee[7] and the findings of previous studies[6,12,13], acid peracetic is an effective microbicidal. Furthermore, it acts at low concentration, is active even in the presence of organic matter, in addition to being biodegradable[9,11].

The water sorption of methacrylate based composite resin could lead to the swelling of polymer producing polymer plasticization by separation of polymer chains decreasing its mechanical properties[14]. Thus, the solubility of these polymers could cause elution of unreacted components[14] of the composite that may diffuse through the dentinal tubules producing cytotoxic effects on pulp cells[15,16]. High mechanical strength of RBC is desirable to support the masticatory forces without cracking the restorations and the restored tooth.

CONCLUSION

In the present study, all specimens met ISO standard requirements, which therefore indicate that immersion in a peracetic acid-based solution did not materially interfere with the flexural strength, water sorption and solubility of the indirect resin-based composite evaluated. Thus the use of peracetic acid as a disinfectant for indirect resin-based composite restorations may be indicated after the laboratory work and before trial and/or cementation of the restoration without decreasing the properties of the indirect resin.

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