Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.intl.elsevierhealth.com/journals/jden

Longitudinal evaluation of simulated toothbrushing on the roughness and optical stability of microfilled, microhybrid and nanofilled resin-based composites

Eduardo Moreira da Silva *, *Juliana Dória*, *Juliana de Jesus Rodrigues da Silva*, *Guilherme Vinícius Santos*, *José Guilherme Antunes Guimarães*, *Laiza Tatiana Poskus*

Analitical Laboratory of Restorative Biomaterials – LABiom-R, School of Dentistry, Federal Fluminense University, Niterói, Rio de Janeiro, Brazil

ARTICLE INFO

Article history:
Received 15 June 2013
Received in revised form
15 August 2013
Accepted 21 August 2013

Keywords:
Resin-based composites
Simulated toothbrushing
Roughness
Optical stability

ABSTRACT

Objectives: The aim of this study was to evaluate the influence of simulated toothbrushing over ten weeks on the roughness and optical stability (colour, translucency and gloss) of microfilled – Mf (Durafil VS), microhybrid – Mh (Empress Direct) and nanofilled – Nf (Z 350) resin-based composites (RBC).

Methods: The roughness, colour, translucency and gloss of each RBC were measured before and after storage in distilled water (DW) and propionic acid (PA) for ten weeks. The specimens were removed from the media each week, submitted to toothbrushing simulation and the properties measured. The obtained data were analyzed using a multifactor analysis of variance (MANOVA) and Tukey's HSD test ($\alpha = 0.05$).

Results: The roughness significantly increased after ten weeks for the three RBCs ($p < 0.05$), with the final values of roughness presenting no statistical differences among them ($p > 0.05$). Only Mf and Nf immersed in DW and Mh immersed in PA presented a change in colour after ten weeks ($p < 0.05$), although the change in colour was lower after immersion in PA for the three RBCs ($p < 0.05$). None of the RBCs presented significant changes in translucency after ten weeks ($p > 0.05$). Only Mh immersed in DW presented gloss stability after ten weeks ($p > 0.05$).

Conclusions: Toothbrushing increased the roughness and diminished the gloss of the three RBCs. The translucency was not influenced by the toothbrushing. The immersion in propionic acid produced lower alterations in colour than did immersion in distilled water.

Clinical significance: In general, the three RBCs presented similar optical behaviours after toothbrushing over ten weeks. Thus, it is possible that anterior restorations produced with these materials will not present perceptible differences over time.

* *Corresponding author at*: Universidade Federal Fluminense/Faculdade de Odontologia – Rua Mário Santos Braga, n° 30 – Campus Valonguinho, Centro, CEP 24040-110 Niterói, RJ, Brazil. Tel.: +55 21 2629 9832; fax: +55 21 2622 5739.
E-mail address: emsilva@vm.uff.br (E.M. da Silva).

0300-5712/$ – see front matter
http://dx.doi.org/10.1016/j.jdent.2013.08.013

1. Introduction

Resin-based composites (RBC) are widely used as aesthetic restorative materials around the world.[1–4] Specifically, these materials are able to mimic the surface smoothness, colour, translucency and gloss appearance of dental tissues as closely as possible, thereby creating imperceptible restorations. In general, RBCs are constituted of a polymeric matrix of dimethacrylate monomers (Bis-GMA, TEGDMA or UDMA), inorganic filler particles (silica allotropes and synthetic glasses) coated with a methyl methacrylate-functional silane coupling agent to bond them to the organic matrix, and a photoinitiator system to permit photoactivation by light curing units.[5] All these phases influence the physical-mechanical properties of RBCs.

Currently, RBCs are classified according to the features of their filler particles as hybrid, microfilled and nanofilled.[1] Moreover, it is well established that the filler particles can influence the optical behaviour of these materials.[6,7] Published studies have shown that the roughness of microfilled and nanofilled RBCs are better than hybrid RBCs.[8–13] Therefore, clinicians believe that microfilled and nanofilled RBCs are more suitable to be used as the superficial layers in anterior restorations. However, in the oral environment the RBC surfaces are exposed to erosive substances presents on foods and beverages and to the abrasive effects of toothpastes and toothbrushing. Thus, it is possible that the synergistic effect of abrasion and erosion phenomena will roughen all RBC materials over time, irrespective of their filler particles. The result of this surface roughening can be a decrease in gloss and an increase in colour changes, both of which can affect the aesthetic appearance of the restorations.

The RBCs suffer colour changes due to intrinsic and extrinsic factors. Extrinsic factors include biofilm accumulation,[14] consumption of staining beverages,[15,16] effect of tobacco[17,18] and poor surface finishing,[19] among others. This last factor, which is within the clinician's control, provides that a more rough RBC surface produces a greater ability for colour changing of an RBC. Furthermore, a better polished RBC surface would have an improved surface gloss.[20]

A recent study did not show correlation between the colour change of RBCs and water sorption.[21] On the other hand, other studies have shown that organic acids produced by the oral biofilm, e.g., propionic and lactic acid, produced higher sorption and solubility of RBCs than distilled water.[22,23] Thus, it seems to be relevant to evaluate the effect of propionic acid on RBC properties when taking into consideration that this material is widely used to restore class V cavities, which is the area closest to the gingival sulcus and provides a higher concentration of organic acids produced by the oral biofilm.

Although the current literature presents results regarding the effects of toothbrushing upon the optical properties (colour, translucency and gloss) of RBCs,[9,24–28] there is still a lack of longitudinal data on this field. Therefore, the aim of this present study was to evaluate the roughness and the optical stability (colour, translucency and gloss) of microfilled, microhybrid and nanofilled RBCs submitted to simulated toothbrushing over a period of ten weeks. The null hypothesis tested was that, irrespective of media immersion, there would be no difference in the final properties of the three RBCs after ten weeks of toothbrushing.

2. Materials and methods

Three resin composites were chosen in accordance with their type of filler particles and were evaluated (Table 1). The materials were bulk inserted into a stainless steel mould, measuring 9 mm in diameter and 2 mm in height. The mould was covered with a polyester strip and a glass slide (0.7 mm thick) and the resin composite was light activated with a quartz-tungsten-halogen unit (Optilux 501, Demetron Inc., Danbury, CT, USA) using an irradiance of 650 mW/cm^2 for 40 s (26.0 J/cm^2). After removal from the mould, the specimens were light activated from the bottom surface using the same parameters. Ten specimens were prepared for each composite. After 24 h of dry storage at 37 °C, the top and the bottom surfaces of the specimens were sequentially wet polished with 1200 and 4000 grit Sic paper (DPU-10, Struers, Copenhagen, Denmark).

2.1. Baseline measurements

2.1.1. Roughness

All of the specimens had their surface roughness evaluated using a surface roughness tester (Surftest SJ 201, Mitutoyo, Tokyo, Japan). Three traces of roughness spaced at 120°, with a 0.8 mm cutoff and a speed of 0.1 mm/s, were recorded for each specimen, and the average surface roughness (R_a – μm) was determined. The R_a parameter was obtained using the following formula:

$$R_a = \frac{1}{L}\int_0^L f(x)|dx$$

where L is the length of the section and $f(x)$ is the displacement function.

2.1.2. Colour and translucency

The colour of all specimens was measured according to the CIE $L^*a^*b^*$ system by using a spectrophotometer (model CM2600d, Konica Minolta Sensing Inc, Osaka, Japão). A D65 illuminant was used with a 45° entrance angle and 0° observation angle geometry. Before each measurement session, the spectrophotometer was calibrated according to the manufacturer instructions and using the provided white calibration standard. In order to guarantee the consistency of consecutive and repeated measurements of CIE $L^*a^*b^*$ parameters, a device was developed that was precisely attached to the base unit of the spectrophotometer and where a white and a black spectrophotometry ceramic standards (Konica Minolta Sensing Inc, Osaka, Japão) were positioned. This procedure allowed the colour to be consistently measured in the central area and at the same position for all the specimens. The L^*, a^* and b^* values of each specimen were separately measured in triplicate against the white and the black background.

2.1.3. Gloss

Gloss, expressed in gloss units (GU), was measured using a small-area glossmeter (ZGM 1110, Zehntner testing instruments, Sissach, Switzerland), with a square measurement