"*In vitro*" surface roughness of different glass ionomer cements indicated for ART restorations

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Abstract

Aim: The aim of this *in vitro* study was to evaluate the surface roughness of three glass ionomer cements (GICs) indicated for ART restorations. **Methods**: Ten cylindrical specimens of three commercial glass ionomers cements (Vidrion R - S.S. White, Maxxion R - FGM and Vitromolar DFL) were prepared (n=30) without surface finishing or protection. Twenty-four hours after preparation, the surface roughness measurements were obtained as the mean of three readings of the surface of each specimen by profilometry. The roughness values (Ra, μm) were subjected to one-way ANOVA and Tukey's test (p<0.05). **Results:** No statistically significant differences were observed between Vidrion R (0.18 ± 0.05) and Vitromolar (0.21 ± 0.05), whereas Maxxion R presented significantly higher roughness values than those of the other materials. **Conclusions**: It may be concluded that characteristics of particle size and composition of the different GICs affected their surface roughness 24 h after preparation.

Keywords: roughness, profilometry, glass ionomer cements, ART, restorative dental materials.

Introduction

When first introduced in the 1970's, glass ionomer cements (GICs) were used as a lining material or as the basis for restorations[1]. However, alterations to its composition and the powder/liquid ratio affected their mechanical properties, handling time, setting time, consistence and wear, improving the feasibility and application of these conventional fast-setting ionomeric cements in clinical practice. These materials are particularly effective in the atraumatic restorative treatment (ART) and in places lacking the conventional infrastructure needed for clinical treatment[1-5].

The properties of GICs, comprise a coefficient of thermal expansion similar to that of dentin[2,6-7], lower volumetric contraction during the setting reaction[7], chemical adherence to the dental strucutre[2,6-8], biocompatibilty with the pulp tissue[7,9], fluoride release and cariogenic action[2,6-8,10.11], and antimicrobial activity[5,11]. However, bond strength and resistance to wear are rather limited, especially for conventional restorative GICs and fast-setting or high-viscosity GICs, in comparison to amalgam and modern resin composite materials. These properties are also affected by their composition and the acid-base reactions between the inorganic portion of the powder and the organic portion of the carboxylic acids used, the size and number of vitreous particles, and the number and size of bubbles present in the material[12-14].

Mair et al.[15] defines wear as the last consequence of the interaction between the surfaces, leading to the steady removal of the material. Clinically, surface roughness must be observed, as it plays a decisive role in the retention and accumulation of dental biofilm[16]. Surface roughness has been used as a criterion to foresee and evaluate the deterioration of restorations made from different materials. While surface roughness of aesthetic materials *in vivo* is put down to mechanical abrasion, attrition and erosion, most of the current *in vitro* studies have evaluated surface roughness after mechanical abrasion and polishing[16]. Bollen et al.[17] reported that, on a rough surface, the microorganisms are less exposed to the dislocation forces and have the necessary time to adhere to this structure. The surface and the border of the restorative materials, when colonized by cariogenic bacteria, especially *Streptococcus mutans*, favor the development of caries and future damage to the dentin-pulp complex[10-11,18].

Profilometry is the measurement of the surface height variation of an object. It can be used to determine measurements of surfaces, shape and roughness. This latter requires instruments with both high lateral (x axis) and vertical resolution (z axis). This in vitro study used profilometry to evaluate the surface roughness of a conventional restorative GIC and two fast-setting GICs, 24 h after preparation of the materials.

Material and methods

The glass ionomer cements used in this study are presented in Table 1. Ten disc-shaped specimens of each material were fabricated using a matrix with diameter of 6.0 mm and a 4.0-mm-deep cavity. The materials prepared following the manufacturer's instructions by a previously calibrated operator at room temperature (approximately 23°C) and 50% relative air humidity (Humidity/Temperature Meter – HT – 3003 – LT Lutron).

The matrix was placed on a glass plate with a polyester strip (K-dent, Quimidrol) interposed between the matrix and the glass plate. The materials were mixed and inserted in the matrix cavity using a Centrix injector until it was completely filled, and was then covered with another polyester strip and a glass plate[18-21]. A uniform pressure was applied and excess material was removed, leveling of the cement with the top of the matrix.

After 10 min, the polyester strips were removed, and the specimens were stored in 100% humidity, without any surface

protection, finishing or polishing. After 24 h of storage under these conditions, surface roughness was evaluated using the Form Talysurf Series 2 profilometer[22]. The Form Talysurf series 2 instrument consists of a mechanical profilometer in which a mechanical transducer is dragged across a surface and its movement in a vertical direction is recorded to obtain a surface profile[22].

For every reading made, the mean roughness value (Ra, mm) was represented by the arithmetic mean between the peaks and valleys registered, after the needle of the profilometer had scanned a stretch of 3.1mm in length, with a *cut-off* of 0.25mm to maximize the filtering and the undulation on the surface. Each surface was read three times, always with the needle scanning the geometric center of the specimen, starting from three different points[13,21]. The mean value of the three readings yielded the mean value of the roughness of each specimen. Subsequently, a 3D image (Form Talysurf Series 2 profilometer) of the surface profile of the specimens was obtained.

The roughness mean values (Ra, μm) were subjected to one-way ANOVA) and Tukey's test at a 5% significance level.

Results

The roughness mean values (Ra, μm) and standard deviations obtained for the tested materials were as follows: Vidrion R: 0.18 (0.06), Vitromolar: 0.21 (0.06), and Maxxion R: 0.73 (0.38).

The one-way ANOVA and Tukey's showed that Maxxion R presented the highest roughness mean values and differed significantly from the other materials (p < 0.05). There was no statistically significant difference (p > 0.05) between Vidrion R and Vitromolar.
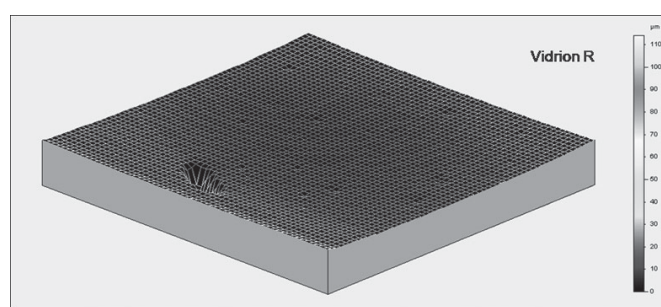

Fig. 1. 3D image of the profile of the glass ionomer cement Vidrion R.

Table 1 – Brand, Manufacturer and powder-liquid ratio of the materials used.

| Brand	Manufacturer	Powder-liquid ratio	Basic composition	Particle size
Vidrion R	SS White Artigos Dentários Ltda(Rio de Janeiro, RJ, Brazil)	1:1	Sodium fluorosilicate, calcium aluminum, barium sulfate, polyacrylic acid, pigments, tartaric acid, distilled water	<75μm
Vitromolar	DFL Indústria e Comércio Ltda(Rio de Janeiro, RJ, Brazil)	1:1	Aluminum and barium silicate, dehydrated polyacrylic acid, ferric oxide, polyacrylic acid, tartaric acid, distilled water	<10μm
Maxxion R	FGM Produtos Odontológicos (Joinville, SC, Brazil)	1:1	Fluoraluminosilicate glass, calcium fluoride, water	±12.5μm

*Information from manufacturers
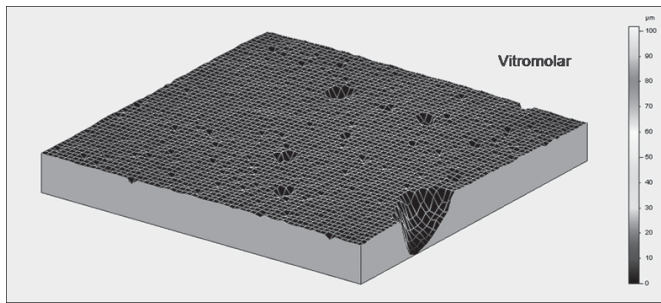
Fig. 2. 3D image of the profile of the glass ionomer cement Vitromolar.
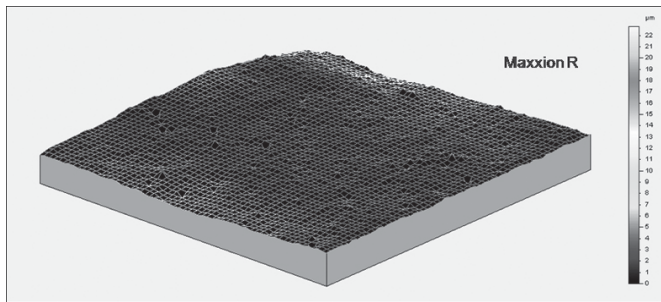

Fig. 3. 3D image of the profile of the glass ionomer cement Maxxion R.

Discussion

GICs have becoming widely used in dentistry due to their properties of adherence, biocompatibility, aesthetics, fluoride release and similar linear thermal expansion to dentin, and because of their clinical uses in both primary and permanent teeth[1-2,4-9]. As a result, the study of their biomechanical properties and clinical applications is important for the evaluation and prediction of the clinical behavior of these cements.

According to the methodology adopted in this study, the specimens were kept for 24 h in an environment where the relative humidity of the air was about 100%, without any protection, finishing system or polishing. Sidhu et al.[23] reported that the cover or finishing used in clinical procedures may veil the characteristics of the material in laboratory experimentations. The best evenness of the surface was attained when the materials were cured in contact with the polyester strip[18-21]. While the setting reaction of GICs is taking place, links are formed between the carboxylic acids (liquid portion) and the alumina cations and/or the inorganic part yielded by the powder (solid portions). These reactions play a role in forming the ionomer, while the others act as reinforcement particles[12,24].

According to the present study, the surface roughness mean values for the conventional restorative GIC (Vidrion R) proved to be lower when compared to the other ionomeric cements. According to Rios et al.[25], the GICs, whose consistence is more fluid during handling and insertion, produce a decreased surface roughness, which may be caused by the greater portion of its gel matrix. Mair et al.[15] observed that the distribution and morphology of the inorganic particles are an important factor in determining surface roughness. The lack of significant differences between Vidrion R and

Vitromolar might be attributed to the similar size and location of the inorganic particles in these materials, despite the differences in their consistency and mechanical properties[4]

Although Vidrion R presented the lowest roughness mean values in the present study, the worse mechanical properties and high solubility of this material restricts its use in the ART technique[4,25-26]. On the other hand, the conventional high-viscosity GIC, which present better mechanical properties and ART indication, presented higher roughness mean values in this study, especially Maxxion R. It is important to point out that, as the surface hardness of GICs is inversely proportional to its wear, the conventional high-viscosity GICs are harder and display reduced surface wear, preserving the initial roughness pattern[12,26-27]. The exception was observed for Maxxion R, suggesting that this behavior may be related to the size and shape of glass particles on its surface[21].

Leitão and Hegdahl[28] reported that the surface is considered rough when it bears peaks and valleys of great amplitude with reduced undulation. The value of the surface roughness (Ra) considered critical for the retention and adherence of microorganisms is equal to 0.2 μm[17]. In this study, two GICs yielded results aligned with the parameters acceptable for surface roughness: Vidrion R (0.18 ± 0.05) and Vitromolar (0.21 ± 0.05), showing evidence of a greater susceptibility to biofilm retention, where the value of 0.2 μm is used as a reference. In contrast, the surface roughness of Maxxion R (0.73 ± 0.38) was much higher than expected, increasing its potential for the adherence of microorganisms. Figures 1-3 show the roughness 3-D images obtained for each material used in this study. It is possible to observe that Figures 1 and 2 illustrate a smoother surface than Figure 3. These results are in agreement with the roughness values obtained.

The study of surface roughness is important due to the fact that this property affects light reflection, color fading, appearance of cracks and aesthetics, in addition to favoring biofilm accumulation[13,17]. Increased surface roughness results in substantial biofilm accumulation, thus aggravating the risk of carious lesion and periodontal disease[17,25].

Since the surface roughness of GIC must be carefully observed when it comes to choosing the material, it is vital for the professional to analyze laboratory and clinical requisites such as surface microhardness, mechanical resistance, solubility, setting time and work, ease of handling, in addition to location and extension of the cavities in relation to the chewing load and, finally, the clinical durability of the restoration.

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