In vitro Study Regarding the Wearing of Glass Ionomer Cements

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The purpose of this study is to assess the effects of artificial saliva with different pH on the wearing of glass ionomer cements. We used three types of glass ionomer cements and three immersion environments. We have prepared a total of 96 samples. We used 6 artificial saliva samples for each environment. Each sample was immersed in the storage solution to a specific pH. Storage solution was changed on days 1, 7, 14 and 28. Glass ionomer cements are influenced by the storage media, showing significant changes in the case of an acidic environment (in our case, artificial saliva with different pH). As long as the material is tolerated and protected by the tooth structure, resistance to abrasion will be satisfactory.

Keywords: glass ionomer cements, pH, artificial saliva, wearing

In general terms, wear and tear can be defined as a consequence of the interaction between moving surfaces, resulting in gradual removal of material. [1] The etiology of this process involves a combination of mechanical strength and chemical dilutions. The most common processes of wear and tear are abrasion, weariness and corrosion. [1, 2] An important factor in understanding the mechanisms of the attrition of dental materials is the synergistic interaction of these types of wear and tear [1, 3, 4].

Corrosive wearing can be connected to a chemical reaction that produces a surface layer that can be removed by contact with the antagonist [2, 4]. Chemical dissolution that occurs during corrosive wearing can be caused by exposure to chemicals in beverages, microorganisms and saliva [2, 3, 5-7]. Thus, resin-based materials may present roughened surfaces that determine the surface to be more susceptible to physical forces that occur during attrition and abrasion.

Wearing of resin based materials can be influenced by various factors: load applied [8], aging, degree of polymerization, the organic matrix type, the type and content of sealant particles [9, 10] and environmental conditions (pH) [2, 3, 11, 12].

Despite their many advantages, glass ionomer cements have disadvantages as well: they are brittle, have low mechanical strength and poor abrasion resistance, all of which have restricted their use to only some current low stress areas such as class V and III injuries [13, 14].

Glass ionomer cement is a water-based material, which consolidates through a reaction of acid-base, between the fluoro aluminosilicat powder and a polyacid aqueous solution. During the fixing process, the protons of the carboxyl group-containing polyacid attack the glass surface of the fluoro aluminosilicat particles of Ca, resulting in releasing of Ca ions, Al ions and F ions [15, 16]. The longevity of dental restorations depends on durability of the material and its properties such as resistance to wearing, durability of the tooth-restoration connection and the destruction degree of the tooth. The finishing of the restoration surface is important from the point of view of the plate retention, of the restoration colour and the patient comfort.

Jones et all have shown that patients can detect and distinguish between the levels of surface roughness from 0.25 to 0.50 μm. They concluded that the restoration should be finished to a maximum roughness of 0.50μm to be detectable by the patient tongue [17].

The purpose of this study is to assess the effects of artificial saliva with different *p*H on the wearing of glass ionomer cements.

Experimental part

Experimental draft.

In this study we used three types of glass ionomer cements and three immersion environments.

We have prepared a total of 96 samples. We used 6 artificial saliva samples for each environment.

Each sample was immersed in the storage solution (3 mL) to a specific *p*H. Storage solution was changed on days 1, 7, 14 and 28.

Preparation of specimens.

Materials used in this study are presented in the following table 1. All materials were prepared according to manufacturer instructions.

Right after mixing, the materials were inserted into the celluloid mold having a diameter of 15 mm and a thickness of 2 mm. Slightly overfilled molds were covered with a strip of celluloid and a glass plate and then pressed under a load for 30 s to remove excess material. After removing the weight, and the glass plate, the suggested materials have been polymerized, the following the recommended

Tested material	Type of material	Powder/liquid ratio
S 1 (Ketac Molar, Espe)	Conventional glass inomer cement (CGIC)	3.0g : 1.0g
S 2 (Dyract , Dentspy)	Polyacidly modified composite resin (PAMRC)	-
S 3 (Vitremer, 3M)	Glass imoner cement modified with resin (RMGIC)	2.5g : 1.0g

Table 1
TESTED MATERIALS

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All authors had equal contributions in accomplishing this work.

Tested material	Weight loss	Standard deviation
S1	1.4905	1.0345
S2	2.3230	1.1056
S3	1.8934	0.1381

Table 2
AVERAGE VARIATIONS OF WEIGHT LOSS OF SPECIMENS

polymerization time by the manufacturer. Finishing and polishing were performed by means of sequences of grinding superfine, fine and medium (Sof-Lex) wheels. The instrument was used in one direction for 15 s.

Conventional glass ionomer cement was immediately protected with a nail varnish, while the specimen-modified ionomer resin with Finishing Gloss (3M ESPE). After preparation, all the specimens were placed at 37°C in relative humidity for 24 h.

The surface of each sample was measured accurately, to obtain the standard size sample. The average size was about 200x2 = 400 mm^2. The total weight of all samples was assessed with an electronic balance.

Used artificial saliva.

Artificial Saliva had the following composition: NaCl, 0.400g; KCl, 0.400g; $CaCl_2H_2O$, 0.795g; NaH_2PO_4 0.69g; $Na_2S \cdot 9H_2O$, 0.005g; urea 1.0g; distilled water 1000mL. The *p*H was adjusted to 3, 7, 9 with NaOH or HCl and the volume brought up to 1 liter.

Determination of surfaces roughness

Each specimen was dried with absorbent paper, and surface roughness measurements were made through with profilometer device. Diamante head of Profileograph was scheduled to perform 10 parallel routes at equal distances along the surface of each specimen, starting from a predetermined point.

Surface roughness was recorded as the average (R_a) of the 10 recordings. The length of the routing was 5 mm, in which a portion of 0.5mm fell in the first part and the last part of the section. Measurements at the material surface, and analysis were repeated at 1, 7, 14 and 28 days. Average roughness per specimen was considered the average of the 10 records of routes.

Statistical analysis

Results were analyzed according to the single criterion into a single direction and Tukey and ANOVA tests with a significance level of $p < 0.05$ to highlight morphological changes in the specimens surface of glass ionomer cement used in our research.

Results and discussions

The specific mass of each specimen made of the three restorative material (cement conventional glass ionomer glass S1, S2 polyacid modified composite resin, cement, resin modified glass ionomer S3) was measured using an electronic balance, every 24 h, up when the specimens had a stable weight in 5 successive measurements, which was considered the initial weight. At the same time the surfaces roughness was determined and analyzed.

The surface roughness was characterized by a R_a parameter height (μm) defined as the arithmetic mean of the absolute values of the profile deviations from the length.

Wearing was measured by weight loss. The analyses were based on the difference between the initial weight and the final weight for each specimen.

The results were analyzed according the single criterion in one sense, ANOVA and Tukey test with a significance level of $p < 0.05$.

Variations in the adjusted mean (standard error) in the percentage of weight loss for each test material are presented in table 2.

Average R_a values of all the materials tested in the reference and subsequent exposure to different storage media with artificial saliva at different *p*H and different time intervals are presented in the graphs below.

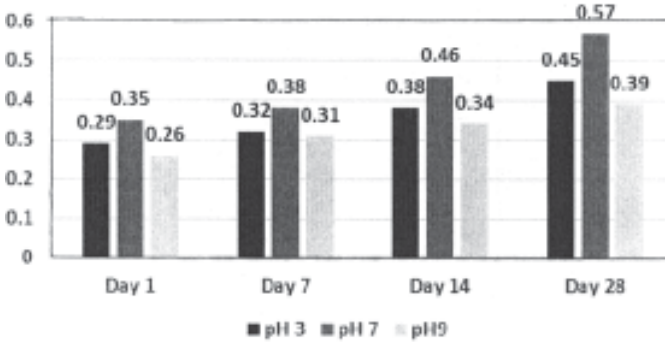

Fig. 1. Roughness values (μm) for S1 material immersed in SAL with different pH

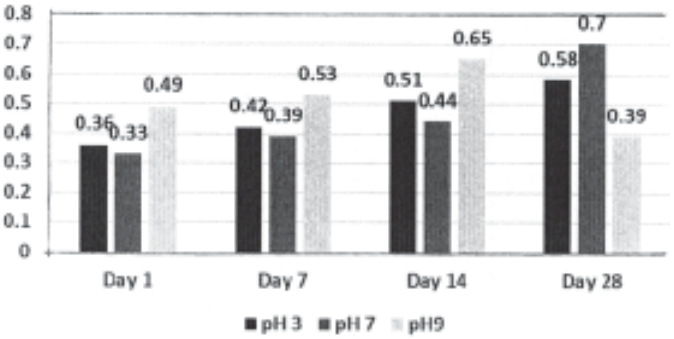

Fig. 2. Roughness values (μm) for S2 material immersed in SAL with different *p*H

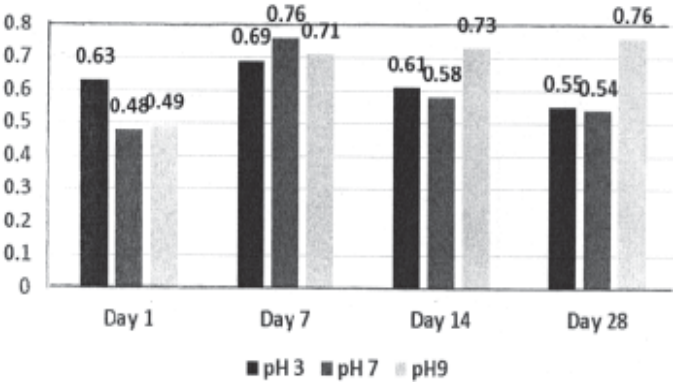

Fig. 3. Roughness values (μm) for S3 material immersed in SAL with different *p*H

The results obtained can be compared with other studies that address a similar problem.

Abrasion rate depends on several factors, but we can say that an important factor can be the *p*H of the storage medium. The resistance depends on the inherent properties of the material [17, 18] .

In fact, the differences between the material regarding the wearing are likely to be the result of several factors. One of these factors is the characteristic of the mold, which is formed by a reaction acid-base of the polyacid

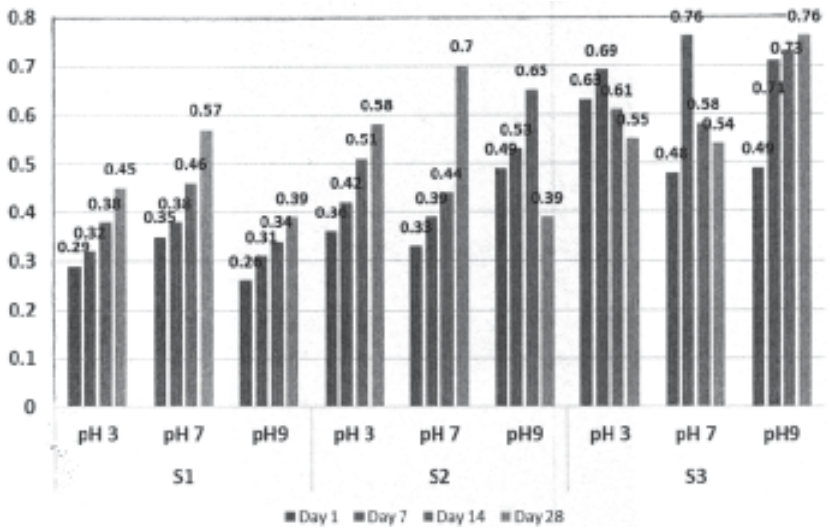

Fig. 4. Roughness values (μm) of the tested materials immersed in artificial saliva with different pH values at 1, 7, 14, 28 days

with ions of metals (the conventional ionomer cements), through a network of overlapping polymers, and combining the acid-base reaction with the polymerization of the monomer system, or by the additive action of the polymer in the case of RMGIC. Another factor is the rate and size of the inorganic glass particles as well as the formation of air bubbles during the preparation of the materials [19 - 21] .

The materials which showed the worst results of roughness after immersion in artificial saliva with different *p*H values were those with a higher liquid content than the powder. A possible explanation may be that the decrease of material glass particles increases the susceptibility to erosion, causing a pronounced shift of inorganic particles, and a more pronounced exposure of air bubbles incorporated during mixing [22-24].

Chemical degradation after immersion in artificial saliva was restricted to the superficial layer of the material examined, and our methodology has not been able to quantify depth changes and degradation processes.

It is expected that an increase in abrasion of the surface to produce a faster colonization and maturation of dental plaque, thus increasing the risk of cavity processes, although glass ionomer cements have anti-cariogenic action due to the release of F ions.

The subject was also studied in [25].

Conclusions

Strength of materials depends on their inherent properties. The differences in wear and tear between different materials is due to several factors.

Glass ionomer cements are influenced by the storage media, showing significant changes in the case of an acidic environment (in our case, artificial saliva with different *p*H).

As long as the material is tolerated and protected by the tooth structure, resistance to abrasion will be satisfactory.

Changes in surface roughness and wearing rate cannot fully specify the clinical behaviour of the materials studied.

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