SURFACE ROUGHNESS OF THREE DIFFERENT GLASS IONOMERS WITH OR WITHOUT FINISHING/POLISHING: AN *IN VITRO* STUDY

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ABSTRACT

Purpose: This study aimed to compare the surface roughness among 3 types of glass ionomers (GI) before (no polishing) and after polishing with three different materials. **Methods**: 20 discs for each GI group were obtained (A-Ionolux; B-IonoStar Plus; C-Ketac). Those groups were subdivided according to finishing and polishing: subgroups 1 (control) - no polishing, 2 - polishing with prophylactic brush and pumice paste, 3 - Enhance tips with water, and 4 - Sof-Lex system with Easy Glaze and polymerization. For each disc face, the total distance analyzed was 2.88cm (6x48mm). Then, the roughness was compared using the Kruskal-

Wallis with Bonferroni test, with significant data if $p<0.05$. **Results**: The mean of roughness within Group A was lower for subgroup 4 (1.07±0.54 μm) and higher for subgroup 2 (2.33±1.17 μm). Within group B, B4 had the lowest mean of roughness (0.93±0.38 μm) and B2 (1.24 ± 0.78 μm) the highest roughness. Within group C, Group C4 had the lowest mean roughness value (0.84±0.54 μm), and C3 had the highest mean (2.48±1.05 μm). After polishing, subgroup 4 had the general lowest values for surface roughness (mean Ra 0.95), followed by subgroup 1 (Ra=1.27), subgroup 2 (Ra=1.89), and higher values for subgroup 3. All intragroup analysis for A, B, and C were statistically significant. Group A presented the highest roughness ($p<0.05$), and no statistically significant evidence existed between groups B and C ($p>0.05$). **Conclusion**: The reduction of the roughness of the materials is dependent on their composition and the polishing and finishing techniques applied.

Keywords: Glass ionomers; Surface; Roughness; Polishing; Finishing

INTRODUCTION

For several years, dental restorations were made with materials that required retentive preparations, which implied the removal of the healthy dental structure, and were considered non-esthetic. In the mid-50s, with the incessant search to improve the esthetical results respecting dental tissues, there was the application of the first biocompatible silicate material, named glass ionomer (GI), which also could release fluoride (CHISINI et al., 2018). Currently, GI is a restorative material regularly applied in conservative pediatric techniques, besides being used as a restorative material, cavity lining, and cement (CROLL AND NICHOLSON, 2002; FOOK AND AZEVEDO, 2008; SILVA et al., 2011; KHOROUSHI AND KESHANI, 2013; GEBHARD, 2016; PARGAONKAR et al., 2018). Therefore, it has undergone evolutions, and there are wide varieties, differing in how to apply, its composition, and its indications (GEBHARD, 2016).

GIs are classified according to the clinical use (GEBHARD, 2016), and their similarities with dental structures, biocompatibility, lower sensitivity in the application protocol, chemical foreplay, and fluoride absorption/release (up to 1 year after application) make this material the "gold standard" for Pediatric Dentistry (SILVA et al., 2011). Also, GI is the material of choice to perform Atraumatic Restorative Technique (ATR) treatments since it presents a simple clinical application protocol, is less sensitive to moisture, and releases and captures fluoride from the oral cavity. The current GIs present better physical characteristics and a reduction in the setting time (CROLL and NICHOLSON, 2002). Otherwise, marginal adaptation and the lower non-esthetic profile are complicated compared to composite resin, which are their most significant disadvantages (Hassan, 2020). Therefore, the application of protecting material on the GIs may lead to an improved longevity of the restorative biomaterial in a complexed oral environment (KHAN et al., 2016).

A level of evidence of GI/techniques for deciduous dentition was published as guidelines by the American Association of Pediatric Dentistry (PRD – AAPD, 2022), according to the Black's classification for carious lesions, reporting strong evidence to use GI in class I, based on ART trials; for class II, it was found contrary evidence due to conflict with multi-surface ART restorations; the favorable recommendation was found for classes III and V, whereas no data was reported for class IV.

GI powders predominantly comprise silicate glasses, fluoride, and calcium ions. Particles do not exceed 15 µm for GI used for cementation and 50 µm for GI used for restoration (RODRIGUES, 2014). GI liquid is the reaction's acidic component, consisting of an aqueous solution of polyacrylic acid of approximately 40 to 50% concentration. The improvement of the properties, the increasing working time, and the delay in the hardness are directly linked to the presence of tartaric acid. Therefore, each manufacturer can provide different compositions and proportions of powder and liquid (NICHOLSON, 1998; RODRIGUES, 2014; GEBHARD, 2016). This fact interferes directly with many GI characteristics, such as roughness. The surface roughness (Ra) of GI materials permits a greater accumulation of biofilm, a greater risk of caries, adverse effects on the brightness of the material, periodontal inflammation, loss in the quality and esthetic of the restoration, and consequently, its longevity (BOLLEN et al., 1997).

However, there are forms of treatment for the surface that led to decreased roughness, such as polishing, finishing, brushing, and compression of the material with dies during placement (DA MATA, 2012; BESSA, 2021). Moreover, the application of protective agents, such as varnishes, bondings, and glazes, improves the smooth surface of the GI and allows to preserve of the material against moisture, better filling the porosities (ZANCOPÉ et al., 2009; BRITO et al., 2012; ALMEIDA et al., 2017).

Finishing is a process that eliminates defects in the surface of materials and marginal irregularities, promoting smoothness and consequently decreasing Ra and a possible pigmentation of the restoration (JEFFERIES, 2007; ALMEIDA et al., 2017). While polishing is the step that follows finishing and reduces the Ra by eliminating imperfections resulting from the finish, producing a macroscopically uniform, smooth, and bright surface (JEFFERIES, 2007; JANUÁRIO, 2016).

Thus, this investigation aimed to compare the surface roughness values among 3 types of glass ionomers (Ionolux®, IonoStar Plus®, and Ketac®) before and after finishing/polishing. Specifically, evaluate the surface roughness quantitatively without any polishing and after polished with a prophylactic brush and pumice paste, or an abrasive tip or Sof-Lex® with glaze and polymerization system. The first null hypothesis was that no statistical difference for roughness was found between modified GIs (Ionolux® and IonoStar Plus®) compared to the conventional GI (Ketac®); and, secondarily, polishing/finishing did not improve the surface roughness. This in vitro experimental test can validate and bring reasoned data and information that can assist clinicians in choosing the most suitable GI for each clinical situation.

MATERIALS AND METHODS

Sample composition and distribution

Six cylinders pieces were designed in the Autodesk MeshMixer® (Autodesk, Inc., Mill Valley, CA, U.S.A.) software with the dimensions of 20mm in diameter x 3mm in height and then segmented and prepared for 3D printing (Anycubic photon S) in the Lychee Slicer® software (Mango3D). The parts were processed with monocure rapid gray resin, which limited the materials.

From these printed cylindrical parts, 60 discs of three distinct commercially available GI were obtained: 20 discs of resin-modified glass ionomer (Ionolux®, VOCO, Germany) – Group A; 20 discs with high viscosity of GI (IonoStar Plus®, VOCO, Germany) – Group B; and 20 discs of conventional GI (Ketac®, 3M, ESPE, USA) – Group C.

Then, those groups (A, B, and C) were subdivided into subgroups (1, 2, 3, and 4): G1 (control) - no polishing; G2 - polishing with prophylactic brush and pumice paste; G3 - Enhance® tips on refrigeration; G4 - Sof-Lex® system with Easy Glaze® and polymerization. The description of the type of GI, the type of polymerization, and the mixing system is shown in Table 1.

Table 1. Overview of glass ionomers under study.

Group	Materials	Type	Polymerization	Mixing System
A	***Ionolux®*** (*VOCO GmbH, Germany*)	Modified by Resin	Light-cured material	Self-mixing
B	***Ionostar Plus®*** (*VOCO GmbH,* Germany)	High Viscosity	Auto-cured Material	Self-mixing
C	***Ketac®*** (*3M ESPE*, USA)	Conventional	Auto-cured Material	Self-mixing
1	Control	No polishing	-	-
2	Pumice paste	Polishing with prophylactic brush and pumice paste	-	-
3	Enhance® tips	Polishing	-	-
4	Sof-Lex® system with Easy Glaze®	Polishing after polimerization	-	-

Sample preparation

The materials used correspond to unit doses of 0.14 ml of GI in capsules previously activated to obtain a homogeneous mixture that requires a mixer. The disc confection protocol was similar for the 3 GI; only the activation of group C requires an Aplicap® activator. The protocol followed the steps: (i) slightly Vaseline the glass plates on both sides to avoid excesses that can cause roughness capable of interfering with measurements; (ii) Vaseline, also, the inner and outer surface of the parts; (iii) place a first plate flat with the overlapping parts; (iv) activate and mix each resin as indicated by the manufacturer; (v) insert the Ionomer with the applicator to complete the inside of the workpiece; (vi) place an additional plate on the discs; (vii) compress until the material completely occupies the inside of the workpiece; (viii) wait for the ionomer's polymerization time; (ix) remove excesses and remove from the disc; (x) restart the protocol to reach the number of discs desired (Fig. 1). Individualized explanation of the methods applied is in Suppl. Table 1, as well as the protocols for polishing and finishing, is in Suppl. Table 2. A diagram was done with the distribution of the sample and the respective techniques applied to each group (Fig. 2).

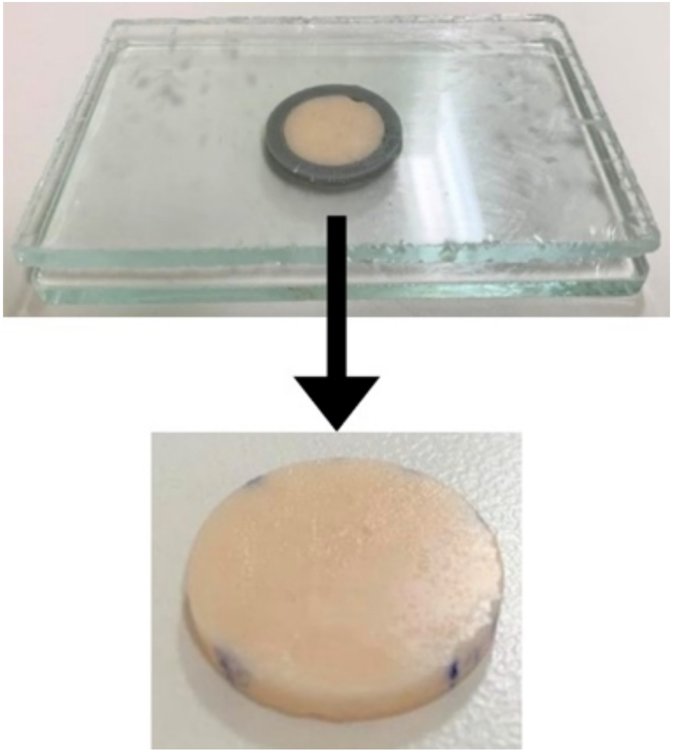

Figure 1. Preparation of the samples.

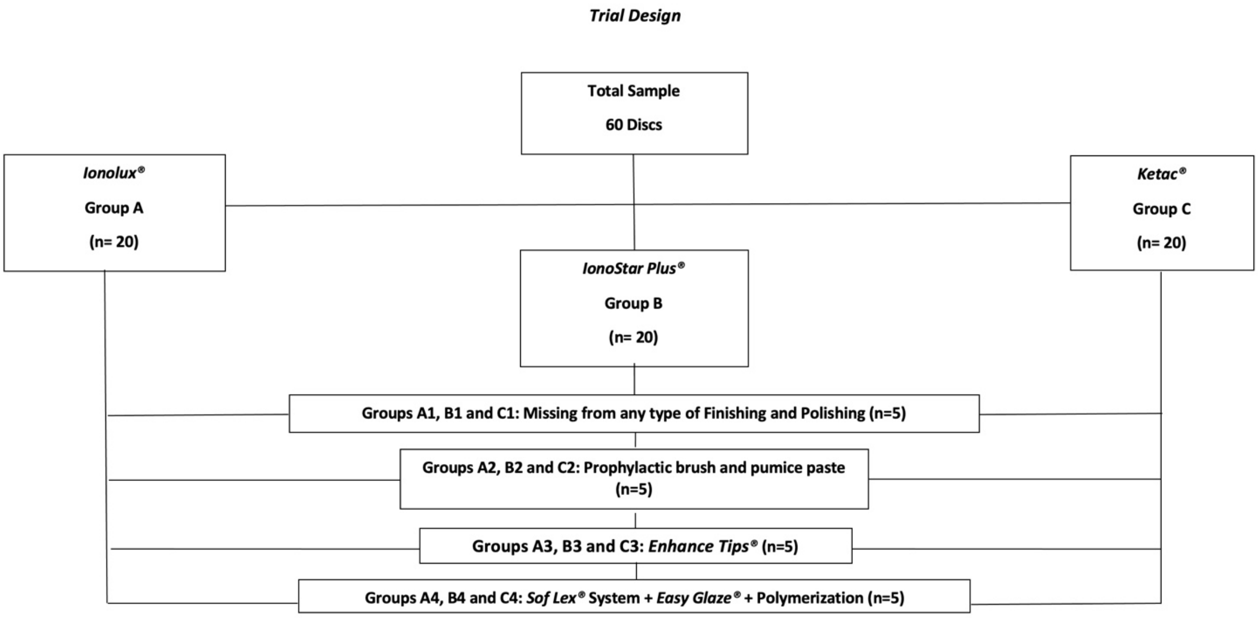

Figure 2. TRIAL DESIGN - a division of the sample by groups.

Finishing and Polishing

The same operator always performed finishing and polishing techniques. The samples were maintained in the respective pieces, and circular movements were made from the center to the periphery to standardize the surface treatments.

Four main techniques can be described. **Group 1**: no polishing; **Group 2**: the prophylactic brush with pumice paste, which is a method to reach anatomical points and contain abrasive microparticles to reduce the surface roughness of GI; **Group 3**: Enhance® tips and Sof-Lex® abrasive discs are finishing and polishing instruments consisting of fine or ultrafine particles (aluminum oxide) deflating incorporated into a soft, flaccid matrix. There are various other formats and dimensions to allow complete access. Its clinical use is limited, as the thin abrasive layer remains effective for a limited duration. The tips are beneficial by the possibility of multiple applications, unlike the discs, which are used in a gradual sequence concerning the different granulometry (from the most abrasive to the smallest) and are single use (disposable). After their use on different dental materials, they have smooth and polished surfaces, consequently decreasing Ra (JEFFERIES, 2007); **Group 4**: Easy Glaze® is a light-curing nanoparticulate varnish that allows the sealing of surfaces through its protective film. Promoting the sealing of superficial imperfections of dental matters favors superficial smoothness and provides a natural shine (BOLLEN et al., 1997; ALMEIDA et al., 2017).

Groups A1, B1, and C1 (Control Group): No polishing (n = 5/group) - as illustrated in the study diagram (Fig. 2), superficial roughness measurements were performed on discs without finishing or polishing; **Groups A2, B2, and C2: Prophylactic brush and pumice paste (n = 5/group) -** the surface of 15 discs was polished, applying pumice paste with the aid of the prophylactic nylon brush used in NSK contra-angle handpiece following the procedure (Fig. 3) described: (i) wet the prophylactic brush with pumice paste; (ii) the application was performed with the contra-angle devoid of water, in low rotation, for 1 minute on each face of the disc; (iii) rinse thoroughly with water and dry with the air/water syringe; **Groups A3, B3, and C3: Enhance® tips on refrigeration (n = 5/group) -** In this group, the disc face with enhancing abrasive tips (Fig. 4), in disc form, of single application was treated. These tips were placed against a low-speed motor with refrigeration to avoid heating for 30 seconds. Initially, a higher pressure was applied to remove excess glass ionomer. Then, a slight pressure was made to make the surface smoother and promote the final polishing, giving the disc a smooth and shiny appearance; **Groups A4, B4, and C4: Sof-Lex ® system + Easy Glaze® + polymerization (n = 5/group) -** finishing and polishing was started with the Sof-Lex flexible disc system® sequentially, in a decreasing way: more abrasive grain (dark red), medium grain (dark orange), and finally the superfine (yellow). A counter-angle was used, without water and low rotation and chuck, for the placement and use of this system (Fig. 5). The procedure was performed for 30 seconds for each disc.

As indicated by the manufacturer, the surfaces of the samples were washed and dried with an air jet after using each disc to avoid the accumulation of debris that could create roughness. After polishing with the discs, Easy Glaze® was applied, and a 30-sec light-curing allowed the sealing and protection of the GI. Prior to the roughness evaluation, all samples were washed with water and dried with an air jet (Fig. 5).

Figure 3. Polishing and finishing protocol with pumice paste. A. Impregnate the prophylactic brush with pumice paste; B. Application without water; C. Washing and drying with an air/water syringe.

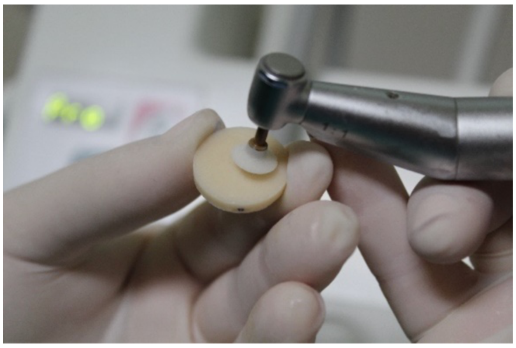

Figure 4. Polishing the GI with Enhance®.

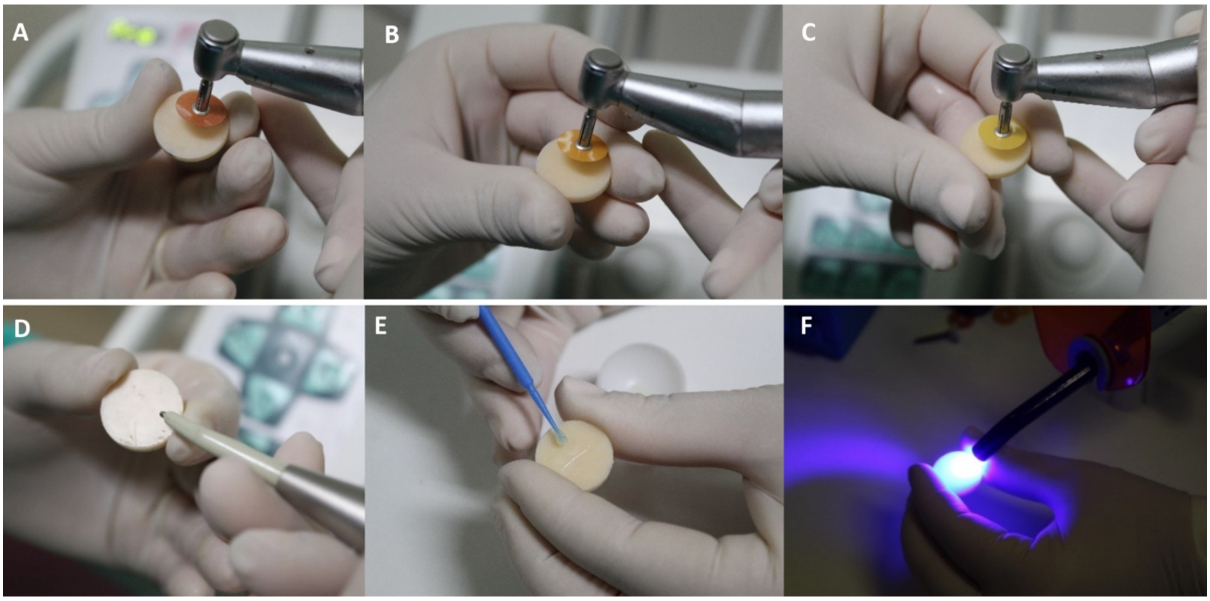

Figure 5. Polishing and finishing protocol with Sof-Lex®+ Easy Glaze®. A. Use of the thick disc of the Sof-Lex System®; B. Use of the average disc of the Sof-Lex System®; C. Use of the Sof-lex® system thin disc; D. Washing/drying with air/water syringe; E. Easy Glaze Application®; F. Polymerization.

Roughness measurement

The HOMMEL Tester T1000® (provided by the Department of Engineering and Industrial Management, from the Polytechnic Institute of Viseu, Portugal) was used to measure roughness and recorded Ra value (surface roughness) (Fig. 6). For each disc, 5 horizontal measurements were performed, from the periphery to the center of the disc, and an additional measure, in the opposite direction of the previous ones, equally random. For each disc face, the total distance analyzed was 2.88 cm (6 x 48 mm), and a calibration test was used, with a cutoff system of 0.80 mm, at a speed of 0.50 mm/s.

Figure 6. HOMMEL T1000® device used to obtain the measurements of surface roughness.

Statistical analysis

After collecting the mean values of surface roughness in micrometers (μm), previously and after applying the different polishing and finishing techniques, statistical analysis was performed using the IBM SPSS Statistics® software (v. 28, Statistical Package for the Social Science software, U.S.A.).

The results were presented using tables presenting means, standard deviation, medians, and quartiles, represented by average graphs and diagrams of extremes and quartiles. In statistical inference, the comparison of roughness between ionomer types was made by stratifying the different polishing techniques. Thus, for each polishing technique, the roughness of the three ionomers was compared using the Kruskal-Wallis test with post-hoc tests of multiple comparisons of Bonferroni correction. A p-value < 0.05 was considered statistically significant.

RESULTS

Descriptive analysis

Initially, it was compared the results for the different types of ionomers according to polishing and finishing techniques. In the descriptive analysis by group, the mean roughness values were obtained, resulting from collecting the 6 linear measurements practiced by each face of the glass ionomer disc (Table 2). The group C4 had the lowest mean roughness value (0.84 ± 0.54 μm) and, on the other hand, group C3 had the highest mean (2.48 ± 1.05 μm).

Table 2. Descriptive analysis.

Ionomers Polishing techniques			Average	Median	Standard Deviation (SD ±)	Percentile 25	Percentile 75
Roughness	Group A	A1	1.85	1.42	1.67	0.79	2.04
		A2	2.33	1.84	1.17	1.39	3.23
		A3	2.28	1.85	1.20	1.44	2.84
		A4	1.07	0.92	0.54	0.70	1.19
	Group B	B1	1.08	0.56	1.08	0.33	1.46
		B2	1.24	1.00	0.78	0.77	1.47
		B3	1.17	1.05	0.68	0.60	1.60
		B4	0.93	0.89	0.38	0.63	1.15
	Group C	C1	0.87	0.49	0.67	0.33	1.47
		C2	2.10	1.64	1.31	1.25	2.58
		C3	2.48	2.29	1.05	1.62	3.03
		C4	0.84	0.72	0.54	0.47	1.00

Considering the different GI, the mean of roughness for Group A was lower for subgroup 4 (1.07 ± 0.54 μm) and higher for subgroup 2 (2.33 ± 1.17 μm). In Group B, subgroup 4 was also the one with the lowest mean of roughness (0.93 ± 0.38 μm) and a higher roughness for subgroup 2 (1.24 ± 0.78 μm). Group C achieved higher mean values for subgroup 3 (2.48 ± 1.05 μm) and, identically, lower for subgroup 4 (0.84 ± 0.54 μm).

Taking into account the analysis of the mean by polishing and finishing technique, we can verify that subgroup 4 had the general lowest values for surface roughness (mean Ra 0.95), followed by subgroup 1 (without polishing), with mean Ra values of 1.27, subgroup 2 that obtained the mean value of Ra = 1.89, and the higher values for subgroup 3.

When we analyze the GIs and the different surface treatments, the greatest and lowest mean of Ra value were in Group C, as mentioned above (Figs. 7 and 8). It is possible to observe some particularities, mainly when comparing the groups' variability with the presence of atypical values ("outliers"). These values are justified due to the gaps obtained during compression with the glass plates when the discs were made. Analyzing the types of ionomers by themselves, it was found the Group B presented the lowest dispersion of results (Fig. 7). In Figure 8, the diagram presented the polishing and finishing techniques separately. Groups A4, B4, and C4 achieved the lowest values.

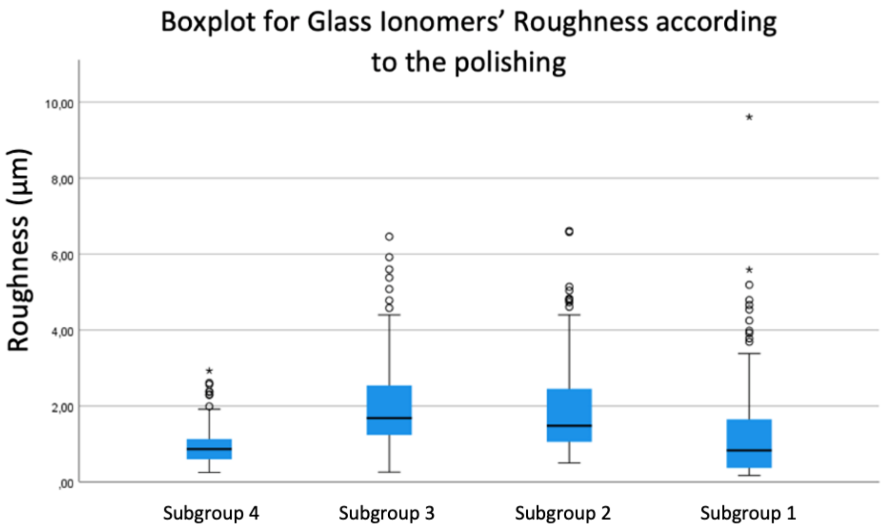

Figure 7. Boxplot for glass ionomers' roughness.

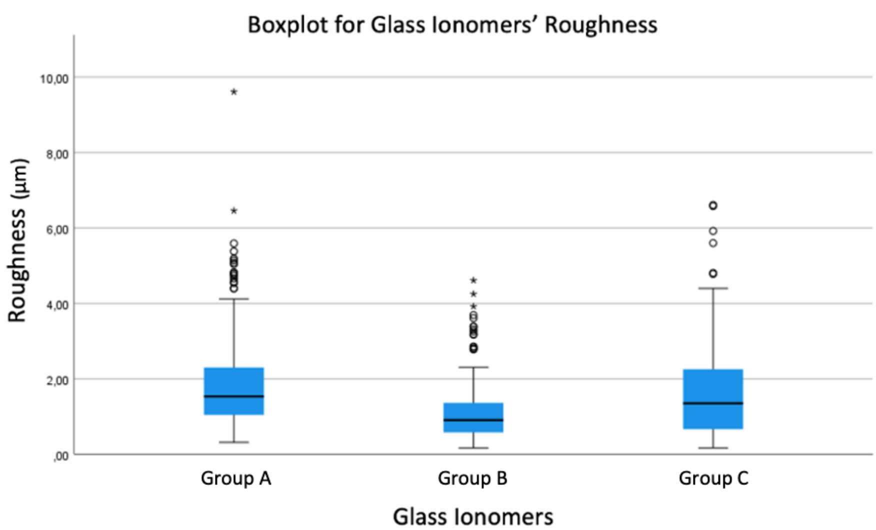

Figure 8. Boxplot for glass ionomers' roughness varying according to the polishing technique.

In order to observe all the glass ionomers and polishing techniques, a graph of means was elaborated with the measurements for each sample (Fig. 9). It was possible to verify that subgroup 4 had the lowest average roughness surface for all groups (A, B, and C). Subgroups 2 and 3 presented higher values of superficial mean roughness.

Inferential analysis

The factorial ANOVA model, involving the analysis of roughness between the types of glass ionomers, polishing technique, and interaction between the GI and the polishing technique, cannot be approached because it violated the assumptions of applicability of this technique, which calls into question the conclusions that could be taken through statistical inference. They are violated: (i) the assumption of normality of the residues (Kolmogorov-Smirnov normality test with $p < 0.001$); (ii) the assumption of the equality of variances between groups (Levene test with $p < 0.001$); (iii) the assumption of heteroscedasticity, that is the variance of the residuals is influenced by the values of the independent variables (White test for heteroscedasticity with $p < 0.001$).

It was chosen to compare the three types of GIs for the different polishing techniques. Again, it is not possible to apply variance analysis because the assumptions of its applicability are not met, using the non-parametric alternative Kruskal-Wallis tests and the tests of multiple comparations. Then: (i) GIs were analyzed separately for the surface treatment technique they received, subgroup 1, subgroup 2, subgroup 3, and subgroup 4; (ii) the outliers (*) found in the following graphs are atypical values in relation to what was expected and that differ drastically from all others.

Initially, groups A1, B1, and C1 (without polishing) were compared for different types of GIs ($p < 0.001$). Statistical evidence of non-equality of roughness among the three GIs absent of superficial treatment. For group A, the GI presented the highest roughness ($p < 0.05$). No statistically significant evidence exists between groups B and C ($p > 0.05$). Similarly, it was compared the GIs for polishing and finishing of groups A2, B2, and C2 ($p < 0.001$), with statistical evidence of non-equality of roughness among the three ionomers, and group B had the lowest roughness. Also, groups A3, B3, and C3 were analyzed for the different GIs ($p < 0.001$), with statistical evidence of non-equality of roughness among the three GI that subgroup 3; group B had the lowest roughness. The last groups A4, B4, and C4 had $p = 0.009$, showing statistical evidence of non-equality of roughness between the three GIs polished by the subgroup 4. There was a statistical difference between group A and C ($p < 0.05$), with lower roughness for group C (Fig. 10).

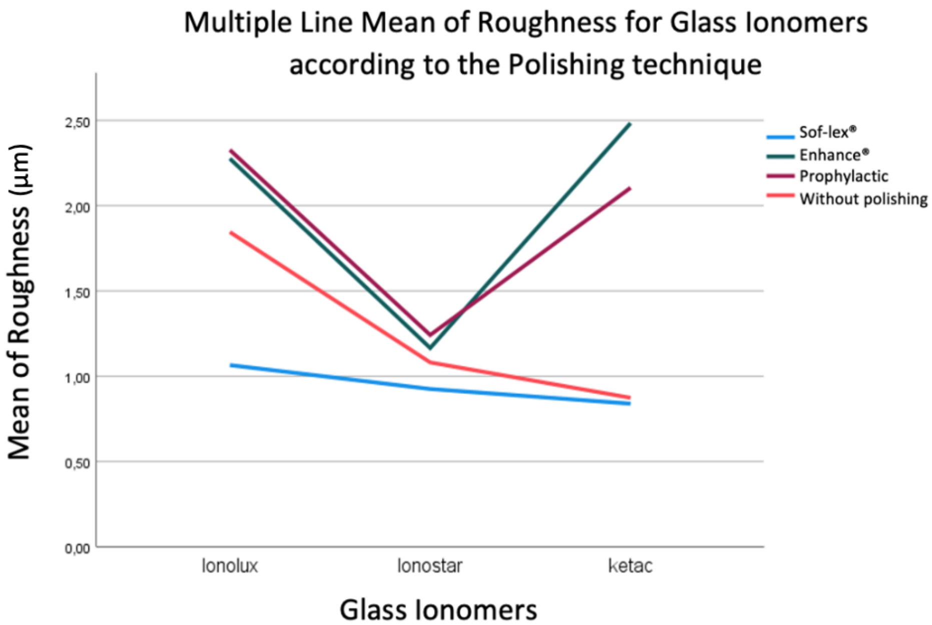

Figure 9. Multiple lines of the mean of roughness for Glass Ionomers according to the polishing technique.

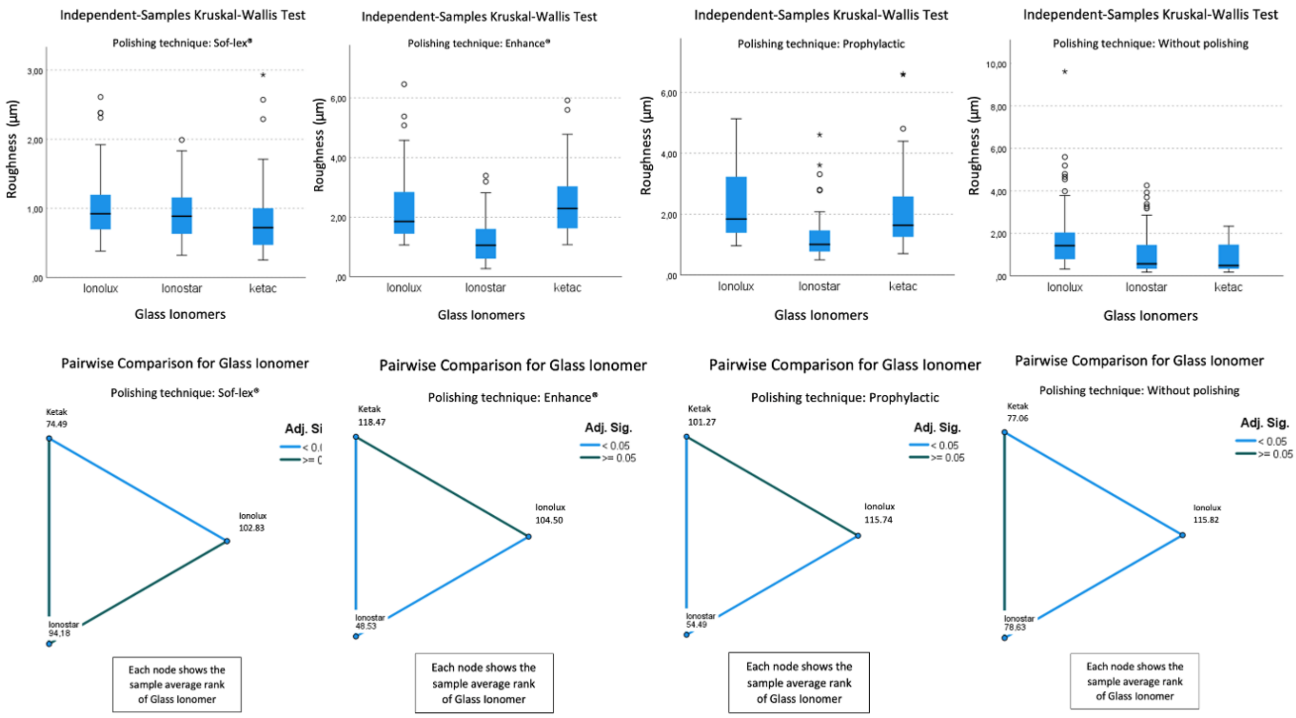

Figure 10. Multiple adjusted tests for each group studied.

DISCUSSION

As previously described, GIs are frequently used in Dentistry, especially in Pediatric Dentistry, when less sensitive application protocols are required. GI application is recommended when patients are not cooperative, either due to phobia or even because they are younger, which makes it challenging to carry out treatments with a longer duration (CROLL and NICHOLSON, 2002).

The surface roughness is an important feature of material because, theoretically, the greater the roughness, the greater the accumulation of biofilm and, thus, the greater risk of periodontal inflammation, caries, recurrence of lesions, and, consequently, loss of longevity, quality, and hardness of the restoration and increased need for reintervention (BUSSCHER et al., 2010). Therefore, it can be reduced through polishing and finishing techniques after the placement of the material. Thereby, this investigation aimed to compare the surface roughness among 3 types of glass ionomers before and after finishing/polishing. The evaluation method was the most used for analyzing the materials and surfaces used in Dentistry.

Polishing and finishing are considered effective in reducing the Ra of materials, promoting a smoother surface, and decreasing biofilm adhesion, even though the manufacturers and the literature do not have a specific protocol (ISMAIL et al., 2020). Moreover, according to the literature, the additional application of protective varnishes after finishing and polishing procedures also helps decrease the materials' Ra (HABIB et al., 2021).

Furthermore, GIs are the materials of choice for restorations (definitive and provisional) that are less sensitive to the application technique when there are cases of many caries lesions, extensive caries, or when there is a necessity for ART (SCHMOECKEL et al., 2020). Prophylactic brush with pumice paste is the polishing/finishing technique that has been typically used, which is easy to use and has the possibility of covering certain anatomical points that are difficult to reach by other protocols. The microparticles incorporated in the pumice stone paste promote surface smoothness to the materials (JEFFERIES, 2007).

Wu et al. (2005) compared GI with similar compositions to those evaluated in this study, having obtained an increase in surface roughness for the group with prophylactic brush and pumice stone paste, as observed in our study. Abrasive tips have aluminum oxide particles in their composition that promote the reduction of Ra, hence being a frequently used method. Hondrum et al. evaluated the surface roughness of two GIs and one composite using abrasive points similar to this study. The surface roughness was increased in our study, contrary to the results obtained by those authors, in which the Ra decreased.

The subgroup 4 used discs are known for their extensive ability to reduce Ra, and the glaze for its effectiveness in sealing imperfections on the surfaces of dental materials (BOLLEN, 1997; JEFFERIES, 2007; ALMEIDA et al., 2017). Ismail et al. (2020) and Perez et al. (2009) similarly concluded that the application of the glaze after using the use of the Sof-Lex® system effectively increased the GIs' surface smoothness, as observed in this study.

The evaluation of the Ra of materials used in Dentistry is critical. The roughness of dental materials depends on the shape, size, type, distribution, and quantity of filler particles in the kind of matrix and the matrix/filler ratio. To top it off, the ease, abrasion, and application method of the finishing and polishing systems also interfere with the Ra of the materials (ERDEMIR et al., 2012). Then, higher Ra values adversely impact abrasion resistance and marginal dental integrity, resulting in clinical failure, promoting staining of restorations, biofilm agglomeration, and gingival inflammation (BALA et al., 2012; ALMEIDA et al., 2017).

In the purely descriptive analysis in relation to the different types of GIs, and prior to the statistical analysis, there was a tendency to: (i) lower roughness values were found in the group B with a high GI viscosity, possibly due to the different composition in the load of the particles, which differs in relation to the other materials analyzed. The same result was achieved by other authors when comparing with composite (AL-ANGARI et al., 2021; KARAKAŞ et al., 2021); (ii) Group A contains resin in its composition, and as expected, this GI has the highest roughness values.

In the exclusively descriptive analysis by polishing and finishing groups, it is worth noting: (i) subgroup 4 showed the lowest values of surface roughness, probably due to its broadly abrasive capacity, its pristine state, and its single-use; also, by the application of the glaze, which is a light-curing varnish that allows the sealing of inaccuracies; (ii) group 1, without any type of surface treatment, was the second to present lower roughness values when compared to groups 2 and 3; these results corroborated the idea that these materials are designed for easy and quick uses, often without the opportunity to make great finishes or polishes.

After statistical analysis, we found that: (i) subgroup 1, without polishing and finishing, presented no statistically significant difference in the results for the surface roughness of GIs (groups B and C). However, group A had a higher roughness compared to the previous ones, probably due to the resin matrix incorporated in its composition; (ii) for subgroups 2 and 3, with prophylactic brush and pumice stone paste, group B had the best results (probably, as previously described, by the difference in its composition); (iii) regarding subgroup 4, group C had the lowest surface roughness due to its conventional composition.

Miličević et al. (2018) listed two GIs and three types of polishing materials. The GIs used in their analysis were similar in composition to those used in our study, and one of the polishing and finishing techniques was also identical. The methodology used is different, but the analysis of roughness is equivalent. The authors concluded that, in the same way, the high GI viscosity revealed lower roughness values both in the control group and with surface treatment with Sof-lex® discs. Identical results were obtained in our study since, of the 3 ionomeric compositions, the high GI viscosity presented the lowest surface roughness, with or without finishing and polishing.

The literature demonstrates that GI, when submitted to polishing and finishing, is favorable to the increase of fluor release, decreasing the surface roughness, and consequently less bacterial adhesion, which leads to a lower failure rate of the restoration, resulting in its application in multiple disciplines of the restoration (BAYRAK et al., 2017; ŠALINOVIĆ et al., 2019). On the other hand, several factors negatively influence the advantages of GIs, such as the type of diet, polymerization, the cleaning method, low tensile strength, longer setting, and sensitivity to humidity (DIONYSOPOULOS et al., 2003; ALMEIDA et al., 2017).

In Almeida et al.’s study (2017), the authors listed 4 different GIs, 3 conventional (Ketac®, Molar Easymix, Maxxion-R®, and ION-Z®), and the last one modified by resin (Vitremer®). Ten samples were distributed among 12 groups. The control group did not undergo surface treatment; the next group had the Sof-lex® discs as polishing and finishing, and the last one, the Enhance® abrasive points. The control group did not show significant differences between the materials and respective polishes. Identical results were obtained for the Vitremer® group with both surface treatments, and the lowest surface roughness was achieved in the conventional GI with polishing and finishing with the Sof-lex® system. In this clinical trial, the lowest Ra values were obtained in the group with surface treatment with the Sof-Lex® disc system, highlighting the compatibility between these studies since the choice of materials and the polishing and finishes are similar.

As previously mentioned, the literature reports that materials are less prone to bacterial biofilm adhesion when the maximum surface roughness value does not exceed 0.2 mm (BOLLEN et al., 1997; SILVA et al., 2006; ZANCOPÉ et al., 2009). In our study, the average values obtained for all the GI analyzed, even after polishing and finishing, are above the ideal value. The interest in further studies is highlighted to devise a surface treatment system capable of reaching values closer to the standard, thus conferring the best clinical benefits. Moreover, evaluate other factors such as hardness, bacterial adhesion, and fluor release, since the surface porosity should not be a single criterion to be considered and, in this way, choose the ideal GI for a clinical dental practice.

Limitations of the study

Some limitations of this study were: (i) the samples are entirely flat, contrary to the typical anatomy of each tooth, which simultaneously influences the finishing and polishing, simplifying the process. Thus, any extrapolation of the results to clinical practice requires caution and should be the subject of criticism and analysis;

(ii) to prepare the samples, it was necessary to apply Vaseline inside the resin parts and face of the plates in contact with the resin to facilitate its removal. It should be noted this procedure unintentionally leads to some surface roughness, which may moderately interfere with the results obtained from the surface analysis. In an attempt to minimize this limitation, the amount of Vaseline applied was standardized and significantly reduced, and excesses were removed;

(iii) often, methods to aid the placement of the material on the tooth are used, such as lateral action spatula, microbrush, and dielectric matrices. In this study, only compression by the glass plates was used to carry out the samples;

(iv) normally, after the completion of the GI, the light curing agent is applied to assist in the setting of the material. In this case, the material was cured spontaneously between the glass plates. Possibly there was no type of influence for the evaluations of roughness or hardness, but the caveat remains;

(v) subgroup 3 had tips which are also used in dental treatments at the University, which guarantees that their condition is not outdated. The impossibility of using the those tips at maximum efficiency may interfere with the results;

(vi) the subgroups 4 had discs never been used before and was used for both sides of the same disc. It is expected that the face of the disc that had the surface treatment first may present lower values of surface roughness since we had to systematically consider the wear suffered by the materials and rotating instruments resulting from the numerous applications; (vii) another group used the prophylactic brush with pumice stone paste, in the impossibility of using a pre-made pumice stone paste. The pumice stone paste was obtained by mixing 220mg pumice stone (with unknown granulometry) with 1 ml of water, which is necessary to carry out the surface treatment of 1 disc (2 faces). The granulometry being an influencing factor in polishing the GI and, consequently, in the roughness of the material, the knowledge of the used granulometry would be relevant.

CONCLUSION

Within the limitation of this *in vitro* study and observing the hypothesis raised, it was possible to conclude that: (i) the reduction of the roughness of the materials is dependent on their composition and the polishing and finishing techniques applied; (ii) lower surface roughness (Ra) values were observed for the conventional GI (group C) and GI with high viscosity (group B), whereas, higher values were reported for the modified GI (group B), in relation to the previous ones, for the control group, absent from any type of surface treatment ($p > 0.05$).

No significant differences were observed between conventional GI and resin-modified GI after to be treated with prophylactic brush and pumice paste (subgroup 2) and tips (subgroup 3). The high viscosity GI presented the lowest values of Ra. For subgroup 4, the conventional GI (group C) showed the lowest statistical values of Ra. The use of discs (subgroup 4) with the application of glaze proved to be efficient in reducing the surface roughness of the materials, presenting the best results. Otherwise, surface treatments with a prophylactic brush (subgroup 2) and tips (subgroup 3) were unfavorable since the surface roughness was higher in the measurements.

The choice of the best ionomer depends on many clinical factors, particularly the type of polishing technique. In children, when is impossible to perform any polishing, we do not suggest using the GI of the group A; otherwise, in collaborative children (permit polishing), we must evaluate case-by-case to decide.

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