Translucency parameter of conventional restorative glass-ionomer cements

ABSTRACT

Objective. To evaluate the translucency parameter and contrast ratio of different conventional restorative glass-ionomer cements. Materials and Methods. Eighteen brands of glass-ionomer cements were evaluated. Five disks of each material were made following ISO 9917-1. The luminous reflectance and Central Bureau of the International Commission on Illumination parameters of disks were evaluated using a colorimeter, against backings of white and black, to obtain the translucent parameter and contrast ratio of different brands of glass-ionomer cements. The correlation between translucency parameter and contrast ratio was assessed with the Pearson correlation test. The translucent and contrast ratio parameters values were submitted to the one-way ANOVA and Tukey test for multiple comparisons ($p<0.05$). Results. There was a strong inverse relationship between contrast ratio and translucency parameter ($r^2=0.94$, $p<0.001$). The contrast ratio decreased as translucency increased. There were significant differences in translucency parameter and contrast ratio among brands ($p<0.001$). Conclusions. Glass-ionomer cements exhibit different translucency and contrast ratio behavior. Some brands of GICs presented very low TP and this condition would be unacceptable for areas with esthetic demands. In addition, TP and CR showed a strong linear relationship.

Clinical Significance

The results found in this study demonstrated that the knowledge of the translucency and contrast ratio of different conventional restorative glass-ionomer cements is important in order to guide clinicians in the selection of restorative GICs for anterior teeth.

Keywords: Glass-ionomer cements, Translucency, Color, Opacity, Dental Materials.

1. Introduction

Glass-ionomer cements, (GICs) introduced by Wilson and Kent in the early 1970s,[1] are a category of materials widely used in clinical practice, especially because of their beneficial properties such as fluoride release,[2,3] chemical adhesion to tooth structure,[4] biocompatibility and coefficient of linear thermal expansion similar to the tooth.[5]

The GICs are not only indicated for class I,[6] class II[7] but also for class III[8] and class V[9] restorations, non-carious lesions as well as for atraumatic restorative treatment (ART),[10] competing equally or even superiorly with materials that are traditionally used in clinical practice such as the composite resin.[7] In patients with high cariogenic activity, glass-ionomer cements can be considered the first choice materials due to their release and reincorporation of fluoride that gives them cariostatic properties.[11,12]

However, there is a lack of studies in the literature, that evaluate the optical properties of GICs, such as translucency or the comparative analysis of their L^*, a^*, b^* colorimetric coordinates in relation to tooth tissue. Most studies have related the color change of GIC restorations to their effect after tooth whitening,[13–15] or resistance to pigmentation.[16,17]

It has been observed that the natural appearance of teeth depends on their optical properties.[18] In addition to the value, hue and chroma, other properties such as translucency and opacity give the tooth structure its characterization and final harmonization.[18,19] Contrast ratio (*CR*) or opacity is an important property of esthetic restorative materials; this depends on the thickness of the material and the reflectance of the background.[20] Similarly, the translucency of esthetic materials improves color matching with adjacent teeth and materials.[21–25] The translucency parameter (*TP*) has been used to assess the translucency of dental materials.[26–28] The literature shows a correlation between TP and CR when dental materials are analyzed.[29-31]

An essential requirement for any restorative material is its masking ability, the absence of it will allow an unacceptable display.[32] This is especially in large cavities where there is no tooth structure to provide a backing for the restoration, such as in a large class III or IV cavity, where translucent materials may provide relatively poor color matches.

A restorative material for use in areas with high esthetic demand must present optical characteristics similar to those of the adjacent tooth structure.[33] As there are several brands of restorative glass-ionomer cements on the market, it is important to assess the translucency and contrast ratio, of these materials in order to guide the clinician to indicate their use. The aim of this study was to compare the optical properties of different brands of glass-ionomer materials available on the market. The null hypothesis for this study were that there was no significant differences in translucency parameter and contrast ratio among different GICs. In addition, there was a correlation between TP and CR.

2. Materials and Methods

The tests were performed *in vitro* using 18 brands of conventional restorative glass-ionomer cements as displayed in Table 1.

Five disks of each material were made using a circular teflon mold (1 mm x 10 mm diameter) following ISO 9917-1:2007.[34] Immediately after cement manipulation according to each manufacturer's instructions, the material was packed with excess into a mold with a Centrix syringe (Nova DFL- Rio de Janeiro, Brazil) in order to avoid trapping air. On both sides of the mold, polyester strips were placed and the material was compressed using two steel plates and a screw clamp. These procedures were carried out in no longer than 120 seconds.

The whole assembly was stored for 1 hour at 37°C and a relative humidity of at least 30%. The thickness of each disk was measured with a digital caliper (Liaoning MEC, Liaoning MEC Group Co, Ltd, Dalian, China) placed near the center; only specimens whose thickness fell in the range 1.0 ± 0.1 mm were used in the study. The cement specimens were then carefully removed from the molds and stored in distilled water at 37°C for 7 days.

To obtain the CR and TP of the GICs, a colorimeter (Konica Minolta CR-400, Konica Minolta Sensing Americas Inc, Osaka, Japan) was used under constant illumination (light source simulating the spectral relative irradiance of D65 CIE standard illuminant). The colorimeter is designed for diffusion illumination of 0º viewing angle geometry, including a specular component, using a pulsed xenon lamp as the light source, which is diffused into a diffusion chamber. This illumination method illuminates the sample from all directions, with almost completely equal brightness, and the reflected light vertically from the sample surface is directed to diffusion plates positioned about 6 mm above the sample surface, finally reaching the detector. The detector is a set of three photocells filtered to closely match the CIE 1931 Standard Observer functions (2º Standard Observer), ensuring the conditions are uniform for all measurements.

The luminous reflectance (*Y*) and CIELab parameters (L*, a* and b*) of disks were measured against backings of white and black, where the lightness L* is the shade alteration in black and white ranging from 0 to 100 (with higher numbers being brighter), a* is the change in saturation from red to green, whereas b* is from blue to yellow.[35,36]

All the optical parameters were calculated over white (Y: 74.49; L*: 85.61; a*-5.1252; b* 9.7467) and black (Y: 7.63; L*: 31.30; a*-2.2495; b* 4.2290) backgrounds, where *b* was the measurement against the black background and *w* was the measurement on the white background[14]. To measure TP, the CIELab parameters were used to calculate using the equation:

$$TP = [(L^*_b - L^*_w)^2 + (a^*_b - a^*_w)^2 + (b^*_b - b^*_w)^2]^{(½)} \quad (1)$$

[35]

The CRs of the GICs were calculated using the formula:

$$CR = (Y_b / Y_w). \quad (2)$$

[14]

The ratio of illuminance (Y) of the test material with a black background (Yb) to the illuminance of the same material when it is placed over à white background (Yw).[14]

The greater the TP value, the higher the translucency of the material. A TP value of 100 indicates the specimen is transparent and a TP value of 0 indicates that the material is opaque [35]. In CR, values could range from 0 to 1, being totally transparent or opaque, respectively. [29]

Statistical analysis

The correlation between TP and CR was assessed with the coefficient of Pearson´s correlation test. When the Pearson correlation coefficient value was between +1 and -1, the closer the coefficient was to +1 or -1, the stronger the association. Data were analyzed with one-way ANOVA and the Tukey test for multiple comparisons, with a significance level of 5%. The TP and CR data were submitted to analysis of residues. The normality of the residues was verified, by the Shapiro Wilk´s test and Q-Q plot. Homogeneity was analysed by Levene's test. All statistical analysis was carried out using Statistica 13.3 software (Statistica®, StatSoft, Hamburg, Germany).

3. Results

Normality tests were performed and the results were found to be normally distributed. Table 2 shows the CIELab color coordinates for different brands of GICs in black and white background. The values for CR are presented in Table 3. The mean contrast ratios of B (0.58 ± 0.02) and VF (0.63 ± 0.02), presented the lowest values. One-way ANOVA showed that the CR values were significantly different among the brands of GICs ($p < 0.001$). Tukey HDS tests demonstrated that the V (0.90 ± 0.06), Ma (0.93 ± 0.03) and Ch (0.95 ± 0.02) had significantly higher CR when compared with the others. Correlations between CR and TP of different brands of GICs are presented in Figure 1. Based on the

Pearson correlation test, a significant correlation between CR and TP was found when all specimens were included ($p<0.001$). Therefore, the correlation coefficient of $r^2=0.94$ indicated a strong inverse relationship between the 2 variables.

The translucency parameter data of GICs are presented in Table 4. The average of TP ranged from 20.04 to 3.94. One-way ANOVA showed that the TP values were statistically different among the brands of GICs ($p <0.001$). Tukey HSD test, comparison between groups demonstrated that B (20.04 ± 0.76) had significantly higher TP, being more translucent, when compared with the other brands. Also V (5.55 ± 1.54) and Ch (3.94 ± 0.52) had lower values of TP, when compared with the other GICs. The Figure 2, illustrates the TP means and standard deviations of different GICs. The TP values of different GICs were measured over white and black tiles being organized in descending order: B < IZ < VF < IG < MG < IS < GL9 < IP < IM < VM < GI < EF < GL2 < KM < R < Ma < V < Ch (Figure 3).

4. Discussion

The present study evaluated the translucency parameter and contrast ratio, of 18 different conventional restorative glass-ionomer cements, in order to facilitate the clinical indication of these materials according to esthetic requirements of the individual situation. The first hypothesis was rejected after statistical analysis revealed that there were significant differences in TP and CR among the GICs studied. The second hypothesis was accepted once there was a strong inverse correlation between TP and CR. The same correlation was found based on dental ceramics. [29, 37]

The translucency of natural teeth has a tendency to decrease from incisal to cervical, and that *L* * decreased with age while *a* * (+ red) and *b* * (- yellow) increased.[37] There have been few studies[27,37] on the measurement of optical parameters of human tooth enamel and dentin, which makes it difficult to find reference studies for comparison with restorative materials in general, and even less so for glass-ionomer cements.

According to a paper presented in 2009, the translucency value of 1-mm thick human enamel sample was 18.7 observed under a spectrophotometer with 3 mm round aperture[14], using illuminating and viewing configuration of CIE diffuse/10º geometry. TP values performed in our study were realized using a colorimeter with 8 mm in diameter, which uses a diffusion illumination of 0º viewing angle geometry so they cannot be compared, since TP values were obtained by different methods.

Thickness is another variable, which can influence TP values. Natural teeth are polychromatic, with a color variation from the incisal to the cervical parts of a tooth because of differences in the thickness of enamel and dentin in each region. The middle third of the tooth is the part that best represents the tooth color. This is because the incisal region is more translucent and is influenced by the color of the background while the cervical area is modified by the scattered light of the gingiva.[14] In addition, the opacity and translucency parameter complement the dental optical properties. One study considered Delta E to be the representative value of acceptable color difference for veneers with the corresponding contrast ratio value to be at 0.91, above it the restoration is capable of masking the background color changes from white to black.[38] In the present study, the two most opaque materials that fulfil this condition in 1mm thickness were Chemfil Rock and Vidrion R. Chemfil Rock is made from a novel zinc-containing glass[39] and Vidrion R contains barium sulphate in the powder which are both responsible for the high opacity of these materials. This behavior can be seen in Figures 2 and

3. Considering that ceramic is the material that has the greatest similarity to tooth enamel, it was previously observed that for leucite-reinforced ceramic material over opaque posts, a full masking or acceptable Delta E may be achieved only with 2mm-thickness of material.[40] Thus, a restorative material with 1mm thickness that masks 100% of the background color may present a relatively poor clinical appearance due its higher opacity.

On the other hand, Bioglass R in 1mm thickness presented the highest translucency. It is well-known that the masking ability of a material improves with increased thickness. Thus, if the clinical situation requires masking ability in a lower thickness, more opaque materials should be used.

The results of the present study demonstrate that there were statistically significant differences in TP among the restorative glass-ionomer cements tested. Chemfil Rock and Vidrion R GICs are indicated by the manufacturers for use in class III and class V lesions in anterior teeth. However, in the results of the present study they were considered as having very low TP: 5.55 ± 1.54 for V and 3.94 ± 0.52 for Ch, which values are close to 0.00 indicating higher opacity of the materials [30]and this condition would be unacceptable for areas with esthetic demands. A previous study[14] evaluated the translucency of tooth enamel and dentin, and found a negative correlation between the mean values of TP and CR. The TP values increased in inverse proportion to the thickness. The CR values of enamel and dentin decreased as the wavelength increased, similar to those of dental restorative materials.

Bioglass R was significantly different from the other groups with greatest translucency. The same can be said of IZ, VF and IG, which were statistically similar to Bioglass R. However, a greater TP value may be a disadvantage against the dark background of the oral cavity. This increase in TP may result in a more grayish appearance in comparison with the surrounding tooth structure, as relatively translucent materials are probably affected by the darkness of the oral cavity when used in large class III cavities. Among the limitations of this study is that GIC is a one layer material while the tooth is a double layer structure (enamel and dentin) with different thickness from cervical to incisal.[18,41] In addition, it was observed that the optical properties of the various dental regions may be different, and the translucency reduced from the incisal to the cervical.[37] It was previously observed by others that age may be another influential factor in these properties.[42] A limitation of the current study may be related to the fact that spectrophotometers and colorimeters are made to measure flat materials, while dental enamel is convex by nature.[27]

Besides that, the perceptibility threshold and acceptability threshold has been suggested to assess the color difference of dental materials.[43] These thresholds can be used to guide the selection of dental materials, evaluate their clinical performance, and interpret visual and instrumental findings in dentistry.[43] Future studies testing perceptibility and acceptability thresholds are indicated in order to guide the clinician in the selection of the GICs for each clinical situation.

5. Conclusions

It is possible to conclude that restorative glass-ionomer cements exhibited different optical behaviors. Some brands of GICs presented very low TP and this condition would be unacceptable for areas with esthetic demands. In addition, TP and CR showed a strong linear relationship.

DISCLOSURE AND ACKNOWLEDGEMENTS

The authors do not have any financial interest in the companies whose materials are included in this article.

The authors of this study would also like to thank the Brazilian funding agencies, Coordination for the Improvement of Higher Education Personnel (CAPES), National Council for Scientific and Technological Development (CNPq) and São Paulo Research Foundation (FAPESP).

Data Availability Statement

No data is available.

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Figure Legends

Figure 1. Relationship between contrast ratio (*CR*) and translucency parameter (*TP*).

Figure 2. Translucency (*TP*) means and standard deviations of different GICs.

Figure 3. Samples of the 18 conventional restorative GIC evaluated over a black and white background, organized in decreasing order of translucency