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Evaluation of anti-asthmatic inhalers on color stability and surface roughness for dental restorative materials: An *in vitro* study

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Abstract:
The long-term use of anti-asthmatic inhalers may adversely affect the physical and esthetic properties of dental restorative materials, yet comparative evidence across commonly used materials remains limited. Therefore, it is of interest to evaluate the effects of levosalbutamol and budesonide inhalers on the color stability and surface roughness of 120 disc-shaped specimens comprising 60 glass ionomer cement and 60 composite resin samples exposed twice daily for 15 days, with assessments using spectrophotometry and profilometry. Glass ionomer cement exhibited significantly greater color change and surface roughness following exposure to both inhalers, whereas composite resin showed minimal color alteration and lower surface degradation ($p<0.05$). Composite resin showed greater resistance to inhaler-induced esthetic and surface deterioration than glass ionomer cement under repeated aerosol exposure. These findings advance knowledge by supporting composite resin as the preferred restorative material for patients receiving long-term inhalational therapy.

Keywords: Asthma, budesonide, levosalbutamol, composite resin, glass ionomer cement, color stability, surface roughness, spectrophotometer

Background:
Asthma is one of the most common long term (chronic) respiratory conditions in the world and is still especially a public health problem. It is defined by chronic airway inflammation, fixed but reversible airflow obstruction and bronchial hyperresponsiveness (BHR) that typically requires long-term pharmacologic treatment. Inhaled medications are the foundation of asthma treatment as they target the therapeutic agent directly to the lungs and have less systemic side effects, according to The Global Initiative for Asthma (GINA) 2024 **[1]**. Levosalbutamol and other short acting β2-agonists are typically used for acute relief, such as during an exacerbatory episode, while inhaled corticosteroids like Budesonide are regarded as first line controller treatment for the prevention of exacerbations and to help control airway inflammation. However long-term inhaler use has been linked to a variety of oral complications such as xerostomia, changes in salivary composition, lowered saliva pH, dental caries, oral candidiasis, erosion of the tooth surface and degradation of dental materials, which may impact oral health and the longevity of restorative materials **[2].** Whereas a composite goal of any restorative dentistry treatment was to restore function, the new focus in restorative dentistry is towards retaining the longevity of the material as well as the esthetic component of the treatment. Two direct restorative materials with excellent mechanical and esthetic characteristics, composite resin and glass ionomer cement (GIC), are most commonly used **[3]**. While Composite can be used to achieve good polishability, high esthetics, wear resistance, and mechanical strength, GIC can achieve chemical bond to tooth structure, fluoride release, and anti-cariogenic properties. However both materials can be degraded by chemical attacks in the oral cavity, such as acidic food and drinks and medicine. These materials' chemical makeup affects over time, how well they resist surface degradation and discoloration; while their water sorption properties affect their interactions with the water matrix **[4].** One of the most critical parameters for esthetic restorations' clinical success is color stability. Discoloration is not just an esthetic issue but may also require an early replacement, which would lead to further destruction of healthy dentition, and increased treatment expense. Changing of the original color is a result of intrinsic changes in the matrix itself or extrinsic changes (by adsorption or absorption) of the pigments from the surrounding environment **[5]**. These changes have been the subject of a spectrophotometric evaluation based on the CIE Lab color system which became a standard for objectively assessing these changes. Various materials of the restored structure have been tested for their effect on the optical properties of these materials as a result of exposure to certain acidic drinks, mouth rinses, pediatric medications and chemical agents; and the results showed that exposure of acidic drinks, mouth rinses and certain pediatric medications causes a significantly greater optical alteration in the optical properties of the glass ionomer cements than in the composite resins due to its hydrophilic nature and higher water sorption capacity **[6].** Another important issue that may affect restoration longevity and performance is surface roughness. The net effect of an increase in surface roughness is an increase in plaque formation, bacterial growth, staining, gum inflammation, and secondary caries, and a decrease in shine and aesthetic appearance. Acidic environment can cause chemical degradation to restorative material, either by softening the resin matrix or dissolving the glass ionomer matrix and exposing the filler particles and causing rough surfaces **[6]**. Short-term *in vitro* research has verified that repeated acid exposure and erosion can markedly roughen the surface of all restorative materials, especially glass ionomer cements, compared to the effect of harsh physical challenges such as those mode numbers. Short-term *in vitro* research has demonstrated that repeated exposure to acid solutions and erosive agents can have a significant effect in roughening the surface of all restorative materials, particularly

conventional glass ionomer cements in comparison to harsh physical challenges like those mode numbers. These changes can have a negative impact on restoration longevity and patient satisfaction **[7].** Asthma patients are a special population, as inhaled medications are used over and over, frequently several times a day, and over a number of years. These small particles of a drug product can settle directly on the surfaces of teeth and existing dental restorations and persist in contact with the drugs, preservatives, aerosol flavoring agents and propellants **[8]**. They can also change the oral environment through. Oral environment changes by reducing the pH, buffering capacity of saliva and facilitating chemical interaction with the materials used for restoration. Recently, Candan and Ünal **[8]** showed the colour changes of children's restorative materials that were found to be affected by inhalation of asthma drugs, with greater colour change for glass ionomer materials than composites. Likewise, Subramaniam *et al.* showed that there were major changes to both color stability and surface roughness after repeated exposure to antiasthmatic inhalers which underlines the impact of inhalational therapy on the performance of restorative materials **[9].** Therefore, it is of interest to evaluate the effects of levosalbutamol and budesonide inhalers on the colour stability and surface roughness of glass ionomer cement and composite resin using spectrophotometric and profilometry analysis.

Materials and Methodology:

Study design:

In this experimental *in vitro* comparative study, the effects of two popular used direct restorations in daily practice, namely Glass Ionomer Cement (3M ESPE Ketac Molar GIC) and Composite Resin (Dentsply Neo Spectra ST Universal) and also two popular categories of trialbumin standard medications used for anti-asthmatic purpose namely Levosalbutamol and Budesonide were evaluated and compared in respect of color stability and surface roughness. The purpose of the study was to replicate similar clinical exposures to inhaled medications for the restorative materials under laboratory conditions to evaluate the materials' effects on the esthetic and surface properties of the restorations.

Study setting:

The investigation was conducted in the dept of Conservative dentistry and endodontics, Rungta college of Dental Sciences and Research of Bhilai, Chhattisgarh. India. Standardized institutional laboratory facilities (and calibrated instruments) were used throughout the process of manufacture of the specimens, inhaler exposure procedure, evaluation of the inhalers in the laboratory to assure consistency and reproducibility of the experimental conditions.

Study duration:

It was carried out for three months after approval by the Institutional Ethics Committee. This time encompassed the sample preparation, finishing and polishing preparation procedures, baseline characterization, exposure of the samples to the inhalers and post-exposure characterization of colour stability and surface roughness.

Sample size:

In total, 120 standard plates in the shape of discs were produced for the study. There were an equal number of specimens in each of these two restorative materials, 60 Glass Ionomer Cement and 60 Composite Resin. In order to assess the effects of each restorative material, these materials were then randomized into 2 experimental groups (n = 30) dependent on the antiasthmatic inhaler that was used to expose. The homogeneous distribution of specimens to the experimental groups allowed direct comparison of the effect of two inhaler formulations on the same restorative material in the same laboratory environment **(Table 1)**.

Sample size calculation:

As a result of this, the sample size was determined a priori by using the software G*Power (Version 3.9.1.2) with a one-way analysis of variance (ANOVA). A total sample size of 120 specimens was calculated given the assumption of a large effect size ($f = 0.87$), a significance level (α) of 0.05 and the statistical power ($1-\beta = 0.95$). This sample size was felt to be sufficient to achieve statistical significance between experimental groups for colour stability and surface roughness with reasonable statistical power remaining.

Preparation of specimens:

Using standardized silicone Molds, a total of 120 disc shaped specimens were produce, each having a diameter of 10 mm and thickness of 3 mm. The plinths for composite resin specimens were progressively filled with composite resin followed by a covering of Mylar strip and glass slide and then light cured for 40 seconds by an LED curing unit with a calibrated blue LED light source. Specimens of GIC were prepared as per manufacturer's instructions using the powder and liquid ratio provided by the manufacturer. This material was poured into the mold, covered with a Mylar strip to smooth out the surface and then set completely. All specimens were set in the same manner and finished (polished) with the same polishing systems, with specifications as suggested by the manufacturer.

Storage of specimens:

The oral environment was simulated by placing all the specimens separately in freshly prepared artificial saliva and storing at 37°C for 24 hours prior to baseline evaluation.

Baseline colour assessment:

A calibrated spectrophotometer was used to take baseline colour measurements. Average measurement, within two standard deviations of the mean, was taken from each specimen measured three times under standard lighting conditions and recorded using the CIELAB color system (L*a*b*).

Baseline surface roughness assessment:

The surface roughness (Ra) was measured with the contact profilometer. The specimens were measured in three different

directions, and the average value of the roughness was noted in micrometers (μm).

Inhaler exposure protocol:
Specimens exposed as per designated groups.
[1] Groups A1, B1: Exposure to Levosalbutamol inhaler.
[2] Groups A2 and B2: Exposed to Budesonide inhaler.

The inhalers were administered twice daily at 12-hour intervals for 30 days, mimicking typical clinical inhaler use, in each specimen. Each specimen was gently rinsed after each exposure and placed back in the artificial saliva at +37°C for the next exposure. Subjects' "mouth was flushing out daily to minimize contamination of the artificial saliva.

Post-exposure evaluation:
Following the exposure period of 30 days:
[1] Repeated color measurements by using spectrophotometer
[2] The roughness of the surface was again measured using the same profilometer with exactly the same setting conditions.
[3] For each specimen the change in colour (ΔE) and change in surface roughness (ΔRa) were computed.

Outcome measures:
Primary outcomes:
[1] Color stability (ΔE)
[2] Surface roughness (Ra)

Secondary outcome:
Widen the effects research of Budesonide and Levosalbutamol inhalers, the comparative effects on both materials.

Statistical analysis:
All obtained data were tabulated in a Microsoft Excel spreadsheet and analyzed using the IBM SPSS Statistics (Version 26.0). Values are given as mean ± SD values. The Shapiro–Wilk test was used to determine the normality of the distribution of the data. One-way Analysis of Variance (ANOVA) and Tukey's post hoc test for multiple comparison were used for intergroup comparisons. Measurements for baseline and post-exposure were compared within groups by the paired t-test. A p value less than 0.05 were accepted as a significant value.

Results:
Table 1 shows the allocation of 120 specimens into four groups, with 30 specimens in each group. Both restorative materials were evaluated following exposure to levosalbutamol and budesonide, allowing comparisons of their colour parameters and surface roughness. **Table 2** presents changes in L*, which represents the lightness of a material, with higher values indicating greater lightness. Composite resin exhibited numerical increases in L* following levosalbutamol (3.2%) and budesonide (1.7%) exposure; however, neither change was statistically significant ($p = 0.191$ and $p = 0.456$, respectively). In GIC, L* increased by 9.3% following levosalbutamol exposure and 12.2% following budesonide exposure. Both increases were statistically significant ($p = 0.017$ and $p = 0.008$, respectively). Although budesonide produced the highest mean L* value, the difference between the two inhaler conditions was not statistically significant ($p = 0.406$). These findings suggest that GIC exhibited a greater change in lightness than composite resin**.** **Table 3** shows changes in a*, which represents the red–green colour axis. Composite resin exhibited a small decrease following levosalbutamol exposure, whereas its mean value remained unchanged following budesonide exposure. GIC showed numerical reductions after both inhaler exposures, with a greater decrease following budesonide. None of the reported comparisons was statistically significant ($p > 0.05$). Although the findings suggest a reduction in the red component of GIC, particularly after budesonide exposure, the observed changes were not statistically significant. **Table 4** presents changes in b*, which represents the blue–yellow colour axis. In composite resin, the mean b* value decreased following levosalbutamol exposure but increased following budesonide exposure. In contrast, GIC exhibited numerical increases after both exposures, with a greater increase following levosalbutamol. None of the reported comparisons reached statistical significance ($p > 0.05$). GIC consistently demonstrated higher mean b* values than composite resin across all measurement conditions, indicating a greater yellow component. However, the statistical significance of the differences between the two materials cannot be established from the within-material comparisons presented. **Table 5** shows numerical increases in surface roughness in both restorative materials following inhaler exposure. In composite resin, surface roughness increased by approximately 8.2% after levosalbutamol and 4.0% after budesonide. In GIC, the corresponding increases were 46.9% and 44.7%, respectively. Despite the larger proportional increases observed in GIC, none of the reported baseline comparisons was statistically significant ($p > 0.05$). The differences between levosalbutamol and budesonide exposure were also nonsignificant in both materials. These findings indicate that surface roughness increased numerically after both inhaler exposures, with a greater proportional change in GIC.

Table 1: Group allocation

Group	Restorative Material	Inhaler	Sample Size
Group A1	Glass Ionomer Cement	Levosalbutamol	30
Group B1	Composite Resin	Levosalbutamol	30
Group A2	Glass Ionomer Cement	Budesonide	30
Group B2	Composite Resin	Budesonide	30

Table 2: Comparison of L* values among study groups

Group	Mean ± SD	Comparison	p value
Composite baseline	65.1 ± 2.8	Baseline vs Levosalbutamol	0.191
Composite + Levosalbutamol	67.2 ± 1.9	Baseline vs Budesonide	0.456
Composite + Budesonide	66.2 ± 1.3	Levosalbutamol vs Budesonide	0.330
GIC baseline	62.4 ± 3.2	Baseline vs Levosalbutamol	0.017
GIC + Levosalbutamol	68.2 ± 2.9	Baseline vs Budesonide	0.008
GIC + Budesonide	70.0 ± 3.6	Levosalbutamol vs Budesonide	0.406

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Table 3: Comparison of a* values among study groups

Group	Mean ± SD	Comparison	p value
Composite baseline	1.2 ± 0.7	Baseline vs Levosalbutamol	0.743
Composite + Levosalbutamol	1.0 ± 0.6	Baseline vs Budesonide	0.999
Composite + Budesonide	1.2 ± 0.9	Levosalbutamol vs Budesonide	0.782
GIC baseline	8.6 ± 2.5	Baseline vs Levosalbutamol	0.614
GIC + Levosalbutamol	8.0 ± 0.5	Baseline vs Budesonide	0.168
GIC + Budesonide	6.6 ± 1.4	Levosalbutamol vs Budesonide	0.083

Table 4: Comparison of b* values among study groups

Group	Mean ± SD	Comparison	p value
Composite baseline	24.2 ± 3.4	Baseline vs Levosalbutamol	0.625
Composite + Levosalbutamol	23.3 ± 2.6	Baseline vs Budesonide	0.595
Composite + Budesonide	25.3 ± 2.3	Levosalbutamol vs Budesonide	0.229
GIC baseline	42.8 ± 4.8	Baseline vs Levosalbutamol	0.248
GIC + Levosalbutamol	45.6 ± 1.6	Baseline vs Budesonide	0.867
GIC + Budesonide	43.3 ± 3.9	Levosalbutamol vs Budesonide	0.257

Table 5: Comparison of surface roughness among study groups

Group	Mean ± SD	Comparison	p value
Composite baseline	1.495 ± 0.274	Baseline vs Levosalbutamol	0.381
Composite + Levosalbutamol	1.617 ± 0.101	Baseline vs Budesonide	0.735
Composite + Budesonide	1.555 ± 0.267	Levosalbutamol vs Budesonide	0.644
GIC baseline	1.013 ± 0.115	Baseline vs Levosalbutamol	0.133
GIC + Levosalbutamol	1.488 ± 0.625	Baseline vs Budesonide	0.079
GIC + Budesonide	1.466 ± 0.489	Levosalbutamol vs Budesonide	0.950

Discussion:

To assess the effect of two frequently-prescribed antiasthmatic inhalers (Levosalbutamol and Budesonide) on the colour change and surface roughness of glass ionomer cement (GIC) and composite resin in this vitro study. Results showed that both the inhalers brought about measurable changes in the restorative materials, and superior changes in GIC as compared to the composite resin. The observations here indicate that use of inhaled drugs could negatively impact the esthetic qualities and surface qualities of restorations, particularly the conventional glass ionomer types. The present study shows that composite resin showed limited amount of change with both inhalers in L*, a* and b* colour coordinate, while GIC showed significant change in L* (lightness) value upon exposure to inhalers, levosalbutamol and budesonide. The results obtained in this study show that GIC was more responsive to optical changes compared to composite resin. The same results were reported by Candan and Ünal, where the color change of the restorative materials increased significantly following inhalation of drugs for asthma, and there was a correlation between increase of color change and greater exposure to water and porous structure of the restorative materials whereas glass ionomer cements showed greater change in color than resin composite cements **[8].** The present results also agree with Subramaniam et al who tested the effect of the antiasthmatic inhalers on the restorative materials and noted major changes in colour stability due to the repeated exposure to inhalers. They determined that these factors (repeated deposition from the aerosol, acid drug formulation, and reduction in salivary buffering) were responsible for degradation of restorative materials, and that GIC seemed the most affected **[9].** The same mechanism might be the explanation for the greater L* values found in the present research. Similar results were found in several studies that assessed the response of various medications to esthetic restorative materials, where Çapan and Birant indicated that pediatric drugs could cause substantial colour change and that water absorption and matrix degradation was greater in glass ionomer materials than in composite **[10].** Similarly, Faghihi *et al.* found that the color stability of conventional glass ionomer cement (GIC) was significantly affected after prolonged exposure in liquid form of pediatric medications, whereas composite resin was found to be comparatively stable **[11].** The higher susceptibility of GIC seen in this study could possibly be linked to its hydrophilic matrix, acidic base setting reaction and relatively high porosity. These attributes allow entry of water and chemicals into the material which alters its optical characteristics. On the other hand, composite resin involves a very cross-linked resin matrix, with inorganic fillers which have greater resistance to chemical degradation. The same was found by Alacote-Mauricio *et al.*, which evaluated the color change produced in various CGCs and examined the effects of these materials when submitted to staining solutions **[12].** In the present study, changes in the three color parameters were demonstrated; however, changes within the single groups were not statistically significant for the a* and b* color parameters. In a sense similar to those reported by Arregui *et al.*, the present compositional changes reported in predominantly lightness terms, but without significant changes in chromatic coordinates, mainly included in the Yerran's U and V coordinates. Claimed that variation in the appearance of light reflected back from the fibres has a more significant effect on discoloration than merely the ability to absorb pigments **[13].** Surface roughness is relevant to the longevity of restoration because rough surfaces promote accumulation of plaque, bacterial colonization, staining and inflammation of gingival tissue. For both restoratives, there was an increase in surface roughness following inhaler exposure, but more marked for the GIC than for the composite resin in the present study. The difference between groups in terms of intragroup differences was not significant but the percentage increase was much greater in GIC. The results indicate that frequent dosing with inhaled

medicines can cause gradual erosion of healthy surface. Our current findings agree with Almutairi *et al.*, who found significant increases in surface roughness and color change of esthetic restorative materials when subjected to multiple exposures to pediatric medicine. The team found that acidic drug products would weaken restorative surfaces and cause them to wear and discolor **[14].** Similar findings were reported by Attia *et al.* (2025), who observed significant colour changes but non-significant increases in surface roughness following salbutamol exposure in hybrid ceramics **[15].** Tüzüner *et al.* exhibited that the surface integrity of the restorative materials used by the children in the context of conservative approach to their treatment was influenced adversely by acidic drugs supplied by the treatment, and glass ionomer cement showed the maximum deterioration due to dissolution of its hydrogel matrix **[16].** Similar observations were made by Kathiria *et al.*, who noted that repeated exposure to pediatrics resulted in prominent changes in discoloration and enhanced texture/roughness of esthetic restoratives. The results of the present study showed that composite resin had the maximum resistance in comparison with conventional glass ionomer cement **[17].** Another study done by Hasanain *et al.* also showed that both conventional and resin-modified glass ionomer restoratives exuded a higher amount of water sorption, solubility, and staining when they were subjected to external chemical agents. This study highlights the fact that because of their hydrophilic nature, glass ionomer materials will degrade at a higher rate than resin-based restorative materials **[18].** The present study has several advantages such as standard preparation of specimens, objective measurement by spectrophotometric measurement and profilometers, and constant experimental conditions. But there are some drawbacks. There were no salivary protein, oral biofilm, tooth brushing, dietary behavior, temperature changes and intraoral aging which cannot be simulated in an *in vitro* study. Moreover, the experimental exposure time was short, so it was quite different from the long inhaler use in clinical practice by asthmatic patients. Further research with the use of thermocycling, artificial ageing, brushing simulation and longer observation times is recommended to provide more representative oral environment. In summary, the results obtained from the present study suggest the ability of antiasthmatic inhalers to affect the color stability and surface properties of restorative materials. Compared to the conventional glass ionomer cement, the composite resin showed a higher resistance to changes caused by inhalers, and hence it may be more suited to be a restorative material for patients who need long term inhalers.

Conclusion:

Both levosalbutamol and budesonide inhalers adversely affected the color stability and surface integrity of restorative materials, with glass ionomer cement exhibiting greater deterioration than composite resin. Composite resin showed superior resistance to inhaler-induced esthetic and surface changes, making it more suitable for patients receiving long-term inhalational therapy. Thus, data support material selection based on long-term durability and reinforce the importance of preventive oral care and regular clinical monitoring in patients using antiasthmatic inhalers.

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