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Original Research

Effect of salbutamol based nebulizer on surface roughness and color stability of different dental resin materials – An invitro study

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ABSTRACT:

Introduction: Several studies have shown that chronic treatment with salbutamol sulfate and inhaled corticosteroids in asthma patients has increased the risk of dental caries and bacterial plaque accumulation, which calls for these patients' special attention by medical and dental health professionals[1,2,3,4]. **Materials and methods:** In this prospective, an invitro study was done to evaluate the surface roughness changes and color stability of three different dental resins i.e., heat cure acrylic resin I (ACRYLYN – H, PINK), cross linked tooth colored acrylic resin (BRULON INTERNATIONAL, shade A1) and bis acrylic temporary resin (PROTEMP 4, shade A1). up on exposure to salbutamol-based nebulizer. The outcome parameters assessed at the end of 30days, 60days, 90days. Statistical analysis was performed using SPSS version 20 software. **Results &. Conclusion:** The study revealed that the inhalation of salbutamol sulfate significantly ($p<0.01$) affected the surface roughness and color stability of all three resins.

Keywords: Bis acrylic resin, Cross-linked acrylic resin, Nebulizer, Polymethyl methacrylate (PMMA), R_a value, Salbutamol sulfate, Spectrophotometer, Surface roughness tester, ΔE value.

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INTRODUCTION

Salbutamol sulfate is a selective β2 agonist which is administered in inhaler form, that elicit fast onset bronchodilation in reversible airway obstruction[1]. Polymethyl methacrylate (PMMA) is most commonly used denture base resin as well as denture teeth because they are economical, easy to manipulate, fabricate, and repair compared to other materials available for fabrication of denture[2]. Studies by Quirynen et al. showed that an increase in the surface roughness of resin strips above the roughness average (R_a) value of 2μm resulted in the bacterial colonization[3]. The discoloration of treatment restorations when used for longer duration can result in an esthetic problem. Minimizing change of color is a factor that should be used in the selection of materials and techniques[4]. Studies revealed that the antiasthmatic medication exerts effects on dental caries and periodontal disease[5].However, there were no such studies which evaluated the effect of antiasthmatic drugs on different resin materials. This study aimed to investigate the effect of salbutamol sulfate inhalation in a mist form on surface roughness and color stability of dental resins.

The null hypothesis was that no significant changes in the surface roughness and color of resin materials would occur after salbutamol sulfate exposure.

MATERIALS AND METHODS

Round metal molds of dimensions 10x 2 mm were taken to fabricate specimens. Sixty wax patterns for groups I and II were fabricated by pouring molten modeling wax into the customized mold space of dimensions 10 x 2 mm and was allowed to solidify, then retrieved from the mold for investment. Dental stone was mixed according to the manufacturer's instructions and poured into the dental flasks' base. The wax patterns were invested into the dental stone to half of their height. After the dental stone is set, cold mold seal was applied and is allowed to dry. Dental stone is then mixed and poured into the flask until it is completely filled to form the second pour. After the complete set of the stone, dewaxing was done by immersing the flasks in the dewaxing unit at 100ºC for 4 minutes. The flasks were then removed from the dewaxing unit, and residual wax was flushed out. After the mold is dried, cold mold seal was applied, and the heat polymerized resin (group I) and cross-linked acrylic resin (group II) materials were mixed in a porcelain jar separately according to the manufacturer's instructions (21 g of polymer to 8 ml monomer). The heat-cured acrylic resin and cross-linked acrylic resin were packed into the stone mold in the dough stage in both the compartments, and the flasks were placed under hydraulic pressure upto1000 psi.

The resin was allowed to bench cure for 30 minutes. The flasks were removed from the hydraulic press and were attached to the clamps and allowed to undergo short- time polymerization in a water bath at 72°C for 1.5 h, followed by 30 min boiling in 100°C water in a dental acrylizer. Flasks were allowed to cool down to room temperature and then removed from the water bath and deflasked. The samples were then retrieved carefully, trimmed by using the acrylic trimmer, and all samples (group I and II) were finished with no. 220, 600, 800 silicone carbide grinding papers and polished with 1000 grade abrasive waterproof paper with intermittent movements lasting 10 s each, rinsed with tap water, and air dried. Specimens were polished using a slurry of water and pumice with a brush wheel.

Group III (Protemp 4) Sample fabrication:

The Protemp 4 (3M Deutschland GmbH, Germany. Lot NO: 3384978) provisional material, which is supplied in cartridge form as base and catalyst pastes were dispensed into the metal mold space. A glass coverslip was placed immediately above the template in order to achieve a uniform thickness (2mm) of the sample. After the final set (5 minutes), the glass coverslip and mold were separated, and the samples were retrieved. Later the samples were polished and finished with pumice.

A total of 30 samples were prepared in the same method and were stored in artificial saliva, same as the above two groups.

The specimens of all (group I, II, III) were then randomly divided into two groups (n = 15), i.e., the control group and the test group, and were named as group IA, IB, IIA, IIB, IIIA, IIIB. All the samples were stored in containers with a lid filled with artificial saliva **(Fig no:1).** The test specimens were stored using a supporting device

Fig no :1 control group samples in artificial saliva

Salbutamol sulfate application in a mist form During the salbutamol sulfate application, the test specimens were place into a chamber using a supporting device that would allow the samples to remain in a vertical position so that the greater part of their surface would be exposed **(fig no:2)**. After exposure to each respule, the test specimens were immersed in artificial saliva, brushed with toothpaste (Colgate Total) and washed under running water to simulate clinical conditions; they were then exposed to the next respule. Each sample was treated with 20 mg respule each day as it is the average daily dose for asthma patients. Readings were noted at the end of 30, 60, 90 days' time intervals.

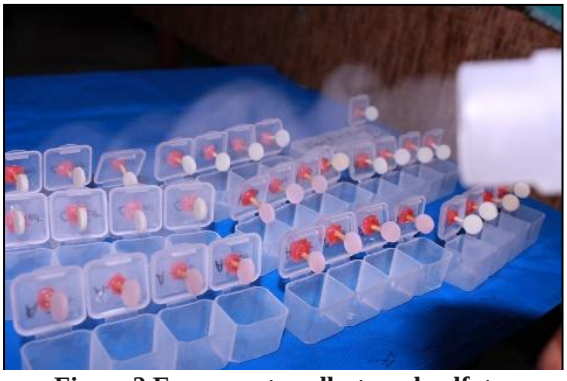


Fig no 2 Exposure to salbutamol sulfate

Method of evaluating surface roughness: (fig no :3)

- Before each reading, the samples were rinsed under running water for 1 minute and dried with a blotting paper.

The surface roughness values (Ra) of the specimens were measured with Talysurf SurfTester (SJ-210P, Mitutoyo Corp, ISO 1997,0.02 inches/sec, Kawasaki, Japan). Three readings were taken from each sample at the center of the specimen, 1mm to the right and 1mm to the left, and the mean R_a value was calculated for each sample. Readings were noted on the control and test group specimens of all groups I, II, III at the end of the 30th day, 60th day, 90th day.

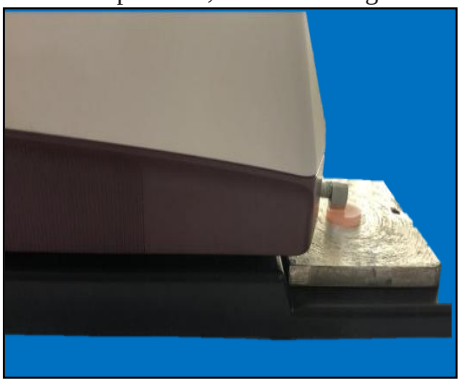


Fig no 3 Measuring surface roughness with surface roughness tester (Mitutoyo)

Method of evaluating color stability: (fig no:4)

Color data was recorded using a spectrophotometer (Datacolor spectrum 600_{TM}) by calibrating with a standard calibrator before recording the color measurements. The diameter of the measurement aperture was 6.6mm; the illumination and light beam angle was 90^0. Color changes were examined for each specimen based on color specifications using the CIE L*a*b* color space system. The CIE L*a*b* system represents a three-dimensional color space with components of lightness (L), red-green (a), and yellow-blue (b).

In terms of ΔE values, color data measurements were noted at the end of 30, 60, 90-day time intervals. All color measurements were observed from the central part of each specimen. Values of ΔE ≥3.3 were considered to be clinically unacceptable.

To relate the color differences (ΔE) to the clinical environment, the color data was quantified by the National Bureau of Standards (NBS), United States units, with the following formula: NBS units = ΔE × 0.92. Critical marks of color differences according to the NBS are classified as trace (T): 0.0–0.5; slight (S): 0.5–1.5; noticeable (N): 1.5–3.0; appreciable (A): 3.0–6.0; much (M): 6.0–12.0 and very much (V): >12.0.

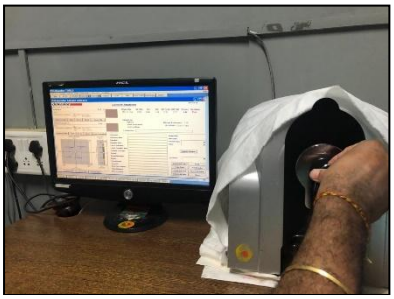


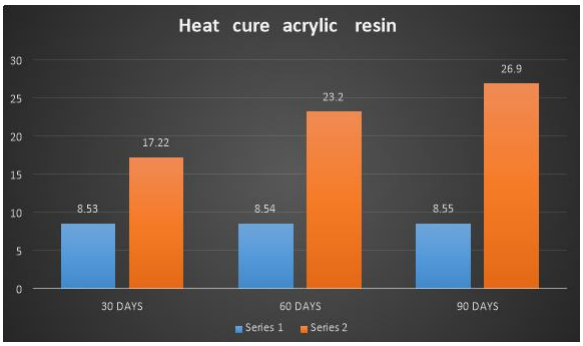
Fig no 4 Measuring color changes in spectrophotometre

STATISTICAL ANALYSIS

The statistical analysis was performed using software SPSS version 20.0 (I.B.M., NY, U.S.A.). Paired t-test was carried to know the mean comparisons of surface roughness between the test and the control groups of three materials at three different time intervals. One way ANOVA was performed to know the between group comparisons of surface roughness, which was followed by post hoc tests for multi pair wise comparisons with the statistical significance value set as $p < 0.05$. One way ANOVA was done to compare the means of color stability between the three groups at three different intervals followed by Tukey post hoc test with the statistical significance level set as $p<0.05$.

RESULTS

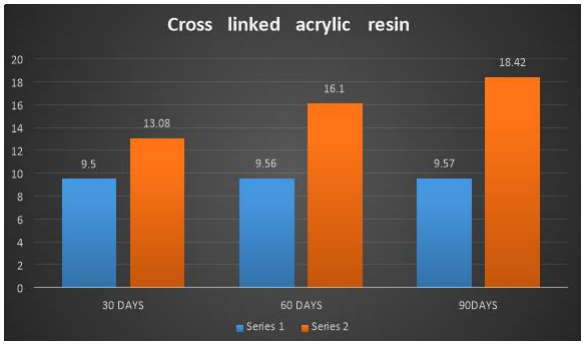
<u>GRAPH 1</u>: R_a Mean values comparison of Group 1 test and control samples (HEAT CURE ACRYLIC RESIN) during different time intervals.



Graph 1 represents the comparison of mean values of Group 1(heat cure acrylic resin) control and test samples, which were obtained during different time intervals. The bar graph represents that there were

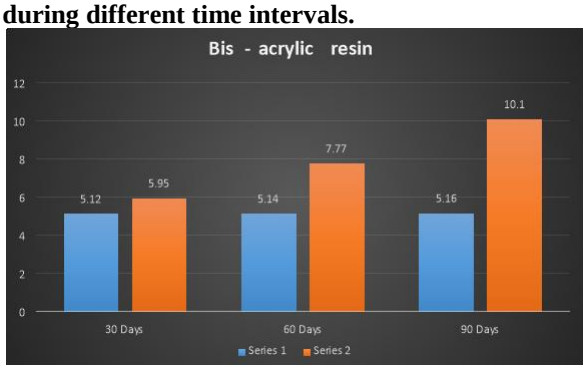
significant differences observed in test group samples from 30 to 90 days. The lowest mean value was obtained in the control group samples at all time intervals, and the highest mean value was obtained in the test group samples.

GRAPH 2: R_a Mean values comparison of Group 2 test and control samples (CROSS LINKED ACRYLIC RESIN) during different time intervals.



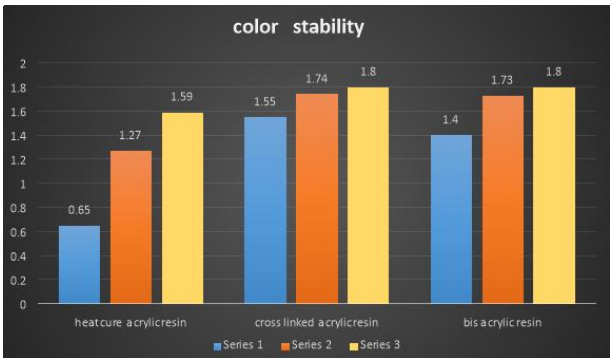
Graph 2 represents the comparison of mean values of Group 2(cross linked acrylic resin) control and test samples, which were obtained during different time intervals. The bar graph represents that there were significant differences observed in test group samples from 30 to 90 days. The lowest mean value was obtained in the control group samples at all time intervals, and the highest mean value was obtained in the test group samples.

GRAPH 3: R_a Mean values comparison of Group 3 test and control samples (BIS -ACRYLIC RESIN) during different time intervals.



Graph 3 represents the comparison of mean values of Group 3 (Bis- acrylic resin) control and test samples, which were obtained during different time intervals. The bar graph represents that there were significant differences observed in test group samples from 30 to 90 days. The lowest mean value was obtained in the control group samples at all time intervals, and the highest mean value was obtained in the test group samples.

GRAPH 4: ΔE Mean values comparison of Group1,2,3 during different time intervals.



Graph 4 represents the comparison of ΔE mean values of groups 1,2,3 at three different time intervals. The bar graph represents that there were significant differences observed in group 3 samples from 30 to 90 days. The lowest mean value was obtained in the group 1 samples at all time intervals, and the highest mean value was obtained in the group 3 samples.

DISCUSSION

Bronchial asthma is a globally significant disease. This chronic lung disease has a detrimental effect on the oral cavity, like the reduction of salivary secretion, change in salivary composition and pH. Inhaled β2 agonists provide a favorable environment for the growth and multiplication of microorganisms causing dental caries (Streptococcus mutans and Lactobacilli) by decreasing salivary secretion[6,7].

However, the effect of these antiasthmatic drugs on different dental resins has not been studied.

This study aimed at evaluating the effect of antiasthmatic medication in a mist form on change in surface roughness and color stability of heat cure acrylic resin, cross-linked acrylic resin, and bis acrylic resin materials.

In this study, both the test and control group samples of all three materials were stored in artificial saliva and were brushed in order to equalize the effect of absorption as well as roughness.

This study evaluated the effect on three resins by antiasthmatic medication through a nebulizer for a period of 90 days, and tests were performed at the end of 30, 60,90 days intervals.

At the end of 30 days of exposure to the mist form of antiasthmatic medication,it was observed that the roughness has significantly increased for heat cure acrylic resin followed by cross-linked acrylic resin and least for bis acrylic resin.

At the end of 60 days, by observing the trend of R_a values it was noted that the change of roughness is more for heat cure acrylic resin when compared to the other two groups of resins.

At the end of 90 days, the R_a values of test group samples have increased.The roughness difference from initial period to final period is comparatively more for heat cure acrylic resin and cross-linkedacrylic resin than bis acrylic temporization resin. Results of the present study showed that the inhalation of salbutamol sulfate significantly ($p<0.05$) affected the surface roughness of all three resins.

Hence the structural properties and finishing procedures of restorative materials affected the surface roughness characteristic[8]. The difference could be the chemical characteristics of the material itself.

This less roughness change of bis acrylic resins can be credited to the fact stated by Balkenhol et al. that bis-acryl composites contain multifunctional monomers, which increase strength due to cross linking. According to Rawls HR, the 3-D network of cross-linked polymer chains forms a rigid structure for the composite resins as the entire network acts as one unit. This phenomenon enhances the surface characteristics of bis-acryl composite resins. Surface hardness is one of the good indicators of resistance to wear and surface deterioration[9]. Diaz-Arnold found that all bis-acrylic resin composite materials exhibit superior microhardness over the traditional methyl methacrylate resins throughout a 14-day interval of investigation[10].

It should also be pointed out that in addition to monomers such as bisphenol A-diglycidyldimethacrylate (Bis-GMA) and triethylene glycol dimethacrylate (TEGDMA), the bis-acrylic resins have an organic matrix and inorganic filler particles. Monomers and their derivatives are tend to provide better mechanical properties, reduction in polymerization shrinkage, and excellent polishing properties[11,12].

Antiasthmatic inhalers may produce some side effects. The manufacturers report that mouth or throat irritation is a common oral side effect of the drug[13]. Surface roughness is an important clinical criterion of restorative materials. Increased roughness may lead to more plaque retention, bacterial adherence, and gingival irritation[14].

The results of the present study may indicate the higher caries susceptibility of asthma patients undergoing treatment with inhalers and nebulizers. During the use of this medication, the drug is applied as a pressurized metered-dose aerosol unit for oral inhalation, which contains a microcrystalline suspension of albuterol sulfate ethanol and oleic acid. These substances cover the teeth and periodontal tissues during inhalation and may remain as a residue after inhalation. Thus, patients using inhalers and nebulizers should be advised to implement more precautionary oral hygiene measures and have their caries activity and periodontal health status regularly examined. Generally, it is advised to rinse the mouth immediately after using the inhaler[15].

Temporary restorations are intended for the period between tooth preparation until insertion of the final prosthesis. Even during the time when interim restorations are being present in the mouth, esthetics are important[16].

Color stability is important for the esthetics of long-term provisional restorations and has been previously studied in vitro for a variety of interim materials. Proprietary variations in the chemistry, such as size distribution of the PMMA particles, the polarity of the monomers, color stability, and efficiency of the initiator system for provisional resins, may lead to different degrees of polymerization, water sorption, and consequently, color stability[17] as highlighted by Mazaro et al., the mixture of monomers may affect color stability, considering that most of the bis-acrylic resin polymers are more polar than acrylic resin(PMMA) polymers. These chemical characteristics increase the affinity of bis-acrylic resins for polar liquid molecules, and consequently, facilitates greater sorption of substances that interfere in the color stability of the materials[11].

In the current study, inhalation influenced the color of all three resins. This discoloration may possibly be due to the active ingredient of the inhaler nebule, which contains a $(C_{13} H_{21} NO_3)_2H_2SO_4$ sulfate group. The ingredients of this drug may affect the sulfate group. The ingredients of this drug may affect the surfaces of the dental materials by forming a pellicle matrix that provides an acidic environment, thus promoting demineralization and increasing surface roughness and discoloration[18].

To relate the color differences (ΔE) to the clinical environment, the color data were quantified by the National Bureau of Standards (NBS)[41], United States units, with the following formula: NBS units = $\Delta E \times 0.92$. Critical marks of color differences according to the NBS are classified as trace (T): 0.0–0.5; slight (S): 0.5–1.5; noticeable (N): 1.5–3.0; appreciable (A): 3.0–6.0; much (M): 6.0–12.0 and very much (V): >12.0.

When the mean ΔE values of the specimens were converted to NBS units, in the present study tooth

colored cross-linked acrylic resins and bis acrylic resins exhibited a noticeable (N) difference after inhalation, while heat cure acrylic resins were classified as trace (T) to slight (S) at the end of 90 days.

Moreover, studies conducted by Gujjari et al., and Mazaro et al.,[12] found that PMMA is more color stable than bis-acryl composite resin, as PMMA showed lower color change values as compared to bis-acrylic resin for cola and coffee solutions. This happens because the PMMA-based materials have a more homogeneous composition, and consequently, the capacity to absorb and adsorb solutions, which may have a direct influence on color stability. Because of the heterogeneity of bis-acrylic resins, the pigmenting solution is capable of infiltrating into the midst of small particles of material, thus causing a greater level of pigmentation[20,12,21].

Thus, the results of this study indicate that the color stability and surface roughness of all the three types of resins were influenced by asthmatic medication in a mist form and also the exposure interval.

However, the present study has certain limitations as it could not completely simulate the oral environment since the results may vary due to the neutralizing effect of saliva, thermal changes of oral cavity and food, food colorants, microbes present in the oral cavity, etc., Furthermore, the dentures have biplanar surfaces which attract more stains rather than flat surface specimens altering the observed results.

To overcome the limitations of this study, dentures of asthmatic patients should be evaluated.

CONCLUSION

The study revealed that the inhalation of salbutamol sulfate significantly ($p<0.01$) affected the surface roughness and color stability of all three resins.

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