

Comparison of color stability and microleakage of bioactive material and a resin infiltration material on hypomineralization in primary teeth

 Priyanka Purohit¹,  Dinesh Rao² ✉,  Sunil Panwar³,  Krittika Samaddar⁴,  Remi Ravi⁵

Highlights

The colour stability and microleakage of a bioactive material and a resin infiltration material were evaluated and compared on hypomineralisation in primary teeth.

The bioactive compound showed significant colour stability and decreased microleakage compared to the resin infiltration material.

The study showed that bioactive compounds can be a better option while managing primary tooth hypomineralization cases.

Abstract

Aim: The current study aimed to evaluate and compare, in vitro the colour stability and microleakage of a bioactive material and a resin infiltration material on hypomineralization in primary teeth. **Methods:** Sixty human primary molars and incisors, which has been exfoliated or extracted were immersed in a demineralizing solution. 20 each specimen were treated by a bioactive compound (ACTIVA KIDS Bioactive-RESTORATIVE, PULPDENT, USA) (Group A), resin infiltration (Icon, DMG, Germany) (Group B) and as Control group (group C). Evaluation of colour stability and microleakage was done by using spectrophotometer analysis. The difference in color stability and microleakage of all three groups was determined by statistical analysis with a one-way ANOVA test for the proportion of the groups. $p < 0.05$ was considered as statistically significant. **Results:** The bioactive compound showed statistically significant colour stability and lesser microleakage than resin infiltration material. **Conclusions:** Since bioactive compound exhibited better colour stability as well as showed lesser microleakage, it can be recommended for the restoration of the hypomineralized primary teeth.

Keywords: Bioactive; Dental; Materials; Tooth Hypomineralization

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INTRODUCTION

Enamel hypomineralization is considered a qualitative fault of the enamel as it interrupts the process of early calcification due to a disturbance during amelogenesis. When underlying enamel demineralization is evident on the smooth surfaces of teeth, white spot lesions (WSLs), also known as "white opacities," develop. White spot lesions are formed due to the consequent diminution of the mineral phase in comparison to the healthy enamel.¹ The hypomineralization in primary dentition is mostly present in the second primary molar, which has a prevalence of 4.9% at the child level and 3.6% at the tooth level.² Deciduous molar hypomineralization (DMH) can be utilized clinically as a predictor for molar incisor hypomineralization because second primary molars erupt 4 years prior in life than the first permanent molars (MIH). Early MIH diagnosis enables the use of preventive interventions like fluoride applications and CPP-ACP.³ White spot lesions can be treated using several methods. The typical treatment plan includes restorative operations, enhancement of remineralization utilising CCP-ACP or products composed of fluoride, microabrasion and bleaching techniques and laminate or veneer repair.⁴

Different techniques for remineralization are somewhat effective, but their cosmetic impact is limited since remineralization frequently occurs just on the lesion surface. Moreover, the patient's compliance is crucial.⁵ In order to cover up white spot lesions, hydrogen peroxide bleaching therapy has been preferred. Nevertheless, its cosmetic outcome is likewise limited, and adverse effects such as post-operative sensitivity are frequently recorded. After bleaching, the microhardness of healthy enamel surfaces and demineralized enamel surfaces may both be lowered. Another method for enhancing the appearance of white spot lesions is microabrasion. However, this method might result

in an aggressive loss of enamel, which is considered one of the side effects.⁴

Finally, tooth reduction restorations, which are highly intrusive, have been widely used. However, most patients are unwilling to undergo an intrusive procedure. This type of procedure frequently results in significant tooth material loss, which hastens the decay of the tooth at a younger age. Thus, in these situations, bioactive materials and resin infiltration materials can be used as alternatives to restorative materials.

This bioactive substance combines glass particles with a hydrophilic ionic resin matrix to promote the dispersion of calcium, phosphate, and fluoride ions, which then react to variations in the pH of the oral cavity.⁶ Aactiva Bioactive Restorative (Pulpdent Corporation, USA) is the first bioactive composite, comprising a shock-absorbing resin component, an ionic resin matrix, and bioactive fillers. It is generally considered a dynamic 'smart' material that is aesthetic, chemically adheres to teeth, and seals teeth against microleakage.⁷ Resin infiltration, also called as 'erosion infiltration', is a technique that penetrates demineralized enamel using a very low viscosity resin. For this method, the only material accessible is Icon (DMG, Hamburg, Germany). The manufacturer of this material suggests using it to treat white spot lesions or incipient caries that extend up to the outer third of the dentine.⁸

As both the materials are aesthetic, their colour stability should be evaluated for their better longevity. Hypomineralized teeth are more prone to secondary caries; hence, microleakage should also be evaluated. To increase the clinician's awareness regarding a potential long-term aesthetic outcome and expectations, it is crucial to investigate the impact of these changes on the colour stability and microleakage of these resin materials. Thus, the main aim of the present study is to evaluate and compare the colour stability and

microleakage of a bioactive material and a resin infiltration on molar-incisor hypomineralisation in primary teeth.

METHODS

The study was approved by the Institutional Ethical committee of Pacific Dental College and Hospital, Udaipur, India ((Ref.No. PDCH/21/EC-252, dated 15.06.21).

A total number of sixty human primary teeth, which has been either exfoliated or extracted for different therapeutic reasons i.e. over retention, nearing exfoliation, case indicated for space maintainer were collected. The specimens were stored by immersing in 0.5% thymol solution and then in distilled water before the experimental steps. The specimens then were immersed in a demineralizing solution for 32 hours. The specimens were immersed in a solution at a concentration of 2 mL/mm² of exposed enamel area. Out of the collected samples, 20 teeth were randomly selected in group A and treated by bioactive compound (ACTIVA KIDS BioACTIVE – RESTORATIVE, PULPDENT). The surfaces (dentin and enamel) were treated with Etch-Rite 38% phosphoric acid etching gel for 10 seconds. Without desiccating the dentin structure, the surfaces were rinsed and dried with compressed air, removing all the extra moisture. A single bulk increment of the ACTIVA restorative was dispensed, and light polymerization was carried out for 20 seconds. In group B, another 20 teeth were randomly selected and treated by resin infiltration (Icon, DMG, Germany). The artificially created demineralized lesions were etched using 15% hydrochloric acid gel (Icon - Etch) and further dried with the ethanol desiccation solution (Icon-Dry, DMG, Germany). In accordance with the instructions, the etching was repeated for deeper lesions. Two separate applications of infiltrant were made, the first for three minutes and the

second for one minute. Light curing of both the applications was done for 40 seconds. The rest 20 collected teeth, which belong to control group consisted of normal teeth specimen used for the evaluation of colour stability and microleakage. Half of the samples were used for the evaluation of colour stability and half for the evaluation of microleakage. Evaluation of microleakage and colour stability was done by spectrophotometric analysis. For evaluation of colour stability samples were kept in turmeric water for one week. Further samples were kept in distilled water for another one week. The supernatant solution was used for analysis. Absorbency was analysed in UV visible spectrophotometer at 400 nm and 670 nm. The results were noted as a measurement of light transmission. Evaluation of microleakage was done by drying the samples and immersing in 5 ml of 2% methylene blue dye (S D Fine Chemical Ltd, India) in a beaker for 24 hours. The samples were washed under running water after 24 hours to eliminate remaining dye. The samples were then immersed and stored in freshly prepared 65% nitric acid (S D Fine Chemical Ltd, India) for 72 hours. After 72 hours, the solutions were filtered using a fine grit filter paper in a centrifugal tube. Further, the obtained sample solutions were centrifuged in a high-speed microcentrifuge machine at 14,000 rpm for 5 minutes. The supernatant solutions thus obtained were used to assess absorbency in a UV visible spectrophotometer at 670 nm. The results have been recorded as a measurement of light transmission.

To perform statistical analyses, Statistical Package for Social Sciences [SPSS] for Windows, Version 25.0. released 2017. Armonk, NY: IBM Corp, was used. Microsoft word and Excel were used to generate tables. The difference in colour stability and microleakage of all three groups was determined by statistical analysis with a one-way ANOVA test for the proportion of the groups. $p < 0.05$ was considered as statistically significant.

RESULTS

The tooth samples treated with the bioactive compound showed better colour stability as compared to other two groups at 400nm as well as 670nm (Figure 1). Intergroup comparison was done using one-way ANOVA test and Tukey HSD test to compare the colour stability between the experimental groups. One-way ANOVA test revealed that there was a significant difference between tested groups. ($p \leq 0.05$) (Table 1).

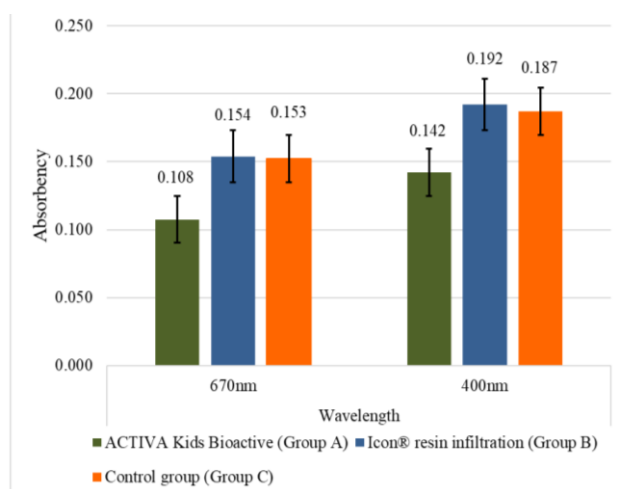


Figure 1. Graphical representation of mean colour stability levels of the test groups at different wavelengths

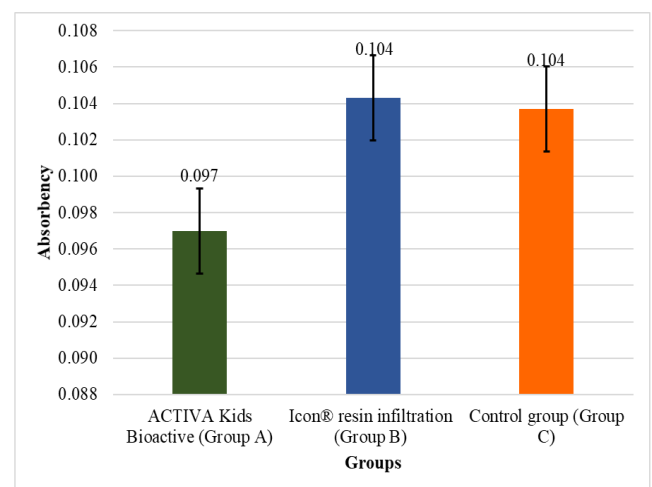


Figure 2. Graphical representation of mean microleakage of the test groups at 670nm

Table 1. Intergroup comparison of colour stability of all experimental groups at 400nm and 670nm using

		Sum of Squares	Df	Mean square	F	p value
Colour stability (670nm)	Between Groups	0.01518	2	0.00759	6.437	0.005*
	Within Groups	0.03185	27	0.00118		

One-way ANOVA test, * indicates significant difference at $p < 0.05$

Table 2. Intergroup comparison of colour stability of all experimental groups at 670nm and 400nm

	Groups		Mean difference	Std. Error	p value
Colour stability (670nm)	ACTIVA Kids BioACTIVE (Group A)	Icon® resin infiltration (Group B)	-0.046400*	0.013	0.004*
		Control Group (Group C)	-0.045000*	0.013	0.005*
	Icon® resin infiltration (Group B)	ACTIVA Kids BioACTIVE (Group A)	0.046400*	0.013	0.004*
		Control Group (Group C)	0.00140	0.013	0.994(NS)
	Control Group (Group C)	ACTIVA Kids BioACTIVE (Group A)	0.045000*	0.013	0.005*
		Icon® resin infiltration (Group B)	-0.00140	0.013	0.994(NS)
Colour stability (400nm)	ACTIVA Kids BioACTIVE (Group A)	Icon® resin infiltration (Group B)	-.049900*	0.015	0.008*
		Control Group (Group C)	-.045200*	0.015	0.018(NS)
	Icon® resin infiltration (Group B)	ACTIVA Kids BioACTIVE (Group A)	0.049900*	0.015	0.008*
		Control Group (Group C)	0.00470	0.015	0.950(NS)
	Control Group (Group C)	ACTIVA Kids BioACTIVE (Group A)	0.045200*	0.015	0.018(NS)
		Icon® resin infiltration (Group B)	-0.00470	0.015	0.950(NS)

Tukey HSD test; * indicates $p < 0.05$; NS: Non significant

Intergroup comparison was done using one-way ANOVA test and Tukey HSD test to compare the microleakage between the experimental groups. One-way ANOVA test revealed that there was a significant difference between tested groups. ($p \leq 0.05$) (Table 3)

The Tukey HSD test revealed there was no statistically significant difference between Group B and Group C. The difference was statistically significant between Group A and Group B, as well as Group A and Group C (Table 4).

Table 3. Intergroup comparison of microleakage of all experimental groups at 670nm

		Sum of Squares	df	Mean Square	F	p value
Microleakage (670nm)	Between Groups	0.00033	2	0.00016	28.4	0.000*
	Within Groups	0.00016	27	0.00001		

One-way ANOVA test, * indicates significant difference at $p < 0.05$

Table 4. Intergroup comparison of microleakage of all experimental groups at 670nm

Groups			Mean difference	Std. Error	p value
Microleakage (670nm)	ACTIVA Kids BioACTIVE (GroupA)	Icon®resin infiltration (Group B)	-0.007300*	0.001	0.000*
		Control Group (Group C)	-0.006700*	0.001	0.000*
	Icon®resin infiltration (Group B)	ACTIVA Kids BioACTIVE (GroupA)	0.007300*	0.001	0.000*
		Control Group (Group C)	0.00060	0.001	0.843 (NS)
	Control Group (Group C)	ACTIVA Kids BioACTIVE (GroupA)	0.006700*	0.001	0.000*
		Icon®resin infiltration (Group B)	-0.00060	0.001	0.843 (NS)

Tukey HSD test; * indicates $p < 0.05$; NS: Non significant

DISCUSSION

In the primary dentition, there appears to be a positive relationship between enamel hypomineralization and dental caries.⁹ The occurrence of molar incisor hypomineralization was also discovered to be positively correlated with the presence of hypomineralization in deciduous teeth, which could increase the frequency of caries in the permanent dentition.¹⁰ Since there appears to be a correlation between hypoplastic enamel and

early childhood caries, known as 'hypoplasia-associated severe early childhood caries' (HAS-ECC),¹¹ it is essential to treat hypomineralised teeth properly to enhance their structure and appearance. The management of hypomineralised teeth is challenging. Therefore, materials that offer quick and superior aesthetic effects coupled with longer durability should be employed, especially in paediatric patients.¹²

The restorative material must offer a colour that is as close to the tooth colour as feasible after application in order to create an aesthetic effect and to be clinically acceptable. It must also maintain its colour stability over time.¹³ Long-term colour stability in paediatric dental care of restorative materials is crucial for a number of reasons, including aesthetics, the added expenses of replacing restorations, and the possibility that children's dental anxiety would worsen as a result of the frequent trips required for replacement.

Dental structures and restorative materials may change colour as a result of both internal and external influences. Some studies^{14,15} suggest that diet is one of the variables that leads to the formation of extrinsic pigmentation. Restorative materials may experience colour changes as a result of being regularly exposed to saliva, food, and beverages in the oral environment. There are few studies that prove that colour pigments found in tea, coffee, and food dyes, including turmeric, cause colour change.^{16,17} In the present study, one week was selected as the test period on the basis of a previous study, where the results suggested that the extreme change in colour was noted after a period of 7 days.¹⁸

The masking effect of resin infiltration on hypomineralized spots was found to be immediate and better when compared to fluoride.¹⁹ On the other hand, when the staining behaviour of demineralized enamel infiltrated by low-viscosity resin was investigated, it was found that the specimen treated with the low viscosity resin showed higher staining ability than other tested groups.^{20,21} In the current study, the colour stability of bioactive material ACTIVA Kids BioACTIVE and resin infiltration material Icon, on primary teeth was compared and the bioactive material showed more stability towards colour change as compared to the resin infiltration. In an *in vivo* study

which assessed the colour stability of infiltrated surfaces, revealed stability of the aesthetic effect after a observational period of 12 months.^{22,23} A few *in-vitro* studies^{24,25} done regarding colour stability of the bioactive material ACTIVA BioACTIVE proved that the bioactive material showed promising results in colour stability of bioactive material when compared with other conventional restorative materials.

Function and aesthetic replacement are the main goals of all restorative systems. Microleakage at the material/tooth structure interface has, however, been linked to all restorations, as shown by the dental literature. The polymerization stress and shrinkage of the restorative material can also cause microleakage.²⁶

In the present study, resin infiltration material when compared with the bioactive material showed higher microleakage in the primary teeth. However, there are few studies revealed that resin infiltrates showed minimal microleakage compared to other resin sealants on permanent teeth.^{27,28} Other studies^{6,25,29} showed that ACTIVA BioACTIVE displayed less microleakage compared with other materials, when used as a restorative material for restoring class II cavities in primary molars. On the contrary, one of the studies exposed that ACTIVA BioACTIVE displayed higher microleakage than incrementally filled composites and resin-modified glass ionomer cement.³⁰

The present study utilized a dye extraction method to quantify the amount of microleakage and colour stability instead of dye penetration. This is because, in contrast to dye penetration, which is more of a qualitative assessment, the dye extraction method is a quantitative evaluation. Additionally, the depth of penetration of the dye around a restorative margin is not consistent and produces results that appear to be chosen at random, casting

doubt on their reliability.²⁹ The results in the current study were documented as a measure of absorbance of light. According to Beer-Lambert's law, the absorbency of the solution is directly proportional to the concentration of absorbing species in the solution and path length. Thus, a UV spectrophotometer is used to calibrate the amount of microleakage and colour stability.³¹

The absence of natural factors like the presence of saliva and oral clearance, which could not have been achieved in the laboratory setup, may have exaggerated the values of colour change and microleakage, as the present study is an *in-vitro* study. Further studies need to be done to evaluate the surface irregularities, the water resorption, and the dissolution of these restorative materials based on different temperatures and pH. This study may serve the basis for the clinician to choose a better restorative option which has stable esthetics as well as better longevity specially in term of secondary caries and failure of the restorations.

CONCLUSIONS

The difference between both the groups regarding colour stability and microleakage was statistically significant. ACTIVA KIDS BioACTIVE-RESTORATIVE proved to be colour stable at both the wavelengths i.e. 670nm and 400nm. Less microleakage was shown by ACTIVA KIDS BioACTIVE –RESTORATIVE as compared to Icon (DMG, Germany). ACTIVA KIDS BioACTIVE – RESTORATIVE showed good colour stability as well as lesser microleakage. Thus, it can be recommended for the restoration of the hypomineralized primary teeth.

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Declarations

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