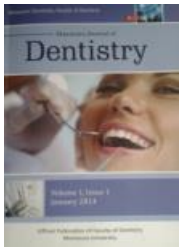
THE EFFECT OF TIME ON SILVER DIAMINE FLUORIDE AND POTASSIUM IODIDE COLOR CHANGE IN CARIOUS PRIMARY TEETH: (IN VITRO STUDY).



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Abstract:

Aim: The aim of the study was to evaluate the staining effect of potassium iodide and silver diamine fluoride

Methods: Sixteen carious primary teeth were collected and stored in saline. Caries was excavated by using a sharp spoon excavator. The teeth received SDF+KI. Color changes (ΔE) were measured using a spectrophotometer at the following time intervals: before solution application (baseline) and immediately after application, then 72 hours after application

Results: showed that within 38% SDI + KI group, there was no statistically significant difference either in ΔE mean values between different time intervals (P=0.2300).

Conclusions: silver Diamine fluoride and KI showed minimal color changes over the 72 hours.

Introduction

Dental caries is defined as a chronic disease which affects people all over the world of all ages and it's also a common dental health problem within school children globally.

When a great amount of tooth structure is destroyed by caries, restorative treatment can restore function, improve esthetics or phonetics. ***(Naaman et al., 2017)***. As children are usually afraid of restorative treatment, restorative treatment may be deferred when caries arrest is achieved, especially in uncooperative children ***(Calatayud et al., 2009).***

Silver diamine fluoride (SDF), is considered one of the most recent means of preventive and therapeutic caries management. It is liquid that has the bactericidal effects of silver and the reminirlization effects of fluoride, it is an excellent new agent for managing carious lesions and treatment of dentine sensitive surfaces in young children and those with special health care needs ***(Crystal and Niederman, 2019).***

When silver diamine fluoride is applied to a decayed surface, it increases its resistance to acid dissolution and enzymatic digestion and the treated lesion has higher in mineral density and hardness and less lesion depth (***Mei et al., 2013)***.

Silver diamine fluoride reduce the breakdown of the dentine organic matrix. While the fluoride strengthens the tooth structure during the bacterial attack by it's acid byproducts and decreases its solubility ***(Horst and Ellenikiotis, 2016)***. Silver ions action is directly against bacteria in lesions it break membranes, denature proteins,

and inhibit DNA replication. Silver diamine fluoride is the only anti-caries medicament that kills cariogenic bacteria in dentinal tubules ***(Poulose, 2016).***

Despite its benefits, the clinical use of SDF may be limited because of formation of black stains within tooth structure caused by silver deposition, leading to esthetic problems. It also stains containers, countertops, gloves, and skin .

To reduce SDF colour change , researchers have suggested using potassium iodide (KI) solution after the use of SDF ***(Knight et al., 2006)***.

The aim of this study is to compare the colour change of SDF and potassium iodide in carious primary teeth.

MATERIALS AND METHODS:

Study Design: In-vitro study.

Study Setting:

- The study was conducted in Pediatric Dentistry and Dental Public Health Department Faculty of Dentistry, Cairo University, Egypt.
- Spectrophotometry measurement was done at National Institute for Standards, Cairo.

PICO proposed in the registered protocol:

P: Carious primary teeth.
I:SDF 38% and KI after 72 hours.
C: SDF 38% and KI immediately after application.
O: Color assessment.

Table (1): Outcome.

Outcome	Method of measurement	Calculation method
Color assessment	Spectrophotometry	calculated using **CIE L* a*B*** equation: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$

Sample Size Calculation:

A power analysis was designed to have adequate power to apply a 2-sided statistical test of the research hypothesis (alternative hypothesis) that the KI in combination with SDF staining effect after 72 hrs is higher than immediately . According to the results of (Sayed et al., 2018), in which the (Mean±SD) values of the control and test groups were (6.23±0.86) and (7.62±2.11) respectively and by adopting an alpha (α) level of 0.05 (5%), a beta (β) level of 0.2 (20%) i.e. power=80%, and an effect size (d) of (0.76), the predicted sample size (n) was a total of (16) samples. Sample size calculation was performed using G*Power version 3.1.9.2.

Materials:

Materials description, composition, manufacturer and appearance are listed in **Table (2)**

Table (2): Materials used, and their chemical compositions.

Materials	Chemical composition	Manufacturer	Appearance
Silver diamine fluoride (SDF) **Figure (2)**	38% Silver diamine fluoride solution F = 44,880 ppm, Ag = 253,870 ppm.	Elevate oral care®, USA.	Liquid.
Potassium iodide.	KI	Wako Pure Chemical Industries, Osaka, Japan .	White, crystalline powder.

Methods:

Sample Collection:

Freshly extracted carious primary teeth ***(Nasr & Saber, 2020)*** were collected from outpatient clinic of Pediatric Dentistry and Dental Public Health Department Faculty of Dentistry, Cairo University by the end of every day.

Inclusion Criteria:

- Carious primary extracted molars.
- Extend of caries into dentin.
- Surfaces involved: occlusal or proximal surface.

Exclusion Criteria:

- Presence of restorations.
- Presence of pits and fissure sealant.
- Presence of hypoplastic pits.

Forty-five teeth were collected totally and sixteen eligible teeth were selected according to inclusion and exclusion criteria. The teeth were then stored in saline each in separate container and the containers were numbered from 1 to 16.

The sample consisted of:

-Six lower second primary molar.

-Three upper second primary molar.

-Seven lower first primary molar.

Sample Preparation:

Teeth were stored in saline**,** then soft caries was excavated with sharp spoon excavator* (Llodra et al., 2005).

The preparation of saturated KI solution:

Potassium iodide (KI) salt is is transparent or white hexahedral crystal composed of 76% of iodine and 23% of potassium. It is photosensitive and highly soluble in water. Its solubility limit varies depending on the solvent used.

One gram (1 g) of the solute can be dissolved in 0.7 ml of water or 0.5 ml of boiling water as solubility increased by boiling ***(Costa et al., 2013)***. The KI and SDF weights were measured by a four digits analytical balance**. So the saturated KI solution was prepared as following: Three grams of KI were dissolved in 1.5 mL boiling water**.**

Application of SDF& KI solution on the teeth:

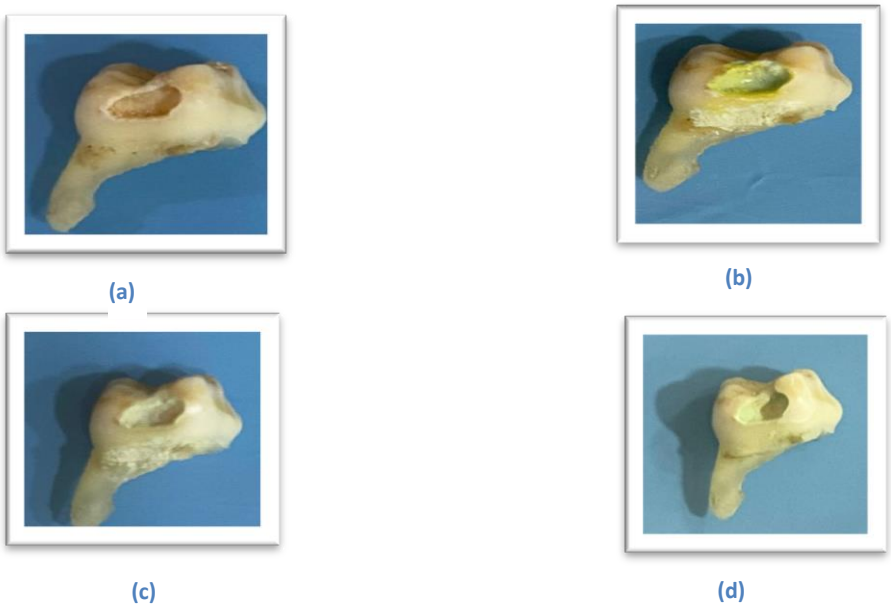
After caries removal, thirty-eight percent SDF solution was applied to the tooth surface and agitated using a micro-brush for 1 min. Immediately after SDF application, KI solution was applied using a separate micro-brush. Solution was agitated until creamy white precipitates turned clear. Then washed with copious amounts of distilled water for 30s. Then specimens were stored for 72 hours in an incubator ***.

*Sharp stainless excavator: Zeffiro Lascod-Italy: ZEF031 # 17W.

**Mettler Toledo four digits analytical

balance, Switzerland, JB1603-L-C.

***Incubator: Digit-ON D12015, Egypt.



Figure(1): (a) The specimen after caries removal before application of SDF + KI. (b) The white creamy precipitate after SDF+ KI application. (c) Immediately after washing of KI and SDF by distilled water. (d) The specimen after 72 hours of application SDF+KI.

Color Assessments:

Color assessment of the specimens was recorded, by a scanning spectrophotometer*, at three time points:
- Before solution application (Baseline).
-Immediately after solution application. Then all the specimens were incubated at 37 °C.
- Seventy two hours after solution application ***(Sayed et al., 2018, 2019)***

Spectrophotometer setting:

- light Source: D65.
- Wave Length: visible light 380:780 nm.
- Angle of Exposure :10°.

Color Difference Calculation

The color difference (ΔE) of each specimen between baseline and each time-interval point (ΔE) was calculated using an equation **CIE L* a *B*:**

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

***Spectrophotometer: SHIMADZU, UV-3101PC Spectrophotometers, Japan.**

Color Space System (frequently denoted as L*Δa*Δb*), where:
- L* represents brightness ranging from dark (0) to bright (100),
- a* describes red (+a*) to green (Δa*),
- b* represents yellow (+b*) to blue (Δb*) (***Lim et al., 2010***).

A single operator repeated the color measurements at the three time intervals for each specimen.
The color difference (ΔE) of each specimen between baseline and each time-interval point was recorded.

Statistical Analysis:

Statistical analysis was performed using IBM SPSS Statistics*. Data was presented as mean and standard deviation (SD). The significance level was set at $P \leq 0.05$. Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess data normality.
Two-Way ANOVA was conducted to evaluate the effect of study variables and their interaction on color change (ΔE). Repeated measures ANOVA followed by Tukey's post-hoc test were used to compare color change (ΔE) between different time intervals within solution.

RESULTS:

This study was conducted to evaluate the colour change potassium iodide and silver diamine fluoride.

Color difference was recorded using spectrophotometer at three time intervals: Before application of solutions (base line), immediate after application and 72 hours after application

Effect of time intervals on color change (ΔE):

Repeated measures ANOVA followed by Tukey's post-hoc test **Table (3) & Figure (2)** showed that within 38% SDI + KI group, there was no statistically significant difference either in ΔE mean values between different time intervals (P=0.2300)

Table (3): Mean±SD and P-value for the effect of time intervals on color change (ΔE) within each solution type.

(ΔE)	38% SDF + KI
Baseline – Immediately after application	6.86±1.37
Immediately after application – 72 h after application	5.02±4.74
Baseline – 72 h after application	7.96±2.89
P-value	0.230NS

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significant at P ≤ 0.05; NS: non-significant at P>0.05

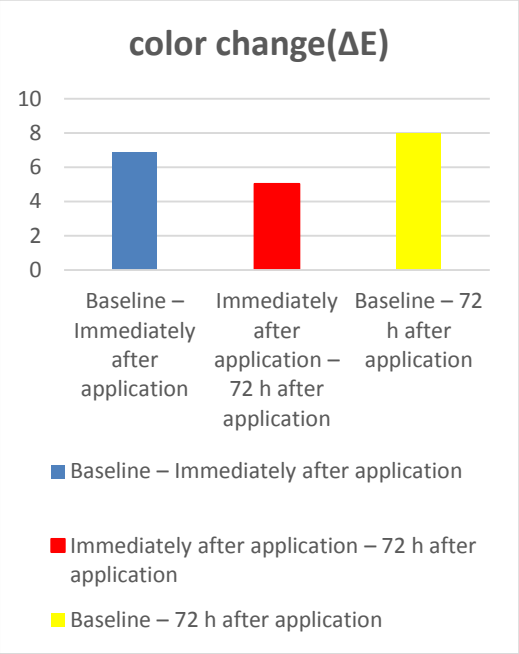

Figure (2): Bar chart showing the effect of time intervals on color change (ΔE) .

DISCUSSION:

The aesthetic appearance of a restoration is important for the pediatric dental patients, Although the promising therapeutic effect of Silver diamine fluoride as treatment for dentin hypersensitivity and it's wide acceptance as a caries arresting agent for young children and those with special care needs ***(Wright and White, 2017)*** significant aesthetic barriers preclude its widespread acceptance by patients ***(Crystal and Niederman, 2019)***.
therefore, this study was conducted to evaluate the colour change of SDF and KI.

SDF at a concentration of 38% is available in several commercial products as Saforide, Advantage Arrest and Riva Star. Riva Star is available only as a combination of SDF + KI. So, Advantage Arrest™ SDF liquid (Elevate Oral Care, LLC, West Palm Beach, FL) was chosen in the present study for standardization, to make sure that the same composition and concentration will be used with KI and GSH. In addition to it is a commonly used SDF product in previous clinical and laboratory studies ***(Yoshikawa et al., 2020).***

Potassium iodide was chosen to this study as It has been suggested when KI solution reacts with SDF silver iodide (a bright-yellow solid compound) can be formed and that is how the excess free silver ions that is the source of black staining can be reduced by addition of KI. ***(Knight et al., 2007).***

In the current study, soft caries and infected dentine were removed by sharp spoon excavator. Although according to ***Sharma et al, (2015) and AAPD (2017)*** the caries excavation might reduce the proportion of arrested caries lesions which become black but it was considered for esthetic purposes.

Also, ***Patel et al., (2018)*** found that the degree of staining was higher in the areas of surface irregularity, and ***Sayed et al., (2019)*** study showed that the degree of dentin demineralization had an increasing effect on the color change which was the same approach considered in the present study.

Color difference was evaluated quantitatively by spectrophotometer instead of the naked eyes, which is more accurate with high repeatability. A spectrophotometer was used in this study as it can record and measure the full visible spectrum for 3D color.

Colour difference was measured at three time points before application , immediately after application and after 72 hours as ***Patel et al. (2018)*** found that we can notice the black staining of carious dentine clinically two minutes after SDF application and it starts to relatively increase in value after five minutes and by 4-6 hr after application the dentine and enamel are stained deeply . twelve hours after application the stain reaches its maximum effect and minimal further staining of the tooth structure.

As metallic silver production is accelerated when exposed to high temperature ***(Zhao et al., 2018)*** that's why all samples in the present study were stored in incubator at 37° normal body temperature.

The result of the current study showed that potassium iodide had minimal amount of color change through time and there was no statistically significant difference in ΔE mean values between the baseline and 72 hours after application (P=0.2300). In

disagreement with the results of ***Knight et al. (2007)***, which showed that the application of potassium iodide did not have a long-term effect on improving the aesthetic problem resulting from black stains.
Garg et al. (2019) described a reduction in the staining with SDF + KI at the time of the placement. However, staining was reported to increase from day 7 to day 14 that was against the result of the present study which showed that within 38% SDI + KI group, there was no statistically significant difference either in ΔE mean values between different time intervals (P=0.2300). This may be due to the longer time interval of ***Garg et al.(2019)*** study which was 14 days.

Primus (2017) found no or minimal color change in SDF + KI treated teeth over the 28 days that come in accordance with the present study results which showed that within 38% SDI + KI group, there was no statistically significant difference either in ΔE mean values between different time intervals (P=0.2300).

Knight et al. (2007), showed that the application of potassium iodide did not have a long-term effect on improving the aesthetic problem resulting from black stains. However, the result of the current study shows that potassium iodide has its major amount of color change immediately after application and there was no statistically significant difference in ΔE mean values between the baseline and 72 hours after application (P=0.2300), which may require long term color assessment.

CONCLUSIONS:

silver Diamine fluoride and KI showed minimal color changes over the 72 hours.

LIMITATIONS:

- The spectrophotometry machine can't be used intraorally.

RECOMMENDATIONS:

Based on the results of such study the followings could be recommended:

- Further studies are recommended to find other materials that can reduce the staining effect of SDF.
- More studies are recommended to evaluate the effect of caries extension and amount of tissue demineralization on SDF discoloration.

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