Potassium Iodide's Influence on Silver Diamine Fluoride Staining Properties

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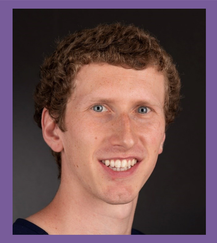


ABSTRACT

The purpose of this study is to determine the impact of Potassium Iodide (KI) on the black/gray staining caused by Silver Diamine Fluoride (SDF) when applied to carious lesions. Methods: The research study examined the use of SDF and SDF followed by KI (SDF+KI) on extracted permanent molars that had caries induced on their surfaces and monitored for a period after application. To monitor the color changes, the CIELAB color space – a color space defined by the International Commission on Illumination – was used. The system is composed of three values *L, *a, and *b, where the *L measures black to white across a span of 0 (black) to 100 (white). Measurements were taken at eight intervals between days 0 to 72. Results: Upon conclusion, *L values were found to be significantly different between SDF and SDF+KI groups and from baseline. On average the SDF+KI group when compared to the SDF group was 9.47 units lighter. Conclusion: The findings indicated the application of KI has the capability to reduce the black staining SDF causes, potentially making it a viable esthetic option for patients with anterior caries.

INTRODUCTION

Caries is the most chronic disease of childhood. Treating children for any medical condition or disease, including dental caries, can often be difficult as the child is developing, and behavior may not allow for ideal treatment and favor an alternative treatment method. In these instances, methods of treatment that involve minimal time and limited cooperation can be the best option. Silver Diamine Fluoride (SDF) has long been used in Japan to treat dental caries. The US Food and Drug Administration approved SDF for the primary use of hypersensitivity in 2014, while also recognizing its off-label use for caries arrest and prevention. It is recommended that SDF should only be applied for carious lesions that do not have pulpal exposure or approach the pulp. Studies show that re-application of SDF on a semiannual or annual basis increases the chances of caries arrest.

A prominent side effect of SDF is the black staining of the tooth structure and adjacent restorations, which poses an issue for patients with its use in esthetic zones. Staining can show as early as 2 minutes following SDF application, with an average time of five minutes after application. To help reduce the induced black/silver staining, the use of potassium iodide (KI) has been proposed. However, studies have shown conflicting evidence regarding the efficacy of KI in the reduction of black staining induced by SDF. There is evidence that the combination of SDF with KI (SDF+KI) can enhance antimicrobial effects. Studies have been performed where carious teeth were treated with SDF+KI prior to receiving a restoration and yielded conflicting conclusions about KI's staining impact. More studies have examined the KI's effect through application to teeth with unprepared carious lesions which again found conflicting evidence with regards to staining between SDF alone and SDF+KI.

The objective of this study was to provide definite and consistent results on if and how KI affects SDF staining with an improved experimental design. This was achieved by utilizing a split tooth experimental design using permanent molars and monitoring for a longer period of time relative to previous studies. Observation over a longer 12-week duration helped show if KI's impact is significant long-term. These changes sought to overcome potential flaws in previous study designs to provide a clearer answer on KI's impact on staining.

METHODS

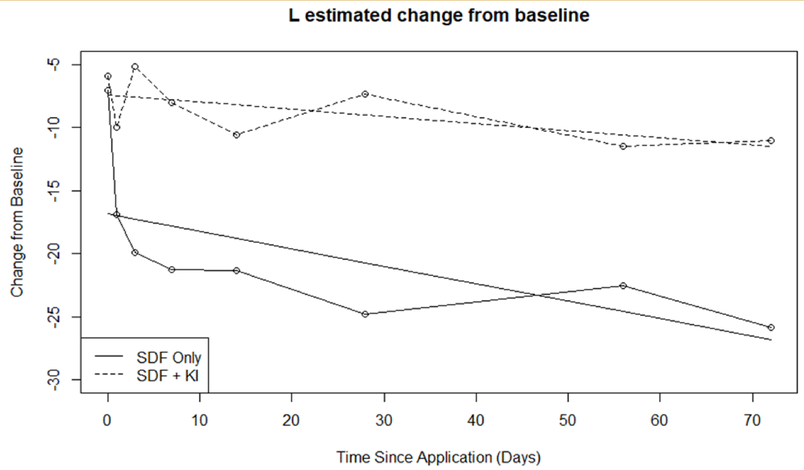
De-identified permanent molars without visible caries were used in part due to their larger surface area for evaluation and ease for sectioning. Teeth were stored in 10% sodium thymol after collection and until sectioning. Twenty teeth were utilized during the experiment. Prior to sectioning, the teeth were cleaned with pumice and prophy cup to remove any debris. A 3mm x 3mm piece of tape was placed on each tooth's buccal and lingual surfaces. The teeth were painted with clear nail polish and allowed to dry for 30 minutes before the tape was removed. The Canary System® (Quantum Dental Technologies, Windsor, Ontario) was used to measure three points across the 9mm2 unpainted area to obtain an average baseline caries value.

The teeth were then placed in a demineralizing solution (pH 4.4, 50mM acetate, 2.2mM KH_2PO_4, 2.2mM $CaCl_2$) at 37°C for 72 hours to demineralize each tooth's exposed area. After removal from the acidic solution, a new caries value for each tooth was obtained using the Canary System®. The teeth were then sectioned mesial to distal. The baseline CIELAB color space reading was recorded for each side using the Nix™ Pro Mini 2 color sensor (Hamilton, Ontario, Canada). The sensor excludes ambient light and uses its own calibrated light source using industry-standard 45/0° measurement to determine CIELAB values to describe the color.

Due to the use of the split tooth design, the section of the tooth, buccal or lingual, was randomly assigned using Microsoft Excel to have 20 subjects in the control and experimental groups. The study utilized SDI's Riva Star® (Bayswater, Australia) and followed the manufacturer's instructions for application. Once all applications were complete, another CIELAB reading was taken. Between measurements, the control and experimental sections of each tooth were stored in separate, individualized, labelled containers filled with sterile water. Measurements were taken at intervals of 1 day, 3 days, 7 days, 4, 8, and 12 weeks.

RESULTS

Figure 1. *L estimated change from baseline



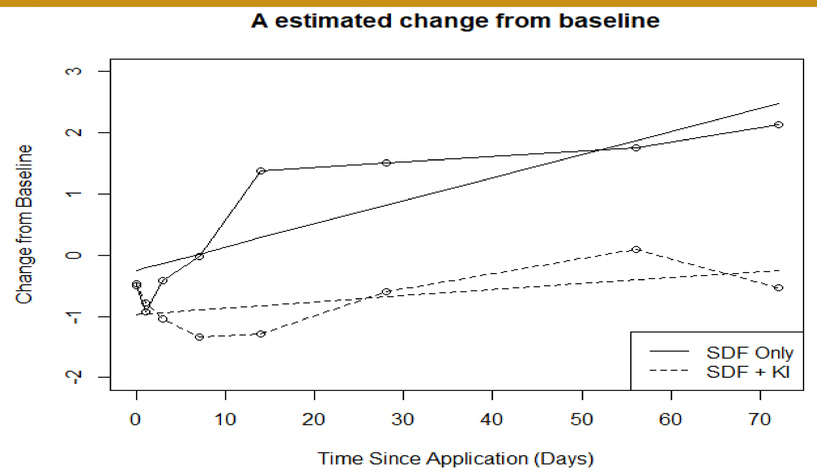
Average estimated *L change from pre-application by treatment group. The connected line segments are the raw mean changes from baseline-while the solid lines are the estimated linear changes, after accounting for repeated measurements and tooth side.

Table 1. Raw mean values (+ SD) for *L, *a, *b across treatment groups.

	*L			*a			*b		
Time (Days)	SDF Only	SDF+KI	PVAL	SDF Only	SDF+KI	PVAL	SDF Only	SDF+KI	PVAL
Before	58.78 (5.82)	61.78 (5)	0.076	3.3 (1.53)	3.08 (1.47)	0.744	20.61 (2.97)	20.43 (2.96)	0.946
0	52.79 (3.66)	56.26 (4.89)	0.007	3.38 (1.3)	2.74 (1.07)	0.127	22.72 (3.44)	21.39 (2.21)	0.18
1	40.71 (9.38)	50.61 (4.55)	<.001	3.73 (1.77)	2.57 (1.18)	0.039	20.02 (4.6)	22.76 (3.5)	0.032
3	39.88 (10.61)	51.42 (4.58)	<.001	3.73 (1.69)	2.82 (2.11)	0.01	18.28 (4.67)	21.38 (2.85)	0.018
7	39.19 (10.35)	51.35 (4.16)	<.001	3.9 (1.67)	2.59 (1.07)	0.002	18.02 (3.49)	20.4 (2.22)	0.021
14	40.25 (12.08)	51.35 (5.87)	<.001	3.57 (1.52)	2 (1.01)	0.001	18.26 (3.99)	20.8 (3.23)	0.048
28	37.16 (9.96)	50.88 (4.5)	<.001	3.6 (1.69)	2.57 (1.01)	0.016	17.44 (3.99)	21.25 (3.11)	0.003
56	36.61 (9.5)	49.64 (4.84)	<.001	4.05 (2.36)	2.39 (1.49)	0.009	18.41 (4.93)	21.75 (2.83)	0.005
72	36.82 (9.85)	50.14 (5.61)	<.001	4.12 (2.25)	2.23 (1.29)	0.003	18.4 (4.86)	21.45 (2.75)	0.007

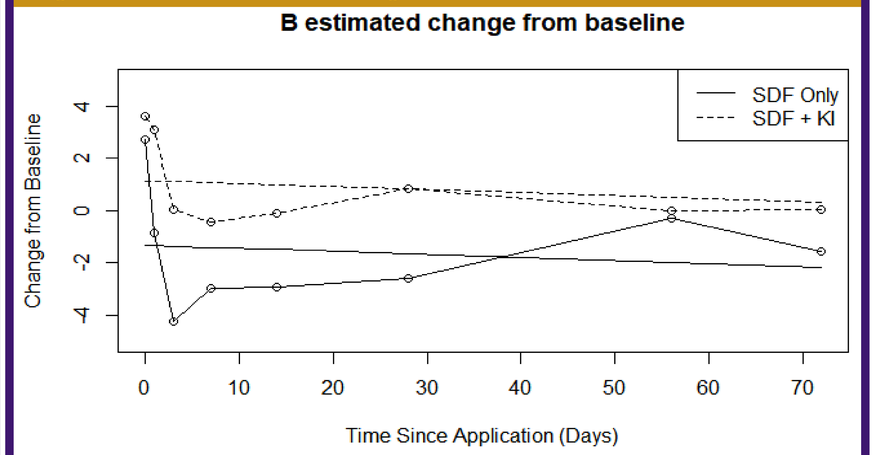
P-values are reported using Wilcoxon rank-sum tests.

Figure 2: *a estimated change from baseline



Average estimated *a change from pre-application by treatment group. The connected line segments are the raw mean changes from baseline-while the solid lines are the estimated linear changes, after accounting for repeated measurements and tooth side.

Figure 3. *b estimated change from baseline



Average estimated *b change from pre-application by treatment group. The connected line segments are the raw mean changes from baseline-while the solid lines are the estimated linear changes, after accounting for repeated measurements and tooth side.

Tests performed:

- Wilcoxon rank-sum tests comparisons of values (*L, *a, *b) between treatment groups within each time period were made between treatments
- Linear mixed models to evaluate overall changes from baseline
- Deviance-based tests to determine if there was a treatment and time interaction, treatment and tooth side interaction, tooth side and time interaction, and a 3-way interaction.
- A repeated measure test to determine how the brightness changes over time for the values (*L, *a, *b)

CONCLUSIONS

Based on the study's results, the following conclusions can be made:

1. The use of SDF+KI can reduce the degree of staining when compared to SDF alone
2. Tooth side, whether buccal or lingual, did not influence the degree of black-white (*L) staining seen in both SDF group and SDF+KI groups separately