Original Research Paper

Volume -10 | Issue - 5 | May - 2020 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Dental science

REMINERALIZING POTENTIAL OF FOUR DIFFERENT TEETH WHITENING AGENTS USED IN TOOTHPASTES ON ARTIFICIALLY DEMINERALIZED HUMAN ENAMEL - AN VITRO STUDY

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ABSTRACT A total of 56 premolars and molars were selected and divided into four groups of 14 each: group I (Sodium phytate), group II (sodium tripolyphosphate), group III (activated charcoal), and group IV (hydrated silica). The teeth were artificially demineralized for 48 hrs followed by application of remineralizing agents for 7 days. All the samples were assessed using DIAGNOdent at the baseline and after demineralization and remineralization.

Results: Group I showed a decrease in DIAGNOdent reading following remineralization whereas group II, group III and group IV showed an increase in the moment value following its application on tooth surface suggestive of demineralization of enamel.

Interpretation and conclusion: The remineralization of artificially demineralized human enamel was seen only with the application of sodium phytate among the teeth whitening agents. Abrasives such as sodium tripolyphosphate, activated charcoal and hydrated silica caused further demineralization of enamel.

KEYWORDS :

INTRODUCTION

Toothpastes are used on a daily basis and are composed of variety of ingredients which make them multifunctional, delivering therapeutic benefits to combat a variety of oral conditions (e.g., caries, gingivitis, dentine hypersensitivity, erosive tooth wear). One such ingredient is the tooth whitening agent which offers cosmetic benefits such as control of extrinsic enamel staining.[1] The tooth whitening toothpastes contain physical abrasives, such as particulate silica or alumina, or soluble chemical agents with affinity for calcium ions, such as condensed phosphates that interfere with attachment of stain molecules to enamel surfaces.[2] Toothpaste with high abrasivity effectively removes attached and incorporated stains. However, their prolonged use causes damage to the outer part of the enamel leading to demineralization thus contributing to the occurrence of dental caries.[3]

Phytic acid known as inositol hexaphosphate (IP6) is an organic acid commonly found in our daily diet including cereals, legumes, oil seeds and nuts[4]. It has a strong negative charge thus having the ability to chelate with minerals (multivalent cations), such as calcium.[5,6] An in vivo study has indicated enhanced stain removal ability for a toothpaste containing 0.85% w/w sodium phytate compared to a regular toothpaste.[7] Phytate may also offer caries protective benefits of its own.[8,9] Charcoal or activated carbon in toothpaste is known to have the ability to absorb dirt and to clean the teeth as well as the gaps between the teeth. The shape and composition of charcoal along with the sizes of its particles makes it an abrasive.[10] Pertiwi et al have reported that charcoal increases the surface roughness of tooth enamel.[11]

Sodium Tripolyphosphate (STP) is a linear condensed phosphate that is commonly incorporated in whitening toothpastes for effective stain removal, where its mild chelating properties interfere with stained pellicle integrity. There is concern whether these chelating properties may negatively impact the surface roughness of enamel and cause demineralization.[12] Hydrated silica is another ingredient of tooth whitening toothpastes which prevents formation of stains and remove stains from the surface. The abrasive nature of silica raises concern regarding its demineralizing potential on enamel by increasing the surface roughness.[12]

Studies have already been performed to understand the effect of phytic acid on enamel remineralization/demineralization using single-treatment 'erosion' in situ protocol.[13] Activated charcoal has been evaluated for increasing the surface roughness of enamel.[11] Sodium tripolyphosphate and hydrated silica have been studied to evaluate its effect on microhardness of enamel and composite.[12,14, 15] The present study aimed to evaluate and compare the remineralizing potential of sodium phytate, activated charcoal, sodium tripolyphosphate and hydrated silica on artificially demineralized human enamel.

MATERIAL AND METHODOLOGY

Fifty six caries-free premolars extracted for orthodontic reasons and caries-free molars extracted for periodontal reason were included in the study. The teeth were thoroughly cleaned to remove debris, calculus, and soft tissues. The cleaned and polished extracted teeth were then randomly grouped into four using simple randomized sampling.

GROUP I (n=14): Sodium phytate
GROUP II (n=14): Sodium tripolyphosphate
GROUP III (n=14): Activated charcoal
Group IV (n=14): Hydrated silica

Each extracted tooth was coated with nail varnish, leaving an enamel window of 3 mm x 3 mm on the buccal surface in the middle one-third of the crown. One window was made on each premolar while two windows were made on the buccal surfaces of molars and were counted as two samples. All the samples were examined using DIAGNOdent® (KaVo, Biberach, Germany) to assess for any surface changes present on the labial window. Samples showing a moment value between 3 and 7 on the digital display were selected. Samples showing a value greater than 7 were discarded and replaced by teeth having a moment value 3 to 7. The baseline values of the four groups were then recorded. A demineralizing solution and artificial saliva was then prepared.

The composition of demineralizing solution and artificial saliva are as follows:

Demineralizing solution	Artificial saliva
• 2.2 mM calcium chloride ($CaCl_2.2H_2O$)	• 2.200 g/L gastric mucin
• 2.2 mM monosodium phosphate ($NaH_2PO_4.7H_2O$)	• 0.381g/L sodium chloride (NaCl)
• 0.05 M lactic acid	• 0.213 g/L calcium chloride ($CaCl_2.2H_2O$)
The final pH was adjusted to 4.5 with 50% sodium hydroxide (NaOH).	• 0.738 g/L potassium hydrogen phosphate ($K_2HPO_4.3H_2O$)
	• 1.114 g/L potassium chloride (KCl).
	The final pH was adjusted to 7.00 at 37 °C with 85% lactic acid.

All the samples were then immersed into a glass container containing 50 ml of demineralizing solution for a period of 48 h at 37 °C using an incubator. After 48 h of incubation in the demineralizing solution, the teeth were washed with deionized water, dried with the help of an air syringe, and placed in four different clean glass

containers until further evaluation.

The teeth were then evaluated with DIAGNOdent and the samples showing a moment value of 9 and above on the digital display were taken for further evaluation. This value indicates the presence of a subsurface lesion on the tooth surface.

The samples in each group were treated with the respective teeth whitening agent every 24 h for 7 days, with the help of cotton applicator tip. Samples in experimental groups were rubbed with respective teeth whitening agent for 4 min, washed with deionized water, and placed in artificial saliva. After 7 cycles of remineralization, the surface was assessed using DIAGNOdent to record the values as described earlier.

STATISTICALANALYSIS

Tables 1 shows the comparison of relative change in DIAGNOdent score at each stage of the study by applying one-way ANOVA. Intergroup comparison of mean score following 7 days of remineralization is given in Table 2; P values less than 0.05 are considered to be statistically significant.

RESULTS

Table 1: Change in DIAGNOdent score in study groups analysed using ANOVA – D0- Baseline score, D1- Score after demineralization, D2- Score after 7 cycles of remineralization

	D0	D1	D2	P*
Group	Mean (SD)	Mean (SD)	Mean (SD)	0.00
1	3.50 (.65)	12.57 (1.34)	9.86 (1.03)	
2	3.57 (.65)	12.71 (1.59)	13.36 (1.78)	
3	3.57 (.65)	12.79 (1.31)	14.64 (1.34)	
4	3.50 (.65)	12.79 (1.48)	13.93 (1.98)	

Table 2: Intergroup comparison of the study groups using Post Hoc Test (Tukey)

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-1.24*	.396	.015	-2.29	-.19
1	3	-1.69*	.396	.000	-2.74	-.64
1	4	-1.43*	.396	.004	-2.48	-.38
2	3	-.45	.396	.666	-1.50	.60
2	4	-.19	.396	.963	-1.24	.86
3	4	.26	.396	.911	-.79	1.31

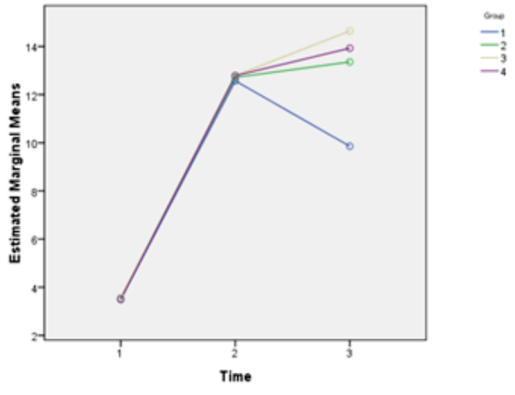

Fig: 1 Estimated marginal means of teeth whitening agents

By applying ANOVA, a highly significant increase in the mean values of DIAGNOdent score of enamel from baseline to after demineralization was seen. There was a decrease in the mean score of enamel from after demineralization to 7 days after remineralization in group 1. This shows that sodium phytate has a potential for remineralizing artificial enamel caries. The moment value for group 2, 3 and 4 showed an increase after 7 days of remineralization. This suggests that sodium tripolyphosphate, hydrated silica and activated charcoal have demineralizing effect on enamel. Group III showed maximum demineralization of enamel, followed by group IV, whereas group II produced least demineralization of enamel surface. Intergroup comparison between groups I-II (p= 0.015), groups I-III (p=0.000) and groups I-IV (p=0.004) showed statistically significant difference in mean score after 7 days of remineralization (Table 2).

DISCUSSION

The present study evaluated the remineralizing potential of four tooth whitening agents used in toothpastes, namely; sodium phytate, sodium tripolyphosphate, activated charcoal and hydrated silica using DIAGNOdent. Among the tested materials, only sodium phytate produced remineralization of the artificially demineralized enamel surface in the current study. Similarly, McClure et al and Nordbo et al have reported the caries inhibitory action of sodium phytate.[16,17] Phytate rapidly absorbs onto hydroxyapatite thus preventing its dissolution and forms a physical barrier that protects against caries attack. Phytate also modifies the transport of ions across enamel and dentine surfaces, thus leading to remineralization.[8]

Sodium Tripolyphosphate (STP) is commonly incorporated into toothpastes for stain removal where its surfactant and mild chelating properties interfere with stained pellicle integrity.[14] The result of the present study showed demineralization of enamel surface after application of STP. Wang et al investigated the effect of STP treatment on the surface finish of enamel and reported minimal changes in enamel surface finish following exposure to STP.[14] Contrary to the findings of this study, Khamverdi et al reported that a dentrifice containing STP did not alter the surface characteristics of enamel.[13] The main action of STP in both the inhibition of salivary protein adsorption to hydroxyapatite and desorption of bound salivary proteins is through competitive binding to the crystal surface.[18] The mild chelating property of STP could be the reason for the demineralization of enamel.

An increase in the DIAGNOdent score following application of activated charcoal on human enamel was seen in the present study, suggesting its role in enamel demineralization. In agreement with this study, Pertiwi et al reported that toothpaste containing charcoal can increase the surface roughness of tooth enamel. Charcoal particles are star shaped or fractal shaped which affects the value of surface roughness of a tooth.[11]

Similarly, hydrated silica also lead to further demineralization of the enamel in the present study. Silica particles are abrasives that prevent stain formation on the tooth surface. Khamverdi et al reported that a dentrifice containing silica decreased the surface roughness of composite restoration.[13] The abrasive materials contained in toothpaste cause scratches on the enamel surface resulting in loss of some minerals from the surface.[11] The loss of tooth minerals leads to an increase in surface roughness which in turn increase the proliferation of bacteria and biofilm formation.[19] The particle size of the material also contributes to the abrasiveness. Larger particle size increases the surface roughness of the enamel surface thus contributing to its demineralization.[11] This explains the demineralization of enamel produced by activated charcoal and hydrated silica in the present study.

Further research should be done to analyse the surface changes of enamel following application of these agents for a longer duration in the presence of fluoride and evaluate the surface changes using scanning electron microscope.

CONCLUSION:

Phytate containing teeth whitening toothpastes can be used for stain removal as it shows protective action against caries progression. Toothpastes containing sodium tripolyphosphate, activated charcoal and hydrated silica used for long term can affect the surface roughness of enamel and predispose it to caries. Adequate care should be taken in patients with composite restorations on tooth surface and defects such as erosion, enamel hypoplasia since sensitivity as a result of demineralization is a potential drawback of these tooth whitening agents.

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