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ORIGINAL RESEARCH

Comparative Evaluation of Remineralizing Effect of Novamin and Tricalcium Phosphate on Artificial Caries: An *in vitro* Study

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ABSTRACT

Aim: The aim of the present study was to compare the remineralizing efficacy of novamin and tricalcium phosphate (TCP).

Materials and methods: Nail varnish was coated to a total of 30 sound human premolars except for 5 mm × 5 mm window. Baseline microhardness was measured for all test samples. Artificial carious lesions were created for all teeth by subjecting them to demineralization process. Then microhardness of demineralized lesion was measured. Later artificial caries teeth were equally divided into two groups to treat with remineralization solution for 10 days; group I: novamin and group II: TCP. After 10 days of pH cycling, microhardness was measured. The data were statistically analyzed using Statistical Package for the Social Sciences (SPSS) statistical software from Chicago SPSS Inc., version 21 and using analysis of variance (ANOVA) *post hoc* multiple comparisons test for intergroup and significant difference at $p < 0.05$.

Results: In the present study, group I indicated a higher value for remineralization compared with group II ($p < 0.05$).

Conclusion: The present study showed that both novamin and TCP were effective in remineralizing the carious lesions.

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Clinical significance: This study evaluates the remineralizing potential of novamin and TCP on initial carious lesions.

Keywords: Initial caries, Novamin, Remineralization, Tricalcium phosphate.

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INTRODUCTION

Dental caries are one of the major causes for tooth loss in all age groups and affects both primary and permanent teeth. Various studies have been conducted to reduce the caries prevalence. Dental caries are a dynamic demineralization and remineralization process.[1] Cavitations occur when demineralization process is ahead of remineralization process. Initial carious lesion appears as white spot lesion.[2]

Saliva and gingival crevicular fluid mainly consist of calcium, phosphate, and fluoride ions. The presence of these minerals at neutral pH helps in maintaining equilibrium condition between the mineral content of tooth and oral fluids. When there is acidic attack or lowering of oral fluid pH (below 5.5), there will be dissolution of hydroxyapatite (HA) crystals and release of calcium and phosphate from tooth surface to oral fluids; this is called as demineralization. When pH increases, supersaturation of the oral solution with calcium and phosphate ions results in deposition of minerals back to tooth surface; this is called as remineralization.[3]

Various preventive measures have been suggested to remineralize the initial carious lesions in primary and

permanent teeth, such as fluoride and application of several remineralizing agents. Casein phosphopeptide (CPP), CPP amorphous calcium phosphate (CPP-ACP), bioactive glass (BAG), TCP, and novamin are some of the remineralizing agents suggested to remineralize the initial carious lesions.[1,3-5] All remineralizing systems depend on calcium and phosphate compounds, and their effect is based on improvement of natural remineralizing capacity of saliva to mineral loss.[2]

Fluoride is a remineralizing agent that forms fluorapatite crystal after bonding to tooth calcium and phosphate ions. This crystal is more resistant to acid dissolution. Due to several disadvantages of fluoride, such as toxicity and staining, other remineralizing agents were advised.[6]

Novamin consists of calcium sodium phosphosilicate (CSP) BAG which disintegrates into sodium that gets exchanged with hydrogen cations (H^+ or H_3O^+) and after interacting with saliva results in the release of calcium (Ca^{2+}) and phosphate (PO_4^{2-}) ions. There will be transient increase in pH which brings precipitation of Ca^{2+} and PO_4^{2-} ions from saliva and the particles to form a calcium phosphate layer on the surface of the tooth. The Ca–P complexes crystallize to form HA, which is structurally and chemically similar to biologic apatite.[3]

Tricalcium phosphate is stable in aqueous environment and does not affect fluoride activity in dentifrices. It has been suggested that the combination of fluoride to TCP provides greater fluoride uptake and remineralization.[2]

Patil et al[2] observed significant improvement in remineralization with the use of different remineralizing agents, such as sodium fluoride (NaF), CPP-ACP, CPP-ACP fluoride, and TCP-fluoride. Palaniswamy et al[3] from their *in vitro* study concluded that BAG and ACP-CPP act as novel agents to repair demineralization.

Very few studies are reported in relation to novamin and TCP. Hence, the present study was done to evaluate and compare the remineralizing potential of novamin over TCP on artificial caries.

MATERIALS AND METHODS

A total of 30 human premolar teeth extracted due to orthodontic reason were selected for the present study. Inclusion criteria were teeth free from caries, cracks, and fracture lines. The teeth were cleaned to remove deposits and sectioned 1 mm below the cementoenamel junction using the slow-speed diamond disk to discard root part. About 200 µm of surface enamel was removed on buccal surface of all teeth with abrasive to avoid variability among samples. All crown surfaces were covered with nail polish leaving the 5 mm × 5 mm of window on buccal surface. Then samples were randomly divided into two groups of 15 samples in each; group I: novamin (Sensodyne Repair and Protect; GlaxoSmithKline; UK) and group II: TCP (ClinPro tooth crème, 3M ESPE, with 0.21% w/w NaF at 950 ppm). Baseline Vickers hardness number (VHN) of all the samples was measured using Vickers microhardness testing machine (Leica VMHT Auto; Germany) using 25 mg load for 5 seconds at working window. The average of three indentations was recorded. All the testing was carried out according to manufacturer's instructions.

Demineralizing solution was prepared using deionized water, 2.2 mM sodium phosphate, 2.2 mM calcium chloride, and 0.05 M acetic acid. The pH was adjusted at 4.4 with 1 M potassium hydroxide. Remineralizing solution was prepared with 0.9 mM sodium phosphate, 1.2 mM calcium chloride, and 0.15 M potassium chloride at 7.0 pH. To create artificial caries-like lesion on enamel, all samples were kept in demineralization solution for 72 hours. Later microhardness of demineralized lesions was recorded using VHT.

Remineralizing agents, such as novamin or TCP were applied with cotton applicator tips on demineralized enamel surface of respective groups for 10 days with minimum application time for 2 minutes. Microhardness of all samples was evaluated after 15th day.

The obtained data were statistically analyzed using SPSS statistical software from Chicago SPSS Inc., version 21 and using ANOVA *post hoc* multiple comparisons test for intergroup and to check significant difference at $p < 0.05$.

RESULTS

Table 1 summarized the comparison of mean microhardness within the group using ANOVA test with $p < 0.001$. In group I, mean microhardness was 374.82 at baseline, 300.23 after demineralization, and 367.63 after remineralization. In group II, mean microhardness was found to be 379.72 at baseline, 312.68 after demineralization, and 349.04 after remineralization.

Baseline microhardness was 383.89 in group I and 383.69 in group II, and after demineralization it was 372.58 in group I, whereas it was 358.06 in group II after remineralization process. This indicated the higher value for remineralization in group I compared with group II ($p < 0.05$; Table 2).

DISCUSSION

Dental caries remain a major health problem despite the advance in the caries prevention measures.[1] Initial white spot demineralized enamel lesion can be reversible with the use of remineralizing agents. Initial enamel lesions have intact surfaces with low mineral content at the enamel surface with lower microhardness value than

Table 1: Intragroup comparison of mean microhardness

Groups	*Time interval*	*Mean ± SD*	*Standard error of mean*	*Mean difference*	*p-value*
I	Baseline	374.82 ± 42.24	10.72	84.422	<0.001**
	After 72 hours of initial demineralization	300.23 ± 14.18	3.84		
	After 72 hours of initial remineralization	300.23 ± 14.18	3.84	−71.248	<0.001**
	After remineralization	367.63 ± 30.87	7.83		
II	Baseline	374.72 ± 28.13	7.47	71.000	<0.001**
	After 72 hours of initial demineralization	312.68 ± 22.86	5.72		
	After 72 hours of initial remineralization	312.68 ± 22.86	5.72	−42.322	<0.001**
	After remineralization	349.04 ± 15.86	4.29		

**p < 0.001, highly significance; SD: Standard deviation

Table 2: Intergroup comparison of mean microhardness

Microhardness	*Groups*	*Mean ± SD*	*Standard error of mean*	*95% CI for mean*		*p-value*	*Significant difference*
				Lower bound	*Upper bound*		
Baseline	I	383.89 ± 42.35	10.64	358.83	409.85	0.103	I *vs* II
	II	383.67 ± 28.12	7.43	363.72	402.88		
After demineralization	I	300.36 ± 14.23	3.86	289.58	307.84	0.173	
	II	315.82 ± 22.85	5.75	301.57	325.93		
After remineralization	I	372.58 ± 31.86	7.92	357.62	387.75	0.012*	
	II	358.06 ± 16.84	4.27	346.73	365.34		

Significance: *p < 0.05; CI: Confidence interval; SD: Standard deviation

sound enamel.[3,7] These white spot lesions can be intact for 6 to 7 years, which either become arrested or revert to sound enamel in 75% of cases and only 25% cases proceed to cavitations.[8] There is a cycle of demineralization and remineralization process of tooth enamel in the oral cavity. Acid attack on the tooth enamel from sucrose or dental plaque results in lowering of salivary and tooth surface pH, which results in loss of tooth minerals leading to cavitations over a period of time. The presence of calcium and phosphate in saliva helps in reversal of initial lesion at elevated pH.[1,7]

In the present *in vitro* study, artificial caries were created using the demineralizing solution and which was subjected to novamin and TCP remineralizing agents to evaluate their efficacy over a period of 10 days. Microhardness measurement is appropriate for enamel, which has a fine non-homogeneous microstructure which is prone for cracking. Identification of surface microhardness is a simple, rapid, and nondestructive method used in demineralization and remineralization studies.[3] In the present study, microhardness was evaluated at baseline, after demineralization and remineralization of artificial caries. Microhardness of tooth enamel can be evaluated using Knoop hardness number (KHN) or VHN. Chow et al stated that KHN and VHN evaluation is equally effective.[9] To avoid bias, average of three readings of VHN was taken in the present study. We observed improvement in the VHN of demineralized enamel after application of remineralizing agents (Tables 1 and 2). In our study, group I with novamin agent showed better remineralization potential (372.58 VHN) over group II with TCP (358.06 VHN), p < 0.005.

Remineralizing agents act by increasing the salivary pH and providing calcium and phosphate ions, thus helping in the formation of HA crystal, which will be similar to sound enamel. Novamin is a synthetic mineral compound made up of BAG particles, which adhere to the tooth surface and continuously deposit crystalline HA (hydroxycarbonate apatite). It releases millions of mineral ions on exposure to humidity, thus forming HA layer on the enamel surface. This process eliminates caries and hypersensitivity. In a wet environment, hydrogen ions were exchanged with sodium ions allowing the calcium and phosphate ions released from the material. This process occurs within a second and release of ions continues in humidity. The release of sodium ions from materials increases pH; thus, ions from materials get deposited in the tooth enamel.[4,5] Released sodium ion provides long-term remineralizing potential.[4]

Similar to our results, Haghgoo et al[5] observed that nano-HA and novamin were effective for remineralization on primary teeth caries. Vahid Golpayegani et al[4] found that novamin dentifrice has greater remineralization effect than fluoride-containing dentifrices on carious-like lesions. The present study indicated that novamin significantly increases the surface microhardness and it was observed that in combination with fluoride, it can provide synergistic effect on remineralization. Mohanty et al[10] also observed significant remineralizing effect with novamin-containing dentifrices.

Several other researchers also found the effectiveness of various remineralizing agents on initial caries, such as CPP-ACP, BAG, novamin, TCP, and CSP.[1,2,6,7,11,12]

Kaur et al[13] observed better microhardness after treatment with GC tooth mousse and toothmin tooth cream on bleached surface. Jose et al[12] observed that pretreatment of the tooth surface with 10% tea showed better microhardness. Cem Güngör et al[14] concluded from their study that topical agents had a remineralizing potential on both carious and caries-free occlusal surfaces. They found better result with CPP-ACP than APF and NaF-ACP on caries-free occlusal surfaces. Singla et al[15] observed from their study that tested groups (ClinPro, PreviDent, and regain), remineralizing efficacy, whereas clinpro group had significant remineralizing efficacy.

A drawback of our study was shorter period of remineralization for 10 days, which could not remineralize artificial caries completely. Remineralization process *in vitro* is quite different than *in vivo* in oral cavity. Thus, there is a need of studies with clinical condition.

CONCLUSION

The present study showed that both novamin and TCP were effective in remineralizing the carious lesions.

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