Section A-Research paper
ISSN 2063-5346

Comparative Evaluation Of Remineralisation Potential Of Sodium Fluoride (Naf) Solution And Novamin(N) Technology On Enamel Remineralization And Micro Hardness: An In vitro Study.

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ABSTRACT
Background: Enamel demineralization during orthodontic treatment can be reversed with the proper remineralizing agent and protocol. NaF solution and N technology have different compositions and produce varying degrees of remineralization.
Aim: Comparative Evaluation of remineralization potential of NaF solution and N technology on enamel remineralization.
Material and methods: This in vitro study involved 106 freshly extracted premolar teeth, which were equally divided into two groups, group A treated with N technology paste and group B treated with NaF solution. The selected teeth were abraded, exposed to a carbonated drink (Thumbs Up) for 14 minutes daily for two weeks, and then air dried with deionized water for seven days. Teeth with poor demineralization or uneven lesions were excluded. Micro hardness was measured using Vicker's hardness scale, and surface topography was evaluated with a scanning electron microscope (SEM).
Results: Intact enamel (normal enamel) and remineralized enamel was significantly harder than demineralized enamel, (p value is less than 0.00). There was no statistical difference in hardness between enamel remineralized with NaF solution and N technology (p value = 0.368). Both agents had conflicting effects on enamel surface topography.
Conclusion: Both remineralization techniques effectively remineralized enamel. The type of agent used did not affect the hardness of the remineralized enamel. N technology produced a smoother enamel surface compared to NaF. However, caution is advised in interpreting these findings.
Keywords: Fluoride, NaF solution, Novamin technology.

INTRODUCTION-

An individual is more susceptible to poor dental hygiene and diet when receiving orthodontic treatment. Poor patient compliance with preventive home care measures, particularly those impacting the mineral composition of the enamel, was significantly associated with the integrity of the teeth, according to Geiger et al. The configuration of the fixed orthodontic appliance in the oral cavity jeopardize the enamel leading to demineralization adjacent to the brackets. Variety of treatment modalities can treat demineralization of enamel, like application of NaF solution or gel (226ppm), clin –pro, Novamin (N) and Caesin phosphate paste.Several studies have cited that NaF solution and N technology is successful in reminerlalizing the tooth structure. Two methods of Enamel remineralization techniques comprise Fluoride and CPP-ACP treatment. Fluoride and CPP-ACP are effective techniques for remineralizing teeth. The choice of technique depends on factors such as the severity of lesion, patient preference, and dental professional recommendation. N technology is a new product that is less popular and accessible than NaF solution. A potential drawback of fluoride is bacteria developing resistance in the mouth. However, the use of bioactive materials and nanoparticles can provide a more targeted delivery of minerals to the enamel, which may be less susceptible to bacterial resistance.

The process of enamel remineralization of both the products is different as one forms the flourappetitie and other forms the hydroxyapatite crystals. However, to current era, it is largely unidentified which approach is more effective in remineralization of enamel among the two.[123] .

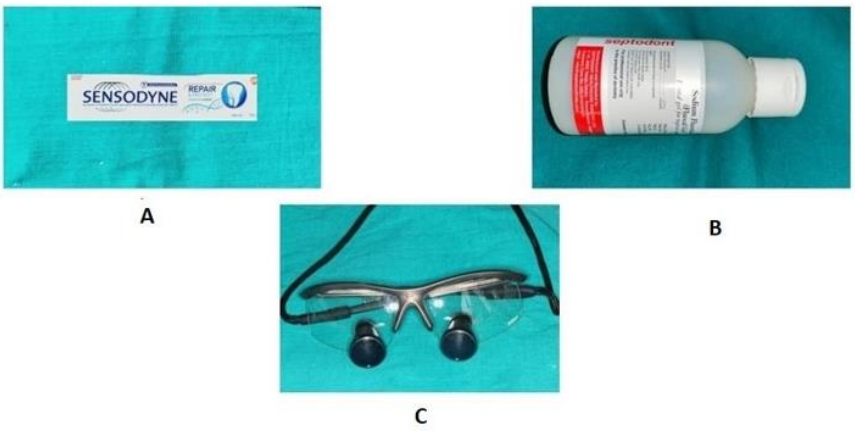
This study was designed for comparative investigation of the remineralization technique efficacy, for improving enamel remineralization and microhardness. The study adopted an in vitro experimental setting, which involves the use of extracted teeth stored in synthetic saliva and laboratory settings to examine the effects of these remineralization technique on dental enamel. This approach was selected to enable a controlled environment that simulates an oral environment to provide a rigorous comparison of the two remineralization techniques. The study aims to contribute for, understanding the most effective methods for enhancing enamel remineralization and microhardness.

The null hypothesis formulated in the study was; there was no significant difference in the remineralization potential and microhardness of enamel treated with NaF solution and N technology under an in-vitro condition.

MATERIALS AND METHODS:

The study was conducted in department of Orthodontics and Dentofacial Orthopaedics, K.M Shah Dental College & Hospital, Sumandeep Vidyapeeth. The study was carried out after obtaining ethical approval from the committee SVIEdon/DenHRP/Jan/23/21 Extracted premolar tooth of the patient who were undergoing fixed orthodontic treatment were included. A sample size of 102 was established by keeping Standard Deviation of ±2 at 95% Confidence Interval and power of the study being 80% (Nishita rana etal).[4] A total of 125 freshly extracted premolar teeth were collected.

Freshly extracted Premolar teeth which were rinsed with distilled water to remove any blood, spoon excavator and toothbrush was used to remove any soft tissue remnants. These teeth were then subjected to disinfection by submerging in 0.5% sodium hypochlorite for ten minutes followed by rinsing with distilled water and drying. Once the disinfection protocol was completed the disinfected teeth were stored in a container having synthetic saliva. Sound teeth with all surfaces intact were included in the study. The study did not include teeth having caries, cracks, hypoplastic enamel and white spot lesions. Extracted teeth were stored in synthetic saliva containing formulation of sodium carboxymethylcellulose 0.5%, methylparaben 0.2%, potassium chloride 0.1%, sodium chloride 0.1%, calcium chloride 0.1%, and water. Preparation of artificial saliva and formulation.



1. Figure : (A) Sensodyne Repair (B) NaF solution (C) Magnification loupes

These extracted teeth were lightly abraded with micro motor (5000 rpm) using 200 grit sand paper with mandrill. The selected teeth were immersed into a carbonated drink i.e. (Thumbs up) for 14 minutes for two week[7]. The samples were blotted dry for seven days after being rinsed with deionized water. The teeth were immersed in methylene blue stain (0.1%) for 5 min and rinsed under tap water for proper staining of demineralised enamel. seven teeth were excluded due to cracks on tooth surfaces, with the help of magnification loops (5x).

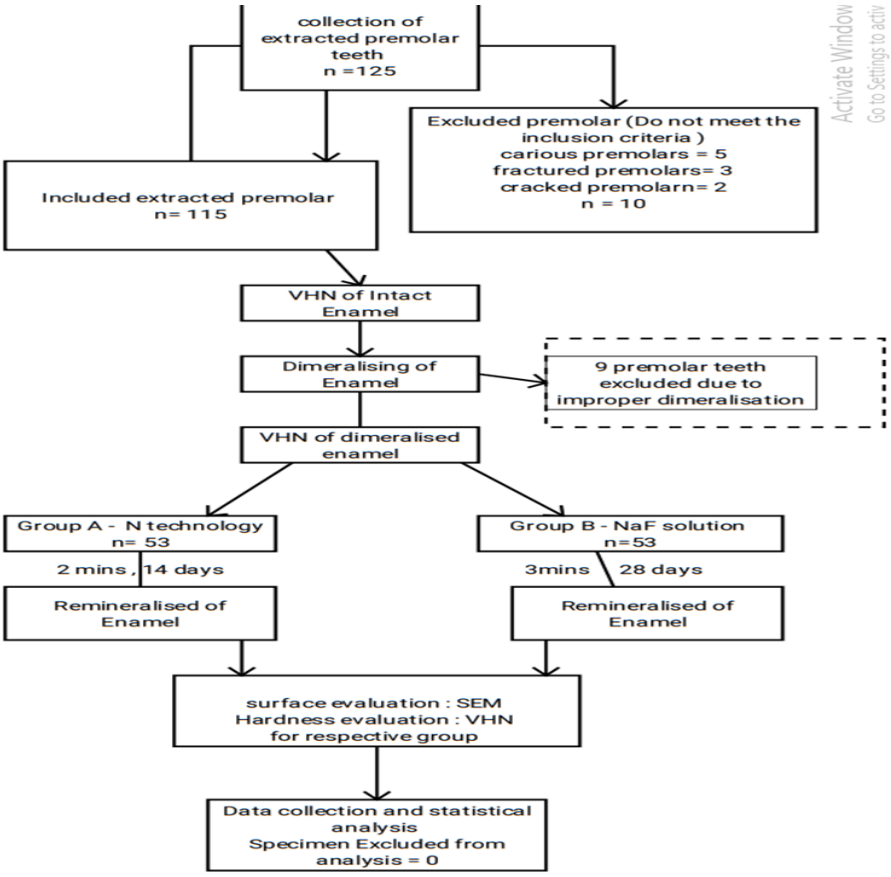


Figure: 2

Diagnodent, CarieScan (Italy) was utilised for evaluation of demineralized enamel. Teeth with arbitrary values falling in the range of 50-70 arbitrary units were deemed suitable for inclusion in the analysis. Twelve teeth were excluded from the analysis because they did not exhibit sufficient demineralization. The study was conducted as per the Consort Guidelines (Figure 2).

The final sample size was n = 106 after accounting for specimen dropout. There were 2 equal groups Group A (Experimental group): N technology toothpaste(Stannous Fluoride, potassium nitrate , sodium fluoride , calcium sodium phosphoslicate ,water) (Figure 1A) (sensodyne repair, maidenhead, Berkshire), Group B(Controll Group): NaF solution (2% fluoride) (Figure 1B) (Prevest Denpro, Jalandhar, Punjab) .

The teeth were then subjected for remineralization after rinsing it with 5% sodium hypochlorite and deionized water. In group A teeth were remineralized using a cotton applicator for 3 min, twice daily for a span of 14 days4. In group B the teeth were remineralized using a cotton applicator tip for 2 min twice a day for a span of 28 days[5]. After the process of remineralizing agent's application the teeth were stored in synthetic saliva for its respective group. The synthetic saliva was changed after each application of the reminerlizing agent.
After the process of remineralization the teeth were subjected first for enamel surface evaluation with the help of Scanning electron microscope (HITACHI, Germany) at 70x magnification for both enamel de and remineralization.

Similarly enamel hardness of each individual tooth was evaluated with the help of Vickers-hardness scale (SICMVHT-01) for intact, de/remieralized enamel. Using this method, the specimen surfaces were indented for 10 seconds on the teeth surface with a diamond indenter (Vickers) at a load of 100 g.

The data was entered into Microsoft Excel and statistical analysis was performed on it using the Statistical Package for Social Sciences (SPSS, IBM version 20.0). Statistical significance was defined as p 0.05, with the threshold of significance fixed at 5%.

ISSN 2063-5346

To ascertain whether the data were regularly distributed, Kolmogorov-Simonov was utilised. The Mann–Whitney U test was utilised to find substantial variations in enamel microhardness between intact and demineralized specimens, as well as between demineralized and remineralized enamel.

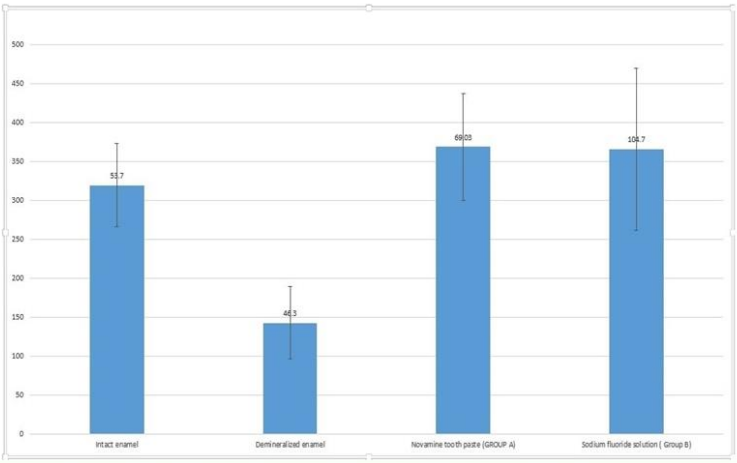


Figure 3:Comparison of Intact, Demineralised, Remineralised enamel with Vickers hardness test. Significant difference was observed with intact enamel, demineralised and Remineralised enamel (P value less than 0.01), non – significant difference (NS) was observed in between Remineralised enamel of both the groups (p value = 0.368) .

RESULTS:

After analyzing the 106 samples included in the study it was observed that, as the tooth was subjected to demineralization the hardness of the tooth was reduced by 43.8%. When the hardness was evaluated after remineralization the group A samples revealed a relatively higher score (Figure 3).

Table no. 1: comparison of hardness between intact and demineralized enamel (g/mm^2)			
Pair wise comparison	n	Mean	P value
Intact Enamel	106	58.70	0.00*
Demineralized enamel	106	22.30	
Mann–Whitney U test p value ≤ 0.05			

Table no. 2: Intra and inter group comparison of de and remineralisation of enamel. $(g/mm)^2$			
Pair-wise comparison	N	Mean	P value
Demineralized enamel (GROUP A)	53	10.70	0.00*
Remineralization (GROUP A)	53	30.30	
Demineralized enamel(GROUP B)	53	10.90	
Remineralization (GROUP B)	53	30.10	
Remineralization with (Group A)	53	22.10	0.368 NS
Remineralization with (Group B)	53	18.90	
Mann–Whitney U test *p value ≤ 0.05 NS: non-significant			

When the hardness was appraised between intact enamel and demineralized Enamel a statistical significance was observed (Table no 1).

The hardness was also appraised for both intra and inter group. When intra group comparison of De and remineralization was compared both the groups revealed a statistical significance with (p value ≤ 0.01) seen in (Table 1). Whereas the hardness between group A and B were compared a non-significant difference was observed, (Table no 2) with (p value =0.368).

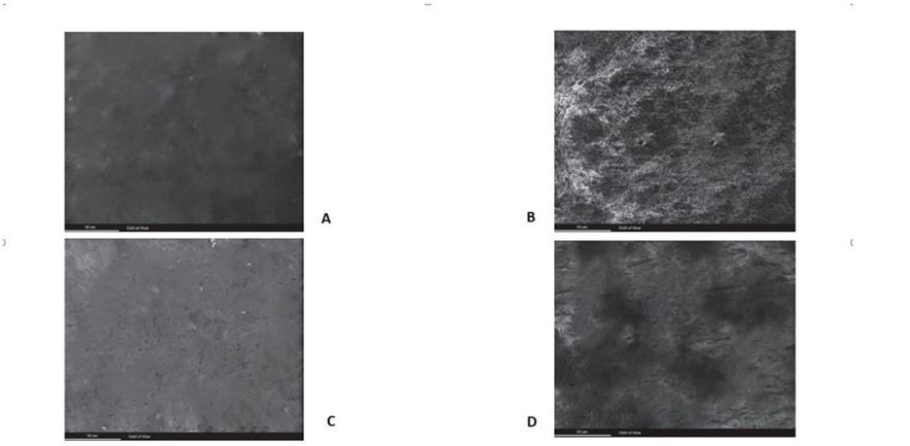


Figure 4:(A) Intact enamel (Normal Enamel) (B) Demineralised enamel (C) Remieralised by N technology (D) Remineralised by NaF solution

The surface of enamel was observed for intact enamel, De and remineralised enamel for both the groups A and B. The intact enamel displayed normal enamel rod and prism deposition (Figure 4A). Demineralized samples had a honeycomb-like appearance due to collapsing enamel rods, irregular prisms, and disorientation of hydroxyapatite crystals (Figure 4B). A thick uniform layer was seen when demineralized enamel was treated with N technology paste, (Figure 4C).The demineralized enamel when treated with 2% NaF solution an rough layer of flourappettite crystal was seen with a morphology of needle like crystal structure (Figure 4D).

These findings suggest that remineralization using both Sodium fluoride (2% NaF) and Novamin(N) containing paste is effective in restoring the hardness of demineralized enamel, with group A showing relatively better results.

DISCUSSION:

The occurrence of white spot lesions (WSL) subsequent to orthodontic treatment can vary depending on several factors such as the type and duration of orthodontic treatment, the patient's oral hygiene, and other individual risk factors.

A systematic review and meta-analysis published by Alessandra et al reported a pooled prevalence of 25.7% for WSLs after fixed orthodontic treatment. John.M etal in 2020 reported a prevalence range of 10.9% to 63.8% for WSLs following orthodontic treatment in there systematic review and meta-analysis.

However, it's important to note that the reported prevalence rates can vary depending on the study design and methodology, the population being studied, and the diagnostic criteria used to identify WSLs. Additionally, some studies have reported a higher prevalence of WSLs in specific populations, such as adolescents or patients with poor oral hygiene.

Altered mineral content of the enamel is risk element disturbing the integrity of dental health, produced due to lifestyle changes in the current scenario. Demineralization of a tooth is caused by recurrent interaction with acids caused due to intrinsic and extrinsic factors in the oral cavity. Extrinsic variables include frequent consumption of acidic meals or beverages and exposure to acidic pollutants at work.[8] the process of demineralization has an impact on the hardness and surface topography of the teeth.

Re/Demineralization is a dynamic process of enamel repair, which occurs in the oral cavity on daily basis.[9] When the delicate balance between the buffering capacity of saliva and salivary Ph is affected, the outer most layer of a tooth, is more prone to manifest a lesion. These lesions at the initial onset are reversible in nature.

ISSN 2063-5346

Hence supplying these lesions with certain reparative minerals within a specific time will help reverse lesion formation.

The remineralizing agents include bioactive glasses made of calcium sodium phosphosilicate compounds, such as Novamin (N), and fluoride, calcium, and phosphate compounds, such as ACP, CPP-ACP, and CPP-ACP with fluoride (CSP).

The remineralization mechanism 2% NaF solution forms a skin of fluorapetite crystals over the enamel tooth structure leading to a stage of supersaturation of hydroxyapatite crystals. These fluoride ions promote remineralization.

Correspondingly the remineralization mechanism of N technology paste involves localization of hydroxyl-carbonate apatite (HCA) which is crystalline in nature, has a structural resemblance similar to the mineral in teeth at the tooth surface which remineralized the teeth from peripheral to deep tooth surface.[10]

The evaluation of Fluoride efficacy regarding remineralization of enamel structure has been assessed in many ways. Authors like Oli yiruyu chal etal and Jelin Diagg etal, S.singh suggested that low doses of solution can be applied for enamel remineralization.[11,12,13] Lissa etal suggested that use of fluoride varnish for enamel remineralization laboratorically.[14] Clinically, J clin etal suggested that 2% NaF dentifrices had the same amount remineralizing effect compared to casein phosphopeptide–amorphous calcium phosphate ACP-CCP.[15] Despite the widespread usage of fluoride, novel remineralizing agents have been suggested and advised for use by individuals or professionals.

Teressa, etal suggested higher efficacy of N technology.[16] It forms crystalline apatite and had deeper penetration which led researchers to test efficacy of technology as remineralizing agent. Sahbar etal and Nishita etal had strongly suggested that the N technology had high efficacy of remineralising the demineralised enamel.[16] When the literature was apprised we could not find adequate research that compared the efficacy between 2% NaF solution and N technology.

So the present study aimed to compare the effect of remineralization and micro hardness of N technology (calcium, sodium, phosphorus and silica) and 2% NaF solution on enamel surface. Microhardness tests are commonly used to study the physical properties of materials, and they are widely used to measure the hardness of teeth. The vicker hardness test method is simple, fast, and only needs a small portion of the specimen surface to be tested.[17] The advantages of Vickers hardness is it can be used on any materials, has only one indenter for every evaluation and is a non-destructive test.[18]

The surface evaluation of the enamel structure was determined with the help of scanning electron microscope (SEM).[19] Which aided in obtaining detailed, magnified images of the tooth surface by a high resolution scanning i.e. at 70× magnification to create an image.[20]

In order to quantify initial enamel hardness, enamel softening as an early sign of the erosion process, enamel hardening after remineralization, and to detect surface changes on the enamel tooth structure, the current study used the Vickers Microhardness Test and a scanning electron microscope (SEM). The samples were submerged in carbonated beverages for 14 minutes each day for seven days to test for enamel degradation. The microhardness values were reduced by 43.8% from the starting point as a result of this treatment. This finding contrasted with that of the Srinivasan et al. (2010) study, in which the carbonated beverage was cola, which has a pH of 2.6418, and the mean microhardness reduction was 24.5%.

The remineralizing chemicals were applied to the demineralized enamel specimens after the checking the hardness of demineralised enamel. A significant difference was observed in the SMH values after remineralization with both 2% NaF solution and N technology remineralizing agents. However, the comparative effect of remineralization with 2% NaF solution and N technology paste was found to be non-significant in relation to SMH values (Table 2 p value = 0.368). Our results were in accordance with the findings of Nishita ran et al[17] where N technology showed greater amount of enamel penetration when compared to ccap with fluoride containing paste , Elangovan et al (226 ppm fluoride) suggested that NaF had the ability to remineralize the enamel structure of demineralised tooth[20]. Our study showed similar SEM observation as suggested by A.K. burwell et al that enamel treated with fluoride shown rougher and irregular surfaces whereas N with fluoride paste showed smoother surface[5]. As the N technology composed of Calcium sodium phosphosilicate N 5.0% w/w, Sodium fluoride (NaF) (0.2299%w/w) (fluoride 0.104% w/w). Aroma, carbomer, cocamidopropyl betaine, glycerin, hydrated silica, PEG-8, sodium methyl cocoyl taurate, sodium

saccharin, and titanium dioxide provide calcium to the demineralised zone and remineralized the tooth in and out unlike fluoride which forms a coating around the tooth structure forming fluorapatite crystal.

These results suggest N technology paste and NaF solution exhibited remineralizing potential when used alone.

The observation and result of present study should be interpreted cautiously as the study condition might not mimic the condition of oral cavity

CONCLUSION-

Based on the appraisal of 106 freshly extracted premolar tooth the remineralizing effects of N technology paste and 2% NaF solution both N technology paste and NaF solution were effective for remineralizing the enamel structure. The application time (in office) for the remineralizing agent on the enamel surface was observed to be significantly more for sodium fluoride. Both the methods of remineralization increased the Microhardness of the teeth similarly. Compared to sodium fluoride the NovaMin therapy induced a smoother surface on enamel tooth structure.

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FIGURE LEGANDS :

1. Figure 1.
(A) Sensodyne Repair
(B) NaF solution
(C) Magnification loupes
2. Figure 2.
Consort flow diagram
3. Figure 3
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(C) Remieralised by N technology
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