Effectiveness of polyacrylic acid-bioactive glass air abrasion preconditioning with NovaMin remineralization on the microhardness of incipient enamel-like lesion

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Abstract

Background: Bioactive glass (BAG) remineralization is a promising method for dental hard tissue regeneration. The aim of this study was to evaluate the microhardness of incipient enamel-like lesions with or without preconditioning by air abrasion using polyacrylic acid (PAA)-BAG before application of NovaMin remineralizing agent.

Materials and Methods: Forty extracted human molars were selected, sectioned mesiodistally obtaining buccal and lingual halves, and embedded in resin molds. Specimens were randomly assigned to four groups (n = 10) according to the remineralization protocol: G1 (control, artificial saliva), G2 (preconditioning), G3 (NovaMin), and G4 (preconditioning and NovaMin). Enamel windows 4 mm × 4 mm were done on the buccal and lingual surfaces. Specimens were immersed in a daily renewed demineralizing solution to create white spot lesions. Remineralizing agents were applied according to the manufacturer’s instructions, and specimens were stored in a daily renewed artificial saliva. Microhardness was assessed using Vickers hardness number (VHN) at baseline (positive control), after demineralization (negative control), and after 24-h and 1-month remineralization.

Results: The preconditioning/NovaMin group after 1 month showed a statistically significant high VHN, with no statistically significant difference between it and the positive control. This was followed by the NovaMin group after 1 month, while the lowest VHN was found in the demineralized group, with no statistically significant difference between it and the preconditioning group, whether after 24 h or 1 month.

Conclusions: Enamel preconditioning with PAA-BAG air abrasion play a major role in enhancement of remineralization when it is accompanied with NovaMin. Furthermore, an extended period of time had helped to attain more benefits from NovaMin remineralization.

Clinical Significance: Enamel remineralization with NovaMin after conditioning by bioactive glass air abrasion, provides the patients with a fast and durable treatment of incipient enamel lesions, which would reduce the possibility of future progression of demineralization and caries occurrence.

Keywords: Air abrasion; bioactive glass; calcium sodium phosphosilicate; NovaMin remineralization

INTRODUCTION

Initially demineralized enamel lesions, which appear as white spot lesions (WSLs), are the first visible evidence of...
enamel caries. In such cases, demineralization commonly occurs underneath the surface layer of enamel, leading to a marked increase in its porosity. The enamel surface layer usually stays intact during subsurface demineralization; however, if left untreated, it will finally break down into a real cavity.\cite{1} Biological advances lately focus on the application of remineralizing agents to early carious lesions in an attempt to control demineralization and encourage remineralization. These agents form a supersaturated environment around the early lesion; therefore, they stop mineral loss and force calcium and phosphate ions into the empty spaces.\cite{2}

Different agents have been described to remineralize initial enamel lesions including calcium sodium phosphosilicate bioactive glass (BAG). It is an extremely biocompatible material that was first formed as bone-regenerative material, which was then developed for intraoral healthcare. Although calcium sodium phosphosilicate BAG, in the beginning, was developed for the treatment of dentin hypersensitivity, by occluding of dental tubules, recent studies have demonstrated a potential for this material to stop demineralization and/or help in remineralization of teeth.\cite{1}

The remineralization of initial enamel lesions is an extremely complicated physicochemical process where the residual mineral crystals are less reactive, covered by salivary proteins, and the incomplete diffusion of ions decreases the total mineral regain. It is proclaimed that pretreatment, either by a chemical method such as acid etching or chemo-mechanical method such as microabrasion, would increase the surface porosity and make the underlying body of the lesion accessible for mineral ion deposition, therefore enhancing the efficacy of the remineralizing agents by simply activating the lesion surface.\cite{3}

Another method of preconditioning the lesion surface is also available, using air abrasion with BAG 45S5 powder in order to promote remineralization using different topical treatments, including calcium sodium phosphosilicate BAG (NovaMin). Polyacrylic acid (PAA) is supposed to expose the subsurface lesion to be readily available for remineralization\cite{4} and is thought to modify the hydroxyapatite (HCA) induced by BAG 45S5, with smaller structures precipitated on the surfaces of enamel WSLs. The (COOH) functional group of PAA may bind to the calcium and phosphate ions to form nano-precursors small enough to break through the carious lesion more successfully.\cite{5} It was found that using the combined methods of chemical and mechanical preconditioning resulted in improved remineralization when compared to using chemical or mechanical methods alone.\cite{6}

However, there are not enough reliable studies and clinical trials proving the efficacy of this latter method. Therefore, it was found beneficial to study the effectiveness of PAA-BAG air abrasion preconditioning and/or NovaMin remineralization on the microhardness of incipient enamel-like lesion after 24 h and 1 month.

The null hypothesis tested was: first, there was no significant difference in the microhardness of enamel, with and without preconditioning by air abrasion using PAA-BAG before application of NovaMin remineralizing agent. Second, time did not affect the remineralization potential of the tested techniques.

**MATERIALS AND METHODS**

**Materials**

Two types of calcium sodium phosphosilicate agents were tested in this study: (a) calcium sodium phosphosilicate-45S5 Bioglass (Pro Sylc, Velopex, London, UK) and (b) calcium sodium phosphosilicate-NovaMin (Restore, Dr. Collins, USA). Furthermore, PAA-Ketac Conditioner 3M ESPE (3M Deutschland GmbH, Germany) was used.

**Specimen preparation**

Forty sound freshly extracted molar teeth were used. The teeth were collected after obtaining the approval of the Ethics Committee of Faculty of Dentistry, Cairo University. The molars were attached to a clip and sectioned mesiodistally using a microtome (Leica 1600 saw microtome, Wetzlar, Germany),\cite{7} to obtain buccal and lingual halves, and then the crowns were decoronated horizontally 2 mm below the cemento-enamel junction. The selected teeth were cleaned using ultrasonic scaling tips, rubber cup/pumice prophylaxis and then stored in saturated thymol solution for 2 weeks. Each two halves of the same crown were embedded in a rectangular acrylic resin block with the buccal and lingual surfaces facing upward; this allows each specimen to serve its own control. The surfaces were polished using disks (Sof-Lex Pop-On Disks, 3M ESPE, St Paul, MN, USA) in progressively finer grits (coarse, medium, fine, and superfine) on a slow-speed contra-angle handpiece (T1 Line series, Sirona, Germany). An adhesive tape (4 mm × 4 mm) was fixed on the middle third of the buccal and lingual surfaces of each specimen while coating the remaining surfaces with an acid-resistant nail varnish. After drying, the adhesive tape was removed creating a standardized exposed enamel window on each specimen. The buccal surface sides were marked by a black permanent marker on the molds. Blocks were randomly given numbers from 1 to 40, and then, they were divided into two equal groups (20 each) using Excel sheet. Specimens from 1 to 20 (both buccal and lingual halves) were allocated for the preconditioning group, while from 21 to 40 (both buccal and lingual halves) were allocated for the no preconditioning group. Lingual surfaces (L) of all specimens were assigned to be stored in daily renewed
Artificial saliva (A. S) only, while buccal surfaces (B) were assigned to be remineralized first by NovaMin and then stored in the artificial saliva [Figure 1].

Demineralization

Artificial caries-like enamel lesions were created by immersing specimens in daily renewed demineralization solution, which was individually calculated for each surface, for 48 h.[8] The solution was composed of 2.2 mM CaCl2 (calcium chloride), 2.2 mM NaH2PO4 (sodium dihydrogen orthophosphate dihydrate), and 0.05 M acetic acid; the pH was adjusted with 1 M KOH (potassium hydroxide) to 4.4 to create a lesion depth of about 50 µm. Specimens were then rinsed with deionized water for 30 s and stored in distilled deionized water as well.

Surface preconditioning using polyacrylic acid and bioactive glass 45S5

A prophy jet handpiece was attached to a dental unit module and kept at a fixed distance from the windows on half of the specimens (first group) using a specially designed prefabricated device to hold it in position. 10% PAA-Ketac Conditioner 3M ESPE (3M Deutschland GmbH, Germany) was applied on the buccal surfaces for 20 s before surface preconditioning, and then excess material was removed gently by a cotton swab, leaving some traces. The nozzle of the prophy jet was kept at a fixed 5 mm distance and at ≈ 90° angle from the surfaces, while the air pressure of the dental unit compressor was adjusted at 20 psi (=0.14 MPa).[5] The 45S5 Bioglass powder (Pro Sylc, Velopex, London, UK) was added inside the prophy jet reservoir. After that, the surface preconditioning was conducted once before initiating the remineralization therapy. The air abrasion was conducted for 10 s in wet abrasion mode fulfilled by shrouding the air stream with a curtain of deionized water.[5]

Application of NovaMin

After surface preconditioning, calcium sodium phosphosilicate-NovaMin toothpaste (Restore, Dr. Collins, USA) was dispensed in a graduated plastic syringe, in order to easily dispense equal amounts of toothpaste (0.5 ml) over the windows of only the buccal surfaces. The paste was brushed gently with a microbrush using 2 or 3 clockwise circular strokes and left for 5 min and then rinsed with deionized water and stored in artificial saliva that was kept at room temperature and renewed daily for the specified storage period till testing.[9] Artificial saliva was prepared according to the formulation of Ten Cate and Duijsters[10] and consisted of 1.5 mM CaCl2, 0.9 mM NaH2PO4, and 0.15 M KCl at pH 7.0. NovaMin was applied twice daily on the buccal surfaces for 1 month. The lingual surfaces did not receive NovaMin treatment and were stored in artificial saliva only, whether preceded by preconditioning or not.

Assessment of surface microhardness

Surface microhardness was measured at baseline of sound enamel (positive control), after demineralization (negative control), and after 24-h remineralization and 1-month remineralization. Surface microhardness (SMH) was performed using a Vickers microhardness tester (Buehler’s Wilson hardness tester, Lake Bluff, USA) with a Vickers diamond indenter. Each measurement was carried out by applying 100 g load for 5 s oriented perpendicularly to the enamel surface. The diagonal lengths of indentations were measured by built-in scaled micrometer, and measurements were converted into Vickers numbers.

Statistical analysis

Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows. The significance level was set at P ≤ 0.05. Data are presented as means and standard deviation (SD) values that were calculated for each group. Data were explored for normality using Kolmogorov–Smirnov and Shapiro–Wilk tests. Microhardness data showed parametric (normal) distribution. The microhardness was evaluated using Vickers hardness number (VHN). Three-way ANOVA analysis was used to determine the effect of different variables on mean microhardness values. Tukey’s post hoc test was used to compare between the groups.

RESULTS

The results of three-way ANOVA analysis for the effect of different variables on mean VHN are shown in Table 1. The mean, SD, and level of significance of the VHN values of the enamel remineralized using different protocols at each time interval are shown in Table 2. It was shown that the effect of preconditioning alone was not statistically significant (P = 0.591). Furthermore, the effect of the remineralizing agent and assessment time were statistically significant at P = 0.001. The interaction term between preconditioning status, remineralizing agent, and time of

**Figure 1:** Diagram illustrating the grouping of specimens
assessment showed no statistical significance at $P = 0.601$. The group of preconditioning that received NovaMin for 1 month showed a statistically significant high VHN, with no statistically significant difference between it and the positive control group ($P = 0.001$). This was followed by the group that received only NovaMin for 1 month, while the lowest VHN was found in the negative control group, with no statistically significant difference between it and that of the group that received only preconditioning, whether after 24 h or 1 month ($P = 0.001$).

Percentage recovery after 1 month was obtained using the following equation $^{[11,12]}$ while values are shown in Table 3:

$$\left(\frac{\text{SMH}_1 - \text{SMH}_3}{\text{SMH}_1 - \text{SMH}_2}\right) \times 100$$

$\text{SMH}_1$ = Intact, $\text{SMH}_2$ = Demineralization, $\text{SMH}_3$ = Remineralization.

The highest percentage recovery was achieved after 1 month of NovaMin remineralization for the group that received preconditioning (91.6%), followed by the group that received only NovaMin (50.5%), followed by the group that received only preconditioning (16.3%), while the lowest recovery was for the group that did not receive preconditioning nor NovaMin remineralization (0.06%).

### Table 1: Three-way analysis of variance results

| Source of variance | Type III sum of squares | df | Mean square | $F$ | $P$ |
|--------------------|-------------------------|----|-------------|-----|-----|
| Preconditioning status | 107.322 | 1 | 107.322 | 0.290 | 0.591 |
| Remineralizing agent | 8133.334 | 1 | 8133.334 | 21.993 | 0.001* |
| Time of assessment | 164,861.704 | 3 | 54,953.901 | 148.596 | 0.001* |
| Preconditioning × remineralizing agent × time of assessment | 691.662 | 3 | 230.554 | 0.623 | 0.601 |

* $P \leq 0.05$ is statistically significant. df: Degrees of freedom

### Table 2: Mean, standard deviation, and level of significance of the Vickers hardness number values of the enamel remineralized using different protocols at each time interval

| Variables | Artificial saliva only | Remineralization protocol | NovaMin + artificial saliva | $P$ |
|-----------|------------------------|---------------------------|-----------------------------|-----|
|           | No preconditioning | Preconditioning | No preconditioning | Preconditioning | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Baseline (positive control) | 347.57$^{\text{a,A}}$ | 21.7 | 340.71$^{\text{a,A}}$ | 21.4 | 351.75$^{\text{a,A}}$ | 17.6 | 342.42$^{\text{a,A}}$ | 23.8 | 0.649 |
| Demineralization (negative control) 24 h | 266.71$^{\text{a,b}}$ | 20.8 | 264.46$^{\text{a,b}}$ | 14.2 | 269.04$^{\text{a,b,c}}$ | 17.6 | 267.88$^{\text{a,c}}$ | 19.2 | 0.878 |
| 1 month | 265.25$^{\text{a,b}}$ | 19.9 | 269.55$^{\text{a,b}}$ | 15.2 | 270.63$^{\text{a,b,c}}$ | 17.7 | 268.92$^{\text{a,b,c}}$ | 19.1 | 0.918 |

* $P \leq 0.05$ is statistically significant, the same superscript small letters in each row indicate insignificance, while the same subscript capital letters in each column indicate insignificance

### Table 3: Percentage recovery after 1-month remineralization

| Equation | Artificial saliva only | NovaMin + artificial saliva |
|----------|------------------------|-----------------------------|
| No preconditioning | Preconditioning | No preconditioning | Preconditioning |
| $\frac{(266.75−266.70)/(347.57−266.70)}{100}$ | $0.06$ | $\frac{(310.77−269.04)/(351.75−269.04)}{100}$ | $0.001^*$ |

### DISCUSSION

In the primary stages of noncavitated carious enamel lesions, despite the fact, the surface layer stays mostly intact, yet the underlying body of the lesion can be extensively demineralized. These enamel lesions manifest clinically as white spots $^{[13]}$. The best treatment modality for WSLs is through the noninvasive approach, remineralization. Although the hypermineralized surface layer of WSLs protects the underlying lesion from cavitation and further demineralization, it may also impede full remineralization and limit the diffusion of ions into the lesion body $^{[14]}$. Therefore, minimally invasive dentistry advocates to modify part of this surface layer to increase surface porosity, rendering the intact, relatively unaffected surface zone slightly porous and making the underlying body of the lesion accessible for mineral ions, thus activating the lesions $^{[3,16]}$.

One of the proposed treatment attempts is preconditioning the lesion surface, before applying the remineralizing agent, and it has revealed a noticeable increase in the remineralization of WSLs $^{[5]}$. It was also found that using PAA-BAG air abrasion before remineralization resulted in the removal of a very thin, clinically insignificant layer from the lesion surface, around 5 \( \mu \)m. Moreover, preconditioning increased the surface roughness, and accordingly, the
average surface area increased and created more spots for crystal ion deposition; in other words, the preconditioned WSL surface presented more sites for remineralization and exhibited better remineralization as well.[9]

Many methods are used to provide evidence of mineral loss or gain. SMH analyses have been widely used to assess demineralization and remineralization changes occurring in enamel.[15,16] SMH evaluations are simple, fast, and easy to measure nondestructively.[17]

The findings of the present study indicated that preconditioning with air abrasion using BAG had no statistically significant effect on remineralization in all the groups except in the group that received NovaMin for 1 month. The fact that there was no significance matched with the results of Al-Khateeb et al. who found that there was no significant difference between etched and nonetched specimens regarding enhanced remineralization tendency.[19] It was mentioned in a previous study[19] that VHN for 45S5 BAG was 458 ± 9.4 which was much higher than enamel’s VHN at baseline (≈345 ± 21). This finding might explain that minerals gained in the preconditioned groups were consumed to replace those lost by air abrasion procedure, because the cutting efficiency of BAG was very high to the extent that it removed more minerals from the already demineralized enamel. On the other hand, the results showed that preconditioning had a significant effect only in the group that received NovaMin for 1 month. This might be attributed to the presence of a remineralizing agent with high source of minerals that were readily available to diffuse into the pores created by the preconditioning step. Moreover, NovaMin and BAG have the same chemical structure which might have lead them to function in an augmentative way, resulting in a 91.6% recovery, which is considered to be a great success, in comparison to the 28.7% recovery that was achieved by Soares et al.[12] [Table 3].

While the results of the present study were in conflict with the results of Al-Khateeb et al.,[3] where the results from the latter study showed that the etched enamel lesions presented a more obvious reduction of the lesion depth after remineralization than the nonetched lesions. This might be due to the difference in the preconditioning protocol used, in which acid etching was used instead of air abrasion. In addition, there was a difference in the remineralization therapy period which was performed; in the latter study (Al-Khateeb et al.), the therapy was performed for 10 weeks, however, in the present study, remineralization therapy was done for about 4 weeks only. Moreover, the current results were also in conflict with Milly et al.,[3] which might be due to the difference in PAA configuration used. In that study, PAA was used in a powder form and was mixed with the BAG powder used for air abrasion, while in the current study, PAA was used as a liquid conditioner in a separate step before air abrasion.

Furthermore, these results were against the results of other studies,[20,21] due to the difference in the method of preconditioning used in which 37.5% phosphoric acid and pumice were used creating a lesion depth of about 33.6 µm which was less than the lesion created by the same demineralizing solution that was used in this study, which was 50 µm.[8] This depth difference in the subsurface lesions might have caused the nature of remineralization difference. The difference in results may also be due to performing the remineralization process in primary teeth in vivo, so they got the benefit of contacting the lesion with human saliva, which helps to activate the release of calcium and phosphate ions from it, while the current study was performed in vitro lacking the contact with human saliva.

On the other hand, the results of this study revealed that NovaMin had a statistically significant effect on increasing VHN of demineralized enamel. This was in agreement with several studies that stated that NovaMin significantly succeeded to increase enamel microhardness.[22,23] This conclusion might be due to the claim that NovaMin replaced the mineral content of the WSLs in the form of HCA, which has a chemical structure similar to that of the enamel crystals, thereby almost reproducing the layer of enamel that was lost.

Moreover, the findings revealed that increasing time from 24 h to 1 month did not have any significant effect on VHN of the tested specimens immersed in artificial saliva. This was in accordance with Shetty et al. who stated that saliva fails dramatically to initiate the process of increasing the levels of calcium and phosphate despite its remineralizing potential.[24] Therefore, the net remineralization achieved by saliva is minimal, with a tendency for the mineral gain to be in the surface layer of the lesion due to the low ion concentration gradient from saliva into the lesion.[25] Whereas, VHN showed a significant increase after 1 month for the specimens that received NovaMin and were immersed in artificial saliva, regardless of the preconditioning status, which proves that remineralization is a time-dependent process for crystallization to occur.[26]

Finally, it must be noted that this study had certain limitations that might require further research. The replication of dynamics of the caries process and complexity of the oral environment is limited in such in vitro models. Further in vivo studies must be conducted to build an evidence-based standard for the most effective technique and materials used for remineralization.

**CONCLUSIONS**

Under the limitations of the present study, it can be concluded that enamel preconditioning with PAA-BAG air abrasion plays a major role in enhancement of
remineralization when it is accompanied with NovaMin. Furthermore, an extended period of time had helped to attain more benefits from NovaMin remineralization.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Burwell AK, Litkowski LJ, Greenspan DC. Calcium sodium phosphosilicate (NovaMin): Remineralization potential. Adv Dent Res 2009;21:35-9.
2. Balakrishnan A, Jonathan R, Benin P, Kumar A. Evaluation to determine the caries remineralization potential of three dentifrices: An in vitro study. J Conserv Dent 2013;16:375-9.
3. Al-Khateeb S, Exterkate R, Angmar-Månsson B, ten Cate JM. Effect of acid-etching on remineralization of enamel white spot lesions. Acta Odontol Scand 2000;58:31-6.
4. Salomão PM, Comar LP, Buzalaf MA, Magalhães AC. In situ remineralisation response of different artificial caries-like enamel lesions to home-care and professional fluoride treatments. BMC Oral Health 2016;16:2.
5. Milly H, Festy F, Andiappan M, Watson TF, Thompson I, Banerjee A. Surface pre-conditioning with bioactive glass air-abrasion can enhance enamel white spot lesion remineralization. Dent Mater 2015;31:522-33.
6. Pliska BT, Warner GA, Tantbirojn D, Larson BE. Treatment of white spot lesions with ACP paste and microabrasion. Angle Orthod 2012;82:765-9.
7. Kumar VL, Itthagarun A, King NM. The effect of casein phosphopeptide-amorphous calcium phosphate on remineralization of artificial caries-like lesions; An in vitro study. Aust Dent J 2008;53:34-40.
8. Mohanty P, Padmanabhan S, Chitharanjan AB. "An in vitro Evaluation of Remineralization Potential of Novamin® on artificial enamel sub-surface lesions around orthodontic brackets using energy dispersive X-Ray Analysis (E DX). " J Clin Diagn Res 2014;8:88-91.
9. Itthagarun A, Verma S, Laloo R, King NM, Wefel JS, Nair RG. Effects of fluoridated milk on artificial enamel carious lesions: A pH cycling study. J Dent 2011;39:817-24.
10. ten Cate JM, Duijsters PP. Alternating remineralization and remineralization of artificial enamel lesions. Caries Res 1982;16:201-10.
11. Mohd Said SN, Ekambaram M, Yiu CK. Effect of different fluoride varnishes on remineralization of artificial enamel carious lesions. Int J Paediatr Dent 2017;27:163-73.
12. Soares R, De Ataide IN, Fernandes M, Lambor R. Assessment of enamel remineralisation after treatment with four different remineralising agents: A scanning electron microscopy (SEM) Study. J Clin Diag Res 2017;11:ZC136-41.
13. Meyer-Lueckel H, Paris S, Kielbassa AM. Surface layer erosion of natural caries lesions with phosphoric and hydrochloric acid gels in preparation for resin infiltration. Caries Res 2007;41:223-30.
14. Hicks MJ. A polarized light and scanning electron microscope study of sodium-fluoride treated, acid-etched, caries-like lesions of human enamel. Arch Oral Biol 1986;31:653-60.
15. De Souza CC, Cury JL, Coutinho TC, Da Silva EM, Tostes MA. Effect of different application frequencies of CPP-ACP and fluoride dentifrice on demineralized enamel: A laboratory study. Am J Dent 2014;27:215-9.
16. Oliveira P, Fonseca A, Silva EM, Coutinho T, Tostes MA. Remineralizing potential of CPP-ACP creams with and without fluoride in artificial enamel lesions. Aust Dent J 2016;61:45-52.
17. Memarpour M, Soltaninezhad E, Sattarzadeh M. Efficacy of calcium- and fluoride-containing materials for the remineralization of primary teeth with early enamel lesion. Micros Res Tech 2015;78:801-6.
18. Al-Khateeb SN, Tarazi SJ, Al Maaitah EF, Al-Batayneh OB, Abu Alhaija ES. Does acid etching enhance remineralisation of arrested white spot lesions? Eur Arch Paediatr Dent 2014;15:413-9.
19. Banerjee A, Paclinelis G, Socker M, McDonald F, Watson TF. "An in vitro Investigation of the effectiveness of bioactive glass air-abrasion in the ‘selective’ removal of orthodontic resin adhesive.” Euro J Oral Sci 2008;116:488-92.
20. Pearsarnay K, Anderson P, Brook AH. A quantitative study of the effect of pumicing and etching on the remineralisation of enamel opacities. Int J Paediatr Dent 2001;11:193-200.
21. Baroni C, Marchionni S, Bazzocchi MG, Cadenaro M, Nucci C, Martignon DJ. "A SEM and non-contact surface white light profilometry in vitro study of the effect of a crème containing CPP-ACP and fluoride on young etched enamel.” The journal of scanning microscopes 2014;36:270-7.
22. Vahid Golpayegani M, Sohrabi A, Biria M, Ansari G. Remineralization effect of topical novamin versus sodium fluoride (1.1%) on caries-like lesions in permanent teeth. J Dent (Tehran) 2012;9:68-75.
23. Mehta AB, Kumari V, Jose R, Iazidakhah V. Remineralization potential of bioactive glass and casein phosphopeptide-amorphous calcium phosphate on initial carious lesion: An in vitro pH-cycling study. J Conserv Dent 2014;17:3-7.
24. Shetty S, Hegde MN. Bopanna TP. Enamel remineralisation assessment after treatment with three different remineralizing agents using surface microhardness: An in vitro study. J Conserv Dent 2014;17:49-52.
25. Elkaissas D, Arafa A. Remineralization efficacy of different calcium-phosphate and fluoride based delivery vehicles on artificial caries-like enamel lesions. J Dent 2014;42:466-74.
26. Madan N, Madan N, Sharma V, Pardal D, Madan N. "Tooth remineralization using bio-active glass a novel approach.” Baba Farid Univ Dent J 2011;2:64-7.