

Efficacy of Resin Infiltration and Fluoride Casein Phosphopeptide Amorphous Calcium Phosphate Varnish on Non-cavitated Active White Spot Lesions in Children: A Randomized Clinical Trial

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ABSTRACT

Objective: To compare the efficacy of resin infiltration and fluoride casein phosphopeptide amorphous calcium phosphate varnish on non-cavitated active white spot lesions in 5-8 years old children. **Material and Methods:** 60 non-cavitated active white spot lesions in 60 patients with ICDAS II score 2 from both genders in the age range of 5 to 8 years were taken. Thirty lesions were treated by resin infiltration (Group 1) and 30 by Fluoride CPP-ACP varnish (Group 2). Resin infiltration was performed on the same day, while Fluoride CPP-ACP varnish was applied once a week for 4 weeks. The follow-up was done at 3, 6 months, and 12 months. **Results:** At 3, 6, and 12 months change in mean ICDAS II Score in group 1 was 1.5 ± 0.5 , 1.13 ± 0.73 and 0.9 ± 0.88 , respectively, while in group 2, it was observed to be 0.30 ± 0.59 , 0.4 ± 0.89 and 0.06 ± 0.82 , respectively ($p < 0.001$). **Conclusion:** Resin infiltration was more successful than Fluoride CCP-ACP varnish in active non-cavitated white spot lesions.

Keywords: Dental Caries; Tooth, Deciduous; Fluorides; Preventive Dentistry.

Introduction

Dental caries is a significant public health concern and one of the most common widespread diseases among youngsters. It originates from interactions between cariogenic bacteria in dental plaque, fermentable carbohydrates (basically sugars), and an imbalance within the system of demineralization and remineralization of enamel because of altered pH levels over time [1].

This cycle of demineralization–remineralization is an ongoing phenomenon, but if the protecting elements of the oral cavity, for example, salivary buffers, fluorides, etc., are not able to hold the stability in favour of remineralization, there is a lack of mineral content which actuate incipient caries [2].

These incipient carious lesions are so-referred to as “white spot” lesions. A white spot lesion is defined as sub-surface enamel porosity from carious demineralization that presents itself as milky-white opacity when located on a clean surface [3]. Differential diagnoses of white spot lesions include incipient caries, dental fluorosis, and developmental defects of non-fluoride etiology. Among white spot lesions, active lesions are described as ‘chalky’/dull and irregular on probing, while inactive lesions are glossy and smooth on probing [4].

Restoring the tooth structure by using dental filling has been the first choice for treating dental caries, but in recent years, the treatment has been modified from the large invasive approach to non-invasive or minimally invasive preventive strategies [5]. In addition, different options have been suggested for developing the remineralization process, i.e., the use of casein phosphopeptide-amorphous calcium phosphate or fluoride containing products, microabrasion, argon-laser irradiation and resin infiltration [6].

The resin infiltration approach is a unique technology offering an excellent middleman treatment option in prevention and restorative therapy [7]. Furthermore, resin infiltration, with its high refractive index (RI = 1.46), which is comparable to healthy enamel (RI = 1.62), additionally creates the so-called chameleon impact – a blended shading of the managed lesions with the enamel surface [8].

Fluoride is a well-recognized remineralizing agent, interacting with oral fluids on the tooth surface and subsurface and combining with calcium and phosphate ions to shape carbonate substituted hydroxyapatite into fluorapatite [9]. As a result, fluoride varnish takes less time, creates less patient discomfort, and enhances patient acceptability, specifically in preschool-aged children [10].

In 1991, the casein phospho-peptide-amorphous calcium phosphate (CPP-ACP) complex, derived from a milk protein called casein, became patented in the United States [11]. MI Varnishes is a 5% NaF varnish improved with 2% RECALDENT(CPP-ACP) to provide an amazing fluoride varnish that releases greater bio-available fluoride, calcium and phosphate. After a single application, MI Varnish has a lovely smooth consistency and an impartial color with natural translucency.

The efficacy of resin infiltration in arresting caries lesions has been investigated *in vitro* [12], *in situ* [13], and *in vivo* [14] studies, and its effect in overlaying white spot lesions has been shown clinically [15,16]. Nevertheless, the camouflage effect of the resin infiltration technique with the possible remineralization effect of fluoride compounds within the non-cavitated active white spot lesions requires to need to be further study. Due to the higher incidence of incipient caries in the age group of 5-8 years, this age group has been chosen for the study [17].

Thus, the presenting study compared the efficacy of resin infiltration and fluoride casein phosphopeptide-amorphous calcium phosphate varnish in non-cavitated active white spot lesions in 5-8 years.

Material and Methods

Study Design and Patients Selection

This is a prospective randomized clinical trial. The patients were selected from both genders in the age range of 5 to 8 years presenting at least one active non-cavitated lesion with ICDAS II score 2; all participants selected were practicing twice daily brushing with fluoridated age-appropriate dentifrice. Exclusion criteria included patients older than 8 years; a known history of chronic systemic illness like diabetes, renal failure, epilepsy, etc.; a history of taking medication for any disease; and a child who was not willing to participate. At baseline, dietary patterns, type, frequency and consumption of food, sweet scores and oral hygiene practices over the past week were evaluated. Diet counselling and oral hygiene instructions were carried out on all the patients by a single investigator. The investigator was trained to satisfaction in the counselling measures by two experienced instructors in the field.

Patients who fulfilled these inclusion criteria were recruited from the outpatient settings of the Department of Paedodontics and Preventive Dentistry, University College of Medical Sciences and Guru Teg Bahadur Hospital, Delhi, India.

Sample Size

Based on literature with a similar methodology, considering an improvement rate of 69% in the Resin Infiltration group and 33% in Fluoride varnish group for early smooth surface lesions [24], to estimate this difference at $\alpha=5\%$ and power=80%, a sample size of 30 lesions in each group was estimated. A total of 60 non-cavitated active white spot lesions in 60 patients were taken. Among selected patients, if they had more than one non-cavitated white spot lesion, then only one lesion was selected for the study in the following preference order.

- Maxillary arch > mandibular arch
- Right side > Left side
- Central incisors > Lateral incisors > Canine > Molars

Allocation concealment was achieved using opaque envelopes to assign the treatment group to the subject. Finally, the randomization sequence was generated by the Statistician.

Clinical Procedures

All the carious lesions other than white spot lesions were treated simultaneously in both groups. In lesions that were not taken up for the study, their appropriate treatment was performed. We maintained all the photographs lesions recorded in all the patients.

The study consisted of two groups: Group 1: treatment with resin infiltration; and Group 2: treatment with Fluoride Casein Phospho-Peptide Amorphous Calcium Phosphate varnish (CPP-ACP).

Thirty lesions were treated by resin infiltration and thirty by fluoride-based CPP-ACP varnish. Resin infiltration was conducted as a single-visit procedure and the application of fluoride-based CPP-ACP was done as four weekly applications. The follow-up was done at 3 and 6 months.

Prior to the initiation of the study, two examiners were trained to evaluate White Spot Lesions (WSL) and in the consistent recording of the ICDAS scale criteria. This was further evaluated by two specialists in the field using a 1-5 Likert rating. The consistency between experts for each examiner was found to be good, with a Cronbach alpha score of 0.82. Disagreements were solved by consensus and a final ICDAS II score was obtained. It was planned in this study to record caries clinically by means of the ICDAS visual scoring system. The selected surfaces were cleaned professionally with dental floss and lesions were scored clinically from

buccal, occlusal, proximal and lingual aspects using the ICDAS II visual scoring system. Lesions were examined by running the probe; if it is rough, it was said to be active lesions and if it was found to be smooth while probing, it was non-active. In addition, restoration and caries status related to surfaces was assessed on the individual child. White Spot Lesions (WSL) treatment was considered successful when lesions regressed (Scores 0 and 1) or remained the same (Score 2) and unsuccessful when lesions had progressed (Score >3). The placement of restoration during the study period was considered as lesion progression.

After rubber-dam application, the lesions were etched with 15% hydrochloric acid for 120 s, followed by rinsing and drying. The lesions were then dehydrated with ethanol for 30 s and air-dried. Subsequently, the infiltrant resin was applied into the lesion with a syringe for 180 s and polymerized with blue light with a wavelength of 450 nm and an intensity of 800 mW/cm. Next, the resin was re-applied for 60 s and polymerized. The rubber dam was then removed and the infiltrated lesion was polished with rubber polishing tips.

Treatment with Fluoride Casein Phosphopeptide Amorphous Calcium Phosphate Varnish

Teeth were isolated with a mouth retractor and the tooth surfaces were dried before the application of MI Varnish. The foil lid had been peeled off the MI Varnish unit dose and stirred through. Applied a thin, uniform layer of MI Varnish using a disposable brush. MI Varnish sets when came in contact with water or saliva. The application was completed by waiting 2-3 minutes as the materials covered all teeth surfaces. MI Varnish remains undisturbed on the teeth for 4 hours. Patients were instructed to avoid hard, hot or sticky foods, tooth brushing and flossing, and products containing alcohol (oral rinses, beverages, etc.) during this period. These clinical procedures were performed once a week for four weeks.

Statistical Analysis

The data was entered into the digital spreadsheets and subjected to analysis in SPSS version 20. Descriptive results were obtained as frequency/ percentages and mean \pm standard deviation. Intra-group comparison at different time intervals was done by using Repeated measure ANOVA. Inter-group comparisons were done by using an independent student t-test and a chi-square test. The level of significance was set at 5%.

Ethical Clearance

Ethical clearance was taken from the Institutional Ethical Committee (Protocol No. IEC-HR/2017/32/126), and parental consent and pediatrics were sent taken.

Results

All patients completed the study, and none were lost in the follow-up period. Sixty children aged between 5 to 8 years (mean age 6.8 years), of which 33 were boys and 27 were girls (Table 1). The mean ICDAS II scores for both the groups at baseline was 2 (as mentioned in the inclusion criteria).

Table 1. Distribution of study population by gender.

Gender	G1 (Resin Infiltration)	G2 (Fluoride CCP-ACP Varnish)
	N (%)	N (%)
Male	14 (46.6)	19 (63.3)
Female	16 (53.3)	11 (36.6)
Total	30 (100.0)	30 (100.0)

Table 2 compares ICDAS scores in both the treatment groups at baseline, 3, 6, and 12 months (Intracomparision).

Table 2. Comparison of ICDAS score at baseline, 3, 6, and 12 months.

Groups	Baseline Mean	3 Months Mean ± SD	6 Months Mean ± SD	12 Months Mean ± SD	p-value ^b
Resin infiltration	2	0.5± 0.50	0.87± 0.73	1.10± 0.88	<0.001**
Fluoride CPP-ACP Varnish	2	1.70± 0.59	1.60± 0.89	1.93± 0.82	<0.05*

^bRepeated Measure ANOVA; **Highly Significant; *Significant.

A one-way repeated measure ANOVA was conducted to compare the effect of Resin infiltration and fluoride CPP-ACP varnish (Independent Variable) on ICDAS score (Dependent variable) at 3, 6, and 12 months. The mean ICDAS II scores at 3, 6, and 12 months in Group 1 were 0.5, 0.87 and 1.10, while in Group 2, it was 1.70, 1.60 and 1.93, respectively (Figure 1). There was a significant effect of resin infiltration (Wilk's Lambda= 0.092, F (3,27)=88.338, p=0.000) and fluoride CPP-ACP varnish (Wilk's Lambda= 0.646, F (3,27)=4.9, p=0.007) on ICDAS Score.

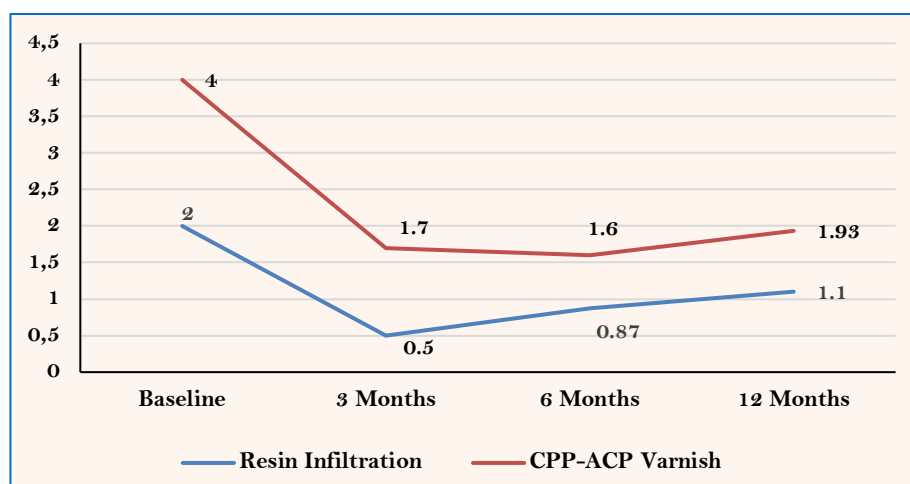


Figure 2. Comparison of mean ICDAS II scores between group 1 and group 2 at baseline, 3, 6, and 12 months.

Table 3 and 4 shows further results of pairwise comparisons among both groups.

Table 3. Pairwise comparisons of time for ICDAS score in resin infiltration group.

Pairwise	p-value
Baseline	3 Months <0.001**
	6 Months <0.001**
	12 Months <0.001**
3 Months	6 Months <0.05*
	12 Months <0.05*
6 Months	12 Months <0.05*

**Highly Significant; *Significant.

Table 4. Pairwise comparisons of time for ICDAS score in fluoride CPP-ACP group.

Pairwise	p-value
Baseline	3 Months >0.05
	6 Months >0.05
	12 Months >0.05

3 Months	6 Months	>0.05
	12 Months	>0.05
6 Months	12 Months	<0.05*

*Significant.

Clinical status of WSLs in both groups after 1-year follow-up. 10% of lesions had progressed to cavitation, and 90% of lesions remained the same or regressed in group 1, and 27% of lesions had progressed and 73% remained the same or regressed. The efficacy of resin infiltration compared with fluoride CPP-ACP varnish is 17% which is statistically highly significant (Table 5).

Table 5. Clinical status of the test and control lesions after 1 year.

Clinical Status	Resin Infiltration	Fluoride CPP-ACP Varnish	p-value
	N (%)	N (%)	
Progressed to Cavitation (ICDAS II Score >3)	3 (10.0)	8 (27.0)	<0.001**
No Progression (ICDAS II Score 2)	4 (13.0)	13 (43.0)	
Regression (ICDAS II Scores 0, 1)	23 (77.0)	9 (30.0)	
Total	30 (100.0)	30 (100.0)	

Table 6 shows a change in ICDAS Score at 3, 6 and 12 months in both the treatment arms (Intercomparison). At 3, 6 and 12 months change in mean ICDAS II Score in group 1 was found to be 1.5 ± 0.5 , 1.13 ± 0.73 and 0.9 ± 0.88 , respectively, while in group 2, it was observed to be 0.30 ± 0.59 , 0.4 ± 0.89 and 0.06 ± 0.82 , respectively ($p < 0.001$).

Table 6. Change in ICDAS Score at 3, 6 & 12 months in both the treatment arms.

Groups	3 Months	p-value ^a	6 Months	p-value ^a	12 Months	p-value ^a
	Mean \pm SD		Mean \pm SD		Mean \pm SD	
Resin Infiltration	1.5 ± 0.5	<0.001**	1.13 ± 0.73	<0.001**	0.9 ± 0.88	<0.001**
Fluoride CPP-ACP Varnish	0.30 ± 0.59		0.4 ± 0.89		0.06 ± 0.82	

SD: Standard Deviation; **Highly Significant; ^aParametric Independent t test.

Discussion

White spot lesions form the earliest stage of the caries process. At this stage, the ongoing demineralization can be arrested or remineralized [18]. White Spot Lesions (WSL) naturally receive remineralizing stimulus from the saliva. Some researchers have suggested that white spot lesions cannot be eliminated completely, whereas others claim that improvement may occur over 5–12 years. Enaia et al. [19] showed that 57.1% of WSL improved, 26% remained the same and 16.7% became worse after a 1-year follow-up without any treatment. The present study was performed to determine the efficacy of the resin infiltration and MI Varnish application on non-cavitated active white spot lesions in 5–8-years-old children and follow-up was done at 3, 6, and 12 months. The age group of 5–8-years-old was selected because the incidence of incipient caries is commonly found to be considerably high in this age group [17].

A study by Paris et al. [20] showed infiltrant penetrates most parts of the demineralized enamel, but lesions with ICDAS scores 3–5 had no infiltration. Furthermore, the depth of infiltration in ICDAS 4 and 5 was significantly lower compared to score 2. In the current study, lesions having an ICDAS score 2 were included, i.e., non-cavitated lesions [20].

The study comprised 14 males and 16 females in Group 1 (Resin Infiltration) and 19 males and 11 females in Group 2 (Fluoride CPP-ACP varnish). The treatment of white spot lesions was considered successful when lesions regressed (Scores 0 and 1) or remained the same (Score 2). The treatment was graded

as unsuccessful when the lesion had progressed (Score >3). At 3 months follow-up, no lesion progressed in Group 1, and only one lesion progressed in Group 2. At six months of follow-up in the resin infiltration group, only one lesion (1\30) had progressed, 26 lesions had regressed, and 3 remained unchanged. In group 2, five lesions (5\30) had advanced and 14 lesions regressed and 11 remained unchanged (MI Varnish). The trend at 12 months follow-up in Resin infiltration group 1 was only 3 lesions (3\30) progressed, 23 lesions regressed and 4 lesions remained the same. Among the cases in group 2, 8 lesions (8\30) progressed, 19 lesions regressed, and 13 remained constant. Hence in Group 1, only 10% of the total lesion had shown progression, and 90% of cases showed successful treatment. While in Group 2, only 27 % showed lesion progression, and 73% of cases showed successful treatment.

In our study, only 10% of lesions had progressed over 1-year follow-up in the resin infiltration group. In a similar study by Meyer-Lueckel et al. [21], only 4 % of lesions were found to progress. However, as per a study by Martignon et al. [22], 32% of lesions had progressed in the infiltration group after 3 years. The possible reason for this might be the inclusion of non-cavitated lesions in our study compared to the Martignon et al. [22] study because the probability of including microcavitated lesions increases with a higher proportion of deeper lesions. These will show incomplete infiltration of cavitated areas and in turn, be more likely to progress compared to non-cavitated lesions with a similar radiographic presentation.

Compared to fluoride casein phosphopeptide-amorphous calcium phosphate varnish, the efficacy of resin infiltration in non-cavitated active white spot lesions was observed to be reduced by 17% (90%-73%). In corroboration with the present findings, Ekstrand et al. [23] showed a clinical and radiological efficacy of resin infiltration in conjunction with fluoride varnish treatment was 35.7% more effective than fluoride varnish alone. In a study conducted by Turska-Szybka et al. [24], it was observed that after one year, 92.1% of the infiltrated lesions (Resin Infiltration + Fluoride Varnish) and 70.6% of the Fluoride Varnish lesions had not progressed ($p < 0.001$) and the efficacy was 21.5%. These results were documented to be lower as compared to our present study. The possible difference in results between our study and the study done by Ekstrand et al. [23] and Turska-Szybka et al. [24] could be due to the presence of casein phosphor peptide amorphous calcium phosphate fluoride nanocomplexes in MI varnish. The presence of these nanocomplexes would explain the superior ability of MI varnish to inhibit demineralization in the present study, as the combination of CPP-ACP and fluoride to form CPP-ACPF nanocomplexes has been shown to be superior to fluoride varnish alone (used by Ekstrand et al. [23] and Turska-Szybka et al. [24]). Other studies [25-27] concluded that fluoride varnishes containing CPP-ACP were more effective in increasing the acid resistance of primary enamel than other fluoride varnishes.

In contrast to the studies mentioned above, Güçlü et al. [28] and Girish Babu et al. [29] observed no significant difference in the remineralizing potential of a varnish containing CPP-ACP and fluoride with that of a varnish containing only fluoride.

In the present study, the mean ICDAS II scores for both the groups at baseline was 2 (as mentioned in the inclusion criteria). Among study participants in the resin infiltration group, the mean ICDAS II scores at 3, 6 and 12 months was 0.50, 0.87 and 1.10, respectively. The Fluoride CPP-ACP varnish group noted a mean ICDAS II score was 1.70, 1.60 and 1.93, respectively, at the specified follow-up intervals. The above-mentioned findings demonstrated a significantly higher decrease in mean ICDAS II score from baseline to 3 months and from baseline to 6 months and from baseline to 12 months in the resin infiltration group as compared to Fluoride CCP-ACP varnish. Additionally, there was an increase in the mean ICDAS II score from 3 months to

6 months (0.50 to 0.87) and from 6 months to 12 months (0.87 to 1.10) in the resin infiltration group due to the progress of a few lesions.





On the other hand, a decline in mean ICDAS II scores from 3 months to 6 months (1.70 to 1.60) and 6 months to 12 months (1.60 to 1.93) was recorded in the Fluoride CCP-ACP varnish. The probable reason why resin infiltration shows higher efficacy than fluoride varnish may be explained by the quick precipitation of minerals blocking the superficial enamel pores in the varnish group. The presence of this hypermineralized layer limits the remineralization of the subsurface lesion body.

Similarly, in a study by Çiftçi et al. [30], the mean ICDAS II score for resin infiltration and fluoride varnish at 3 months follow-up was 0.53 and 1.57, respectively, which was quite similar to the present study. Another study showed the efficacy of the resin infiltration technique and fluoride treatment on white spot lesions were compared [1]; the results showed that the resin infiltration group showed a statistically significant decrease in the amount of reduction in the 6-month demineralization values relative to the baseline values in the fluoride varnish group. Our findings also agreed with a recent *in vitro* study that compared the effect of resin infiltration and fluoride varnish (5% NaF) on enamel surface properties. In this study, the authors also found that the surface microhardness treated by resin infiltration was significantly higher than that in surfaces treated by fluoride varnish.

Conclusion

Both resin infiltration and Fluoride CCP-ACP varnish are clinically feasible and efficacious methods for the treatment of incipient carious lesions, which are capable of arresting incipient caries and preventing the tooth from further destruction. In our study, resin infiltration was found to be more successful than Fluoride CCP-ACP varnish in active non-cavitated white spot lesions. Treatment of incipient lesions with resin infiltration provides good esthetic recovery and high patient satisfaction. The effect of resin infiltration was visible just after one application, while for fluoride CCP-ACP varnish, more applications were required. Moreover, fluoride applications quickly precipitate minerals on the enamel surface and this hypermineralized layer limits the remineralization of the subsurface lesion body leading to only partial remineralization. On the other hand, resin infiltration completely remineralizes the lesions by diffusing deep into the lesion through its capillary action.

Authors' Contributions

MD		https://orcid.org/0000-0002-5025-2316	Conceptualization, Investigation and Writing - Original Draft, Writing - Review and Editing.
RT		https://orcid.org/0000-0003-2953-8077	Conceptualization, Methodology, Formal Analysis, Data Curation and Writing - Review and Editing.
NK		https://orcid.org/0000-0001-6216-827X	Data Curation and Writing - Review and Editing.
AK		https://orcid.org/0000-0001-8071-0501	Validation and Writing - Review and Editing.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

References

- [1] Giray FE, Durhan MA, Haznedaroglu E, Durmus B, Kalyoncu IO, Tanboga I. Resin infiltration technique and fluoride varnish on white spot lesions in children: preliminary findings of a randomized clinical trial. *Niger J Clin Pract* 2018; 21(12):1564-9. https://doi.org/10.4103/njcp.njcp_209_18
- [2] Gugnani N, Pandit IK, Gupta M, Josan R. Caries infiltration of noncavitated white spot lesion: a novel approach for immediate esthetic improvement. *Contemp Clin Dent* 2012; 3(Suppl 2):199-202. <https://doi.org/10.4103/0976-237X.101092>
- [3] Munjal D, Garg S, Dhindsa A, Sidhu GK, Sethi HS. Assessment of white spot lesions and in-vivo evaluation of the effect of cpp-acp on white spot lesions in permanent molars of children. *J Clin Diagn Res* 2016; 10(5):149-54. <https://doi.org/10.7860/JCDR/2016/19458.7896>
- [4] Fejerskov O, Kidd E. *Dental Caries: The Disease and its Clinical Management*. 2nd. ed. New Jersey: John Wiley and Sons; 2009.
- [5] Meligy OAESE, Ibrahim STE, Alamoudi NM. Resin infiltration of non-cavitated proximal caries lesions: a literature review. *J Oral Hyg Health* 2018; 6(1):234. <https://doi.org/10.4172/2332-0702.1000234>
- [6] Son JH, Hur B, Kim HC, Park JK. Management of white spots: resin infiltration technique and microabrasion. *J KorAcad Cons Dent* 2011; 36(1):66-71. <https://doi.org/10.5395/JKACD.2011.36.1.66>
- [7] Weisrock G, Terrer E, Couderc G, Koubi S, Levallois B, Manton D, et al. Naturally aesthetic restorations and minimally invasive dentistry. *J Minim Interv Dent* 2011; 4(2):23-30.
- [8] Meyer-Lueckel H, Paris S. Progression of artificial enamel caries lesions after infiltration with experimental light curing resins. *Caries Res* 2008; 42(2):117-24. <https://doi.org/10.1159/000118631>
- [9] Ten Cate JM, Featherstone JD. Mechanistic aspects of the interactions between fluoride and dental enamel. *Crit Rev Oral Biol Med* 1991; 2(3):283-96. <https://doi.org/10.1177/10454411910020030101>
- [10] Azarpazhooh A, Main PA. Fluoride varnish in the prevention of dental caries in children and adolescents: a systematic review. *J Can Dent Assoc* 2008; 74(1):73-9.
- [11] Reynolds ECNB. Anticariogenic phosphopeptides. U.S. Patent No 5,015,628, 1991.
- [12] Taher NM, Alkhamis HA, Dowaidi SM. The influence of resin infiltration system on the enamel microhardness and surface roughness: an in vitro study. *Saudi Dent J* 2012; 24(2):79-84.
- [13] Paris S, Meyer-Lueckel H. Inhibition of caries progression by resin infiltration in situ. *Caries Res* 2010; 44(1):47-54. <https://doi.org/10.1159/000275917>
- [14] Paris S, Hopfenmuller W, Meyer-Lueckel H. Resin Infiltration of caries lesions: an efficacy randomized trial. *J Dent Res* 2010; 89(8):823-6. <https://doi.org/10.1177/002203451036928>
- [15] Paris S, Meyer-Lueckel H. Masking of labial enamel white spot lesions by resin infiltration—a clinical report. *Quintessence Int* 2009; 40(9):713-8.
- [16] Kielbassa AM, Muller J, Gernhardt CR. Closing the gap between oral hygiene and minimally invasive dentistry: a review on the resin infiltration technique of incipient (proximal) enamel lesions. *Quintessence Int* 2009; 40(8):663-81.
- [17] Hiremath SS. *Textbook of Preventive and Community Dentistry*. 2nd. ed. New Delhi: Elsevier India; 2011.
- [18] Featherstone JD. The caries balance: The basis for caries management by risk assessment. *Oral Health Prev Dent* 2004; 2(Suppl 1):259-64.
- [19] Enaia M, Bock N, Ruf S. White-spot lesions during multibracket appliance treatment: a challenge for clinical excellence. *Am J Orthod Dentofacial Orthop* 2011; 140(1):e17-24. <https://doi.org/10.1016/j.ajodo.2010.12.016>
- [20] Paris S, Bitter K, Naumann M, Dorfer CE, Meyer-Lueckel H. Resin infiltration of proximal caries lesions differing in ICDAS codes. *Eur J Oral Sci* 2011; 119(2):182-6. <https://doi.org/10.1111/j.1600-0722.2011.00807.x>
- [21] Meyer-Lueckel H, Bitter K, Paris S. Randomized controlled clinical trial on proximal caries infiltration: three-year follow-up. *Caries Res* 2012; 46(6):544-8. <https://doi.org/10.1159/000341807>
- [22] Martignon S, Ekstrand KR, Gomez J, Lara JS, Cortes A. Infiltrating/sealing proximal caries lesions: a 3-year randomized clinical trial. *J Dent Res* 2012; 91(3):288-92. <https://doi.org/10.1177/0022034511435328>
- [23] Ekstrand KR, Bakhshandeh A, Martignon S. Treatment of proximal superficial caries lesions on primary molar teeth with resin infiltration and fluoride varnish versus fluoride varnish only: efficacy after 1 year. *Caries Res* 2010; 44(1):41-6. <https://doi.org/10.1159/000275573>
- [24] Turska-Szybka A, Gozdowski D, Mierzwińska-Nastalska E, Dorota Olczak-Kowalczyk D. Randomised clinical trial on resin infiltration and fluoride varnish vs fluoride varnish treatment only of smooth-surface early caries lesions in deciduous teeth. *Oral Health Prev Dent* 2017; 15(2):122.
- [25] Shen P, Bagheri R, Walker GD, Yuan Y, Stanton DP, Reynolds C, et al. Effect of calcium phosphate addition to fluoride containing dental varnishes on enamel demineralization. *Aust Dent J* 2016; 61(3):357-65. <https://doi.org/10.1111/adj.12385>
- [26] Oliveira GM, Ritter AV, Heymann HO, Swift E Jr, Donovan T, Brock G, et al. Remineralization effect of CPP-ACP and fluoride for white spot lesions in vitro. *Dent* 2014; 42(12):1592-602. <https://doi.org/10.1016/j.jdent.2014.09.004>
- [27] Tuloglu N, Bayrak S, Tunc ES, Ozer F. Effect of fluoride varnish with added casein phosphopeptide-amorphous calcium phosphate on the acid resistance of the primary enamel. *BMC Oral Health* 2016; 16:1-7. <https://doi.org/10.1186/s12903-016-0299-4>

- [28] Güçlü ZA, Alaçam A, Coleman NJ. Corrigendum to "A 12-week assessment of the treatment of white spot lesions with CPP-ACP paste and/or fluoride varnish". *Biomed Res Int* 2018; 2018:1816959. <https://doi.org/10.1155/2018/1816959>.
- [29] Girish Babu KL, Subramaniam P, Tele S. Remineralization potential of varnish containing casein phosphopeptides-amorphous calcium phosphate with fluoride and varnish containing only fluoride: a comparative study. *Saudi J Oral Sci* 2018; 5(1):35-40. https://doi.org/10.4103/sjos.SJOralSci_44_17
- [30] Çiftçi ZZ, Hanimeli S, Karayılmaz H, Güngör ÖE. The efficacy of resin infiltrate on the treatment of white spot lesions and developmental opacities. *Niger J Clin Pract* 2018; 21(11):1444-9. https://doi.org/10.4103/njep.njep_235_18