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# Prevention and treatment of white spot lesions during and after fixed orthodontic treatment: A systematic literature review

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## SUMMARY

*Objective.* The aim of the study is to evaluate the effectiveness of fluoride and casein topical preparations in the prevention of white spot lesions during and after fixed orthodontic treatment.

*Material and Methods.* Information search for controlled studies on humans published in the English language between 2008 and 2013 was conducted in Medline via PubMed, ScienceDirect, and Oxford University Press: Oxford journals and The Cochrane Library, as well as the Web search Google Scholar. 177 articles were reviewed; eleven clinical studies fulfilled all inclusion criteria.

*Results.* In the clinical studies it was concluded that high-concentration fluoride supplements are effective in reducing white spot lesions. Results of the studies showed the same usefulness of fluoride varnish, MI Paste, and usual oral hygiene using 1100 ppm of fluoride toothpaste. Effect on the prevention and treatment of white spot lesions of oral hygiene with toothpaste containing 1450 ppm of fluoride in orthodontic patients was evaluated. The positive effect of casein phosphopeptide-amorphous calcium phosphate in white spot lesions treatment was found. Otherwise in some clinical studies use of casein derivates during fixed orthodontics for white spot lesions treatment was not effective.

*Conclusions.* More clinical studies conducted during last five years yielded significantly positive results about the effectiveness of fluoride and caseine supplements in ameliorating white spot lesions during and after fixed orthodontic treatment. For a higher-risk patient group, additional supplements such as high-concentrated fluoride varnish, chewing sticks, or casein derivates, are required. A good oral hygiene regimen using high-fluoride toothpaste is as effective as fluoride or casein derivates in the prevention of new white spot lesions formation.


**Key words:** white spot lesion, fluoride, casein phosphopeptide-amorphous calcium phosphate, fixed orthodontic treatment.

## INTRODUCTION

Demineralization or white spot lesion development in the enamel during orthodontic treatment with fixed appliances still remains well-known clinical problem (1), its' prevention and effective treatment is actual for all clinicians. But still we don't have the best method how to manage it. A white spot lesion (WSL) may become visible around fixed appliances within one month of bracket placement, although the formation of regular caries usually takes at least 6 months (2) (Figure 1). Individuals with malocclusion usually have difficulty in performing proper oral hygiene because of many retention sites. In addition, bonding attachments to teeth make conventional oral hygiene more difficult, and can prolong plaque accumulation on tooth surfaces (3, 4). WSLs mainly appear on buccal surfaces of the maxillary teeth in the following order: lateral incisors, canines, premolars, and central incisors (5, 6). According to literature the prevalence of WSLs after orthodontic treatment varies between 2% to

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97% (7, 8), and its prevention is the goal of every orthodontist.

Primary prevention of WSLs can be done adjacent to fixed appliances and secondary prevention (treatment) is done when the braces are removed. WSLs can be very difficult or sometimes even impossible to improve after appliance removal, and complete resolution of the lesions can rarely be achieved (9), which it influences esthetics and the patients' satisfaction with their smile. More over, untreated WSLs can lead to cavities and end up with dental treatment using dental fillings. Saliva can re-mineralize WSLs to some degree, although this process is greater during the first few months, and is then continuing at a slower rate (10). This is the reason why orthodontists are trying to prevent WSLs development during orthodontic treatment.

Natural remineralization through saliva involving mineral gain in the surface layer of WSLs has little improvement on the esthetics and structural properties of the deeper lesions (23). Therefore, it is necessary to apply remineralizing agents to repair the deeper parts of WSLs for better esthetic results (25). Various fluoride and casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) derivates, such as high-fluoride toothpaste, varnish, mouth rinse, gel or topical cream can be used for better remineralization purposes (11). In the 1980s the first time it was concluded that casein phosphopeptide amorphous calcium phosphate was capable of absorbing through the enamel surface and could influence the carious process (24). CPP-ACP is a delivering system that allows freely available calcium and phosphate ions to attach to enamel and reform into calcium phosphate crystals. In the clinical studies various methods are used for prevention of WSLs, and still it is not concluded which method is most effective.

The aim of the study is to evaluate the effectiveness of topical preparations containing fluoride and casein phosphopeptide-amorphous calcium phosphate in preventing white spot lesions during and after fixed orthodontic treatment.

## MATERIAL AND METHODS

A systematic literature review was carried out to identify relevant studies reporting data on WSLs during and after orthodontic treatment. The literature search covered the following databases: *Medline* via *PubMed*, *ScienceDirect*, *Oxford University Press: Oxford journals* and *The Cochrane Library*, as well as the Web search *Google Scholar*. The following MeSH terms or/and word combinations were used as

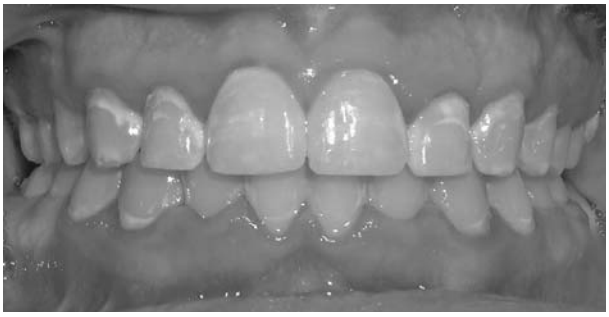

**Fig. 1.** Frontal view with WSLs visible on teeth

principle search terms: "white spot lesion", "caries", "decalcification", "demineralisation", "fluoride", "orthodontic treatment complications", "fixed appliances", and "casein phosphopeptide-amorphous calcium phosphate". Abstracts formed a list of potentially relevant studies. The initial search for literature in the English language published between 2008 and 2013 retrieved 177 papers. Three researchers independently reviewed the titles and abstracts of potentially relevant studies. Where it was apparent from the abstract that the study subjects were inappropriate for the focus of the review (in terms of the exclusion criteria), full-text articles of these studies were not included. The reference lists of articles which were eligible for the review were checked. In the end, 11 clinical studies fulfilled the inclusion criteria (Figure 2).

Inclusion criteria. Studies were selected if they met the following criteria: patients of any age undergoing orthodontic treatment with fixed appliances; human subjects (not extracted teeth); randomized or quasi-randomized controlled clinical studies; fluoride-containing product or casein derivates used throughout the appliance therapy or straightaway after debonding.

Exclusion criteria. Studies were excluded if they were nonhuman, were laboratory-based, were not on the use of fixed appliances, or did not analyze the use of topical fluorides or casein derivates; also, we excluded any study in which the participants underwent any non-remineralizing therapy (e.g., bleaching, enamel micro-abrasion, or restoration) for WSLs after their orthodontic treatment. Case reports and review papers were excluded as well.

## RESULTS

Considering how quickly WSLs can develop and become irreversible, early diagnosis is critically important. It is important to evaluate the oral hygiene status of patients during the first months of orthodontic treatment, and if necessary – to implement the treatment of new WSLs

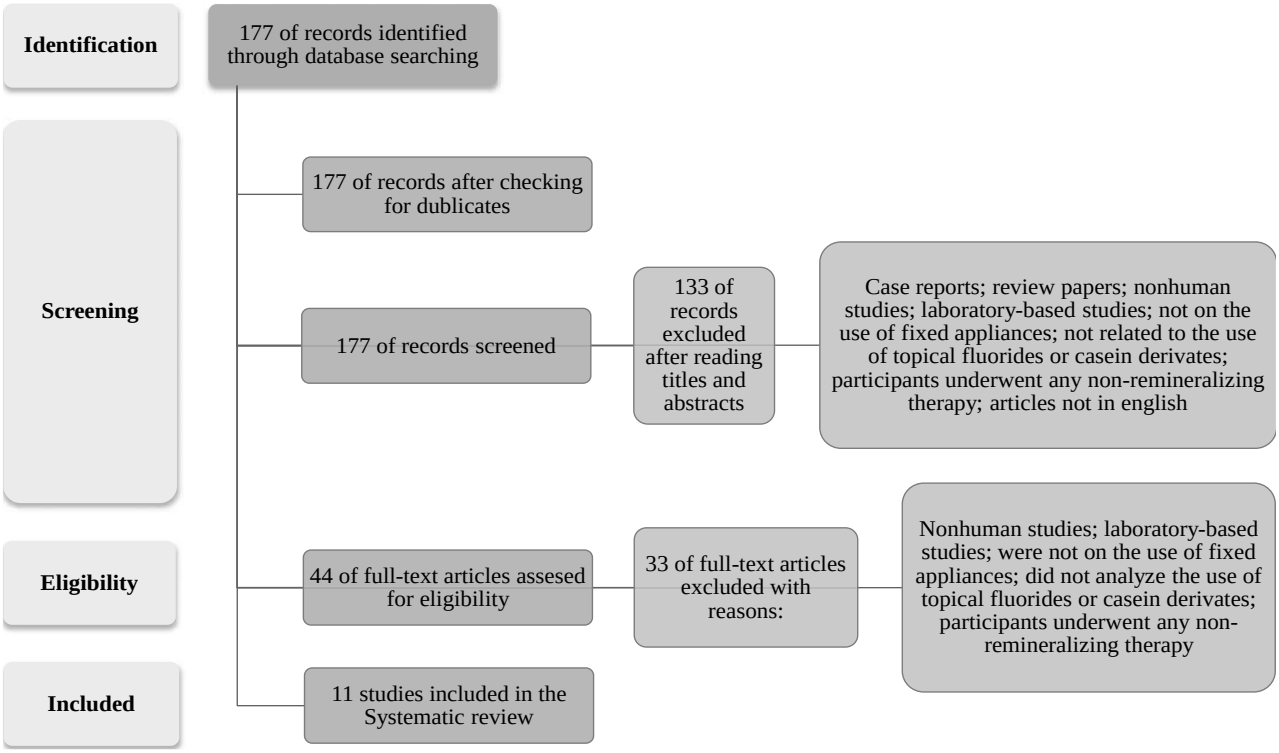


**Fig. 2.** Flow diagram of the literature search strategy

immediately in order to prevent these lesions from becoming cavities. The modern methods for the evaluation of WSLs are the following: the optical caries monitor, quantitative laser and light-induced fluorescence (QLF), digital imaging with fiber-optic transillumination, and computer analysis of digital photographs (4). However, in most studies these techniques are not feasible because of budget limitations. The well-accepted and most popular methods for WSLs evaluation are digital intraoral photography and QLF. Most relevant articles from the literature review used proportional rather than absolute measurements of luminance or size. Other studies used a combined scoring system based on the surface area and the severity of the opacity. Clinical in vivo studies selected according to the inclusion criteria are presented in the Table.

The results of clinical studies conducted over the last five years are controversial. In some clinical studies, it was concluded that high-concentration fluoride varnish is significantly effective in reducing WSLs. Experimental study was performed to evaluate effect of fluoride varnish, two months before extraction fluoride varnish was applied only for one premolar, while opposite premolar was isolated. Evaluating the teeth with polarized light microscopy some demineralization on all experimental and control teeth was detected, but it was found that high-concentration fluoride varnish reduces 40% of WSLs during orthodontic treatment (12). Du *et al.* (13) in their randomized, parallel-group, controlled clinical trial found that fluoride varnish was effective during the first three months after debonding and six months after debonding. In the clinical studies the effectiveness of fluoridated chewing sticks in reducing WSLs in post-orthodontic patients was evaluated and the remineralization effect on WSLs was proved (5).

The negative influence of fluoride was presented in several studies. Huang (8) and Bailey (14) discussed warnings against the use of high concentrations of fluoride because the superficial layer might prevent calcium and phosphate from penetrating to the deeper layers of the enamel, thus inhibiting deeper remineralization and limiting the cosmetic improvement of the WSLs. The conflicting results about effect of fluoride varnish were reported also, according to the results of the studies (8, 15) it was found that the effect of using fluoride varnish, MI Paste or the usual oral hygiene using 1100 ppm of fluoride toothpaste, a toothbrush, and dental floss are similar. Huang *et al.* (8) in their randomized controlled trial evaluating 115 patients, within the past two months after appliances removal, divided into 3 groups of the study: MI Paste Plus, Fluoride varnish and Home-care group. In this clinical trial, researchers did not found that either of two common therapies was better than regular home care for improving the appearance of WSLs over an 8-week period. Richter *et al.* (15) examined 350 orthodontic patients with WSLs, they were divided into 3 groups:

**Table.** The patients' characteristics

| Author of the article, year (ref. no.) | Amount of patients; Examination methods | Treatment | Conclutions |
|---|---|---|---|
| Farhadian N, Miresmaeili A, Behnam E, Mehrabi S. 2008 (12) | 15 patients;<br>• Polarized light microscopy;<br>• Digital photographs. | 1) oral hygiene instructions,<br>2) a tube of toothpaste (250 ppm of fluoride),<br>3) After one week – application of fluoride varnish (Bifluoride 12, 6% calcium fluoride and 6% sodium fluoride). | Fluoride varnish is significantly beneficial as a preventive adjunct in reducing demineralization adjacent to brackets (P <0.001). |
| Huang JG, Roloff-Chiang B, Mills BE, Shalchi S, Spiekerman C, Korpak AM, Starrett JL, Greenlee GM, Drangsholt RJ, Matunas JC. 2013 (8) | 115 patients;<br>• Digital photographs. | 3 groups:<br>1) an 8-week regimen of MI Paste Plus;<br>2) a single application of PreviDent fluoride varnish;<br>3) control group – home care with 1100 ppm of fluoride toothpaste. | MI Paste Plus and PreviDent fluoride varnish do not appear to be more effective than normal home care for improving the appearance of WSLs over an 8-week period. |
| Richter AE, Arruda AO, Peters MC, Sohn W. 2011 (15) | 350 patients;<br>• Digital photographs. | 1) Oral hygiene instructions for all 350 patients;<br>2) topical fluoride applications for 43 patients;<br>3) fluoride rinse for 42 patients. | A significant association was with treatment duration (P=0.01) and the number of oral hygiene discussions (P<0.0001).<br>The preventive therapy was not effective. |
| Robertson MA, Kau CH, English JD, Lee RP, Powers J, Nguyen JT. 2011 (17) | 50 patients;<br>• Digital photographs. | MI Paste Plus using it each day at night after brushing for 3 months. | MI Paste Plus helped to prevent the development of WSLs and decreased the number of WSLs already present (P<0.05). |
| Al Mulla AH, Al Kharsa S, Birkhed D. 2010 (16) | 100 patients;<br>• Clinical examination;<br>• Radiographic examination (bitewings taken with double film). | Colgate Max Cavity toothpaste (1450 ppm of fluoride). | The use of Colgate Max Cavity toothpaste significantly reduces the incidence of WSLs in orthodontic patients (P<0.001). |
| Du M, Cheng N, Tai B, Jiang H, Li J, Bian Z. 2012 (13) | 96 patients;<br>• DIAGNOdent pen. | Fluoride varnish (5% sodium fluoride) or saline was applied onto tooth surfaces with WSLs every month during the first 6 months after debonding. | Topical fluoride varnish application is effective in reversing WSLs after debonding. |
| Bailey DL, Adams GG, Tsao CE, Hyslop A, Escobar K, Manton DJ, Reynolds EC, Morgan MV. 2009 (14) | 45 patients;<br>• Quantitative light-induced fluorescence;<br>• Digital photographs. | Tooth Mousse/MI Paste. | WSLs had a significantly greater chance of regressing at 12 weeks in the remineralizing cream arm of the study (P=0.04). |
| Enaia M, Bock N, Ruf S. 2011 (22) | 400 patients;<br>• Digital photographs. | Special cleaning instructions: daily use of fluoride toothpaste, fluoride mouth rinse, weekly use of products with a high-fluoride content (12.500 ppm of fluoride) | New WSLs developed on 60.9 % of the patients in this survey despite the prevention measures. |
| Beerens MW, van der Veen MH, van Beek H, ten Cate JM. 2010 (19) | 54 patients;<br>• Quantitative light-induced fluorescence. | MI Paste Plus used once a day at bedtime. | No clinical advantage for use of the MI Paste Plus over the 12 weeks was found. |
| Brochner A, Christensen C, Kristensen B, Tranaeus S, Karlsson L, Sonnesen L, Twetman S. 2011 (18) | 50 patients;<br>• Quantitative light-induced fluorescence;<br>• Digital photographs. | Topical applications of Tooth Mousse once daily for 4 weeks. | Topical treatment with a CPP-ACP agent significantly reduced area of the lesions after 4 weeks (P< 0.05). |
| Baeshen HA, Lingstrom P, Birkhed D. 2011 (5) | 37 patients;<br>• DIAGNOdent pen. | Fluoridated miswaks (impregnated in 0.5% sodium fluoride) 5 times per day for 6 weeks after debonding. | Fluoridated miswaks had a remineralizing effect on WSLs (P<0.0001). |

oral hygiene regime, topical fluoride applications and fluoride rinse group, but no significant association between the number of new lesions and fluoride supplements treatments given was found.

The effect of fluoride in toothpaste was evaluated and proved in Mulla *et al.* study (16), oral hygiene was performed with toothpaste containing 1450 ppm of fluoride. In the study 100 orthodontic patients were divided into test group (received verbal and written instructions about the brushing technique) and control group (routine clinical oral hygiene instructions). The results of the study showed that a modified fluoride toothpaste technique significantly reduced the incidence of new caries lesions in orthodontic patients.

The positive effect of CPP-ACP in WSLs treatment was evaluated in recent clinical studies. Robertson *et al.* (17) after evaluating intraoral digital photographs of 50 patients, stated that MI Paste was effective during orthodontic treatment, using it for 3-5 min each day at night after brushing for three months. Brochner *et al.* (18) found the effect of MI Paste used for 4 weeks after debonding and the Bailey *et al.* (14) study showed the usefulness of MI Paste used for 12 weeks after debonding after QLF and digital photographs evaluation.

Although in some studies there was reported no significant usefulness of MI Paste or MI Paste Plus (8, 19), there was some improvement in WSLs. Beerens *et al.* (19) in his study evaluating the effectiveness of MI Paste on WSLs after orthodontic treatment compared test group (CPP-ACFP paste) with control group (control paste), the size of the lesion area did not changed significantly over time or between the groups.

The other factor that can influence the reduction of WSL is topical fluoride and CPP-ACP applications, its' effectiveness was evaluated in several studies. Richter (15) in the study concluded that fluoride varnish or fluoride mouth rinse was not effective. Though, Al-Mulla (16) found a significant use of highly fluoridated tooth paste during orthodontic treatment. The same results were reported by Farhadian *et al.* (12), he found that fluoride varnish is significantly beneficial as a preventive agent in reducing WSLs around braces. In the study performed by Robertson (17) was reported that MI Paste Plus significantly reduces the incidence of WSLs after using it for 3 months.

Most of the last five years clinical in vivo studies were evaluating the effectiveness of fluoride and CPP-ACP therapy after orthodontic treatment rather than during orthodontic therapy. The interest in secondary prevention of WSL has increased noticeably. The significant and neutral results of topical agents usefulness in clinical in vivo studies are almost equivalent. While some studies (5, 13) proved that high-fluoride derivates significantly reduces WSLs after 6 weeks to 6 months, their opponent failed to demonstrate an additional effect of fluoride varnish compared with normal home care over an 8 week period (8). The similar situation is with CPP-ACP derivates. While Bailey (14) and Brochner (18) claim that casein supplements are effective after 4 and 12 weeks, the opponents Huang (8) and Beerens (19) trials prove that CPP-ACP do not appear to be more effective than normal oral care over a 8 to 12 weeks period.

According to our study, the most important factors for preventing decalcification and formation of WSL were a good oral hygiene regimen (including fluoridated dentifrice) (3, 8, 15) and a modifying diet with low carbohydrate intake (12). Other additional methods such as fluoride varnish, rinse, chewing sticks, or CPP-ACP supplements did not totally prevent the formation of WSLs, but their incidence could be significantly reduced (20). Clinical in vivo studies investigating WSLs prevention and treatment are still very rare. Some clinical studies it is difficult to evaluate due to small sample sizes, various inclusion criteria, unreliable statistical analyses that failed to account for clustering effects, and use of unproven assessement methods without relating them to more accepted techniques (only visual examination). The lack of high-quality clinical studies makes it difficult to determine whether various agents are effective and which of them are more effective than others. Concerns have been raised against the use of highly concentrated fluoride to assist remineralization since it may lead to unsightly stainning. Though, there were no recent trials available that could either confirm or reject this important question. The need for new approaches and further high-quality research has been emphasized (1, 21). It is also important to analyze if there are any other predictors for the degree of WSL improvement – such as time since the removal of the appliances, or the severity of the lesions (8). We need further clinical studies evaluating the effectiveness of the methods for preventing and treatment of WSL.

## CONCLUSIONS

The survey of the studies conducted over the last five years showed that more clinical studies made significantly positive conclusions about the effectiveness of fluoride and casein supplements in ameliorating white spot lesions during and after fixed orthodontic treatment. For higher-risk patients,

additional supplements – such as high-concentrated fluoride varnish, chewing sticks, or casein derivates – are required. According to some studies, a good oral hygiene regimen using high-fluoride toothpaste and fluoridated dental floss is as effective as the use of fluoride or casein derivates.

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