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Review

Efficacy of fluoride varnish for prevention of white spot lesions during orthodontic treatment with fixed appliances: A systematic review study

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Abstract

Background: White spot lesions (WSLs) are a problem commonly found in patients who use orthodontic devices. Fluoride varnish can reduce WSLs during orthodontic treatment with fixed appliances. The aim of this systematic review was to evaluate the efficacy of fluoride varnish compared with other agents for preventing WSLs during orthodontic treatment. **Methods**: Studies were searched from four databases- PubMed, Scopus, Web of Science and Cochrane Library- from January 1980 to May 2017; only studies with English abstracts were included. **Results**: Out of 432 studies searched from the databases, 33 studies were evaluated for eligibility. Of the 33 studies, 19 were excluded with reasons and 14 studies were included in the systematic review. Parameters of WSLs (decalcification score, prevalence, incidence, progression score, ΔQ and ΔZ and *DiagnoDent* (DD) pen score) were compared for the various treatments. **Conclusions**: Although there were some limitations for this systematic review study, the review showed that fluoride varnish combined with *chlorhexidine* (CHX) may be a good treatment for WSLs after orthodontic treatment, especially for a 6-month period, and that resin infiltration might also be effective for preventing WSLs. More studies are needed to further investigate these observations.

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Keywords

Chlorhexidine, Fluoride varnish, Orthodontic treatment, White spot lesions

Introduction

Fixed orthodontic appliances create stagnation areas for plaque and thus difficulties for tooth cleaning. Moreover, the irregular and non-uniform surfaces of brackets, bands and wires limit the naturally occurring self-cleansing mechanism of the oral musculature and saliva (Mount et al., 2016). White spot lesions (WSLs) are a problem commonly found in patients who use orthodontic devices. While it takes around 6 months for caries to progress in a patient not submitted to orthodontic therapy, it takes around 1 month for those who are (Lucchese and Gherlone, 2012). WSLs progress around orthodontic ligatures, brackets and bands because these appliances physically prevent thorough dental cleaning and potentiate bacterial biofilm accumulation on tooth surfaces (Lucchese and Gherlone, 2012; Tufekci et al., 2011). Suitable preventative agents or treatments for WSLs or caries have typically fluoride products (e.g. toothpaste, varnishes, gels and mouth rinse), antimicrobials (e.g. chlorhexidine (CHX)), diet counseling, xylitol gum and casein derivatives (Derks et al., 2004). Topical fluoride varnishes can reduce WSLs during orthodontic treatment and they are assumed to have the same effect following orthodontic therapy (Stecksén-Blicks et al., 2007). The aim of this systematic review herein was to evaluate the efficacy of fluoride varnish, compared to other treatments, for preventing WSLs during orthodontic treatment with fixed appliances.

Materials-Methods

Search strategies and study criteria

The studies were searched from four databases (PubMed, Scopus, Web of Science and Cochrane Library) from January 1980 to May 2017. Only publications with English abstracts were included. The search keywords were "orthodontic treatment" and "white spot" and "fluoride".

Study selection

One author (M.S.) conducted the initial search for articles, with a second author (H.R.M.) blinded to the first author's search. If there was any disagreement between the two authors, the third author (F.R.) resolved the problem. All articles included in the study review were subjected to evaluation for any

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indication of the efficacy of fluoride varnish after orthodontic treatment. Only studies with abstracts written in English were included in the review.

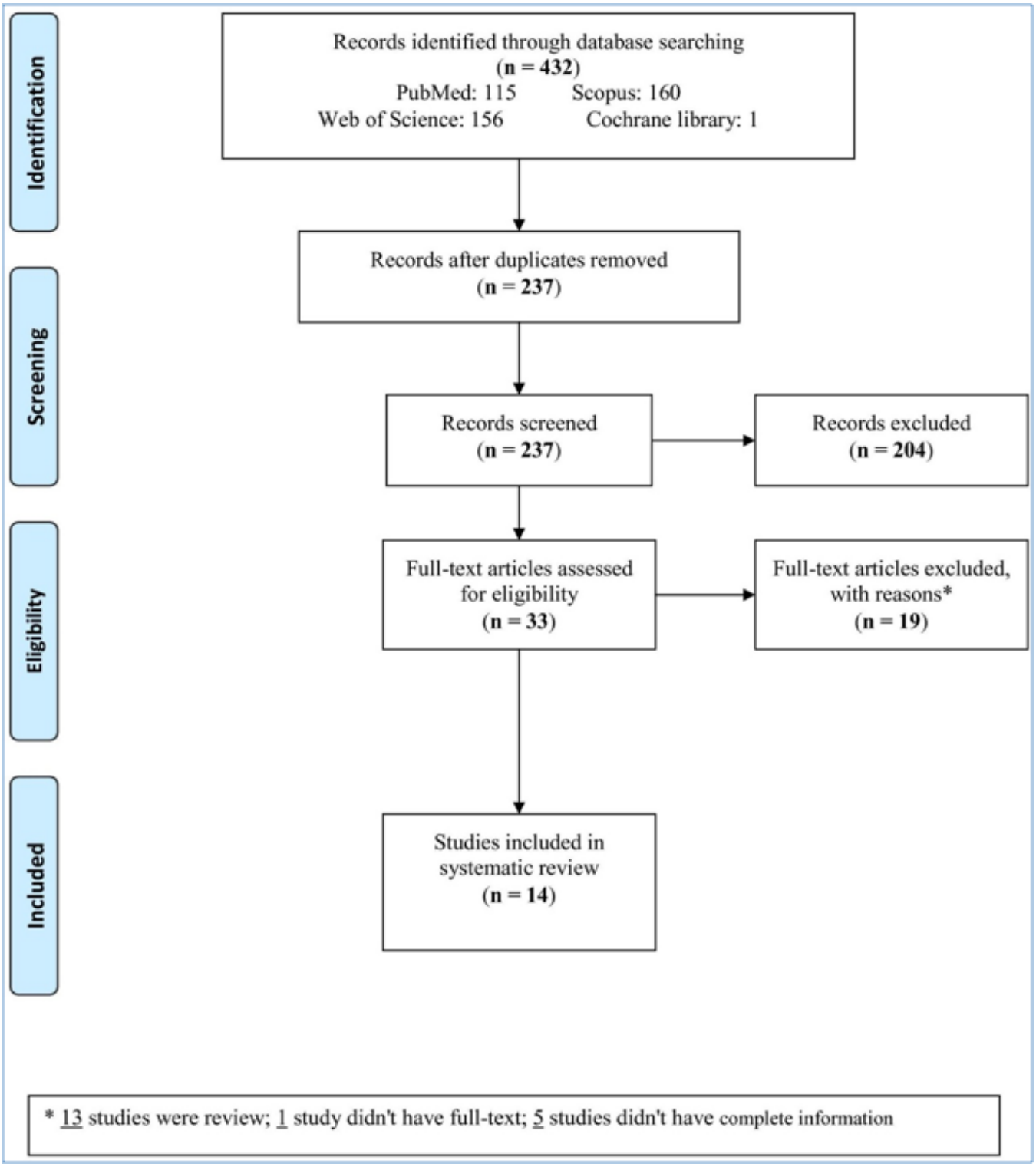

Figure 1. Flowchart of the study.

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Data extraction

The name of the author, year of publication, country, parameters of WSLs, the comparison of groups, and *P*-values were the relevant data extracted from each study. A *P*-value<0.05 was considered to be statistically significant.

Results

Study characteristics

The flowchart of the study selection is shown in **Fig. 1**. Of the 432 studies searched among the databases, 33 studies were evaluated for eligibility. Of the 33 studies, 19 were excluded for several reasons (e.g. articles were reviews and not original studies, they did not have available full-text, or they contained incomplete information) (**Fig. 1**). Thus, the remaining 14 studies were included in the systematic review (**Table 1**). The studies were reported from 1990 to 2016. Of these reported studies, 1 was from Belgium, 1 from Sweden, 4 from Brazil, 1 from Denmark, 1 from Egypt, 2 from China, 1 from Romania, 1 from the USA, 1 from India, and 1 from Poland.

Table 1. Characteristics of the studies included in the systematic review (n=14)

Study, year	Country	Parameters of WSLs	Comparison of groups	P-value
Adriaens et al., 1990	Belgium	Decalcification score at each time, in vitro study	Fluoride varnish less than Control	<0.05
		Decalcification score after 2 years, in vivo study	Fluoride varnish less than Control (4/52 molars vs. 19/52 molars)	<0.001
Ogaard et al., 2001*	Sweden	Prevalence (debonding) of WSLs on maxillary incisors	CHX varnish in combination with a fluoride varnish vs. Control (1.07 ± 0.15 vs. 1.23 ± 0.38)	<0.05
			Fluoride varnish alone vs. Control (1.13 ± 0.28 vs. 1.23 ± 0.38)	<0.05
			CHX varnish in combination with a fluoride varnish vs. Fluoride varnish alone (1.07 ± 0.15 vs. 1.13 ± 0.28)	<0.05
		Increments of WSLs during treatment on maxillary incisors	CHX varnish in combination with a fluoride varnish vs. Fluoride varnish alone (0.04 ± 0.20 vs. 0.08 ± 0.30)	>0.05
		Developed WSLs during treatment	CHX varnish in combination with a Fluoride varnish (58%)	-
			Fluoride varnish alone (61%)	-
Demito et al., 2004*	Brazil	Decalcification depths	Fluoride varnish vs. Control (108.3108± 64.79095 vs. 173.2384± 77.90322)	0.003
		Maximum decalcification depths	Fluoride varnish vs. Control (150.2912± 73.8283 vs. 209.9584± 92.0585)	0.005

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Vivaldi-Rodrigues et al., 2006*	Brazil	Change in enamel decalcification index, after 12 months vs. baseline	Fluoride varnish vs. Control (0.34 ± 0.64 vs. 0.61 ± 1.15)	0.035
		Demineralization	Fluoride varnish had 44.3% less than Control	<0.05
Stecksén-Blicks et al., 2007	Denmark	Prevalence (debonding) of WSLs, %	Fluoride varnish vs. Placebo varnish (11.7 vs. 29.7)	<0.001
		Incidence of WSL, %	Fluoride varnish vs. Placebo varnish (7.4 vs. 25.7)	<0.001
		Progression score*	Fluoride varnish vs. Placebo varnish (0.8±2.0 vs. 2.6±2.8)	<0.001
Shinaishin et al., 2011*	Egypt	Roughness height	Fluoride varnish vs. Control (370.54±2.19 vs. 569.7±2.3)	<0.001
			Unfilled sealant vs. Control (330.28±1.62 vs. 569.7±2.3	<0.001
			Filled sealant (pro seal varnish) vs. Control (307.24±2.58 vs. 569.7±2.3	<0.001
		Total surface area	Fluoride varnish vs. Control (2577.2±5.3 vs. 2886.6±9.20)	<0.001
			Unfilled sealant vs. Control (2561.2±8.07 vs. 2886.6±9.20	<0.001
			Filled sealant (pro seal varnish) vs. Control (2507.2±7.08 vs. 2886.6±9.20)	<0.001
Du et al., 2012*	China	DD scores, baseline vs. 3 months	Fluoride varnish (17.66±5.36 vs. 11.88±4.27)	9.402×10−7
			Placebo (16.19±5.70 vs. 13.75±4.76)	0.024
		DD scores, baseline vs. 6 months	Fluoride varnish (17.66±5.36 vs. 10.10±4.86)	3.794×10−10
			Placebo (13.75±4.76 vs. 13.10±5.19)	0.006
		DD scores, 3 months vs. 6 months	Fluoride varnish	0.0513
			Placebo	0.536
		DD scores, in 3 months	Fluoride varnish vs. Placebo	0.046
		DD scores, in 6 months	Fluoride varnish vs. Placebo	0.004
Jumanca et al., 2012*	Romania	DD scores immediately after take-off	Fluoride varnish vs. not receiving any special treatment; were instructed about the correct dental brushing which must be done 2 times per day (19.76±4.89 vs. 18.40±5.30)	0.197
		DD scores immediately at 3 months	Fluoride varnish vs. not receiving any special treatment; were instructed about the correct dental brushing which must be done 2 times per day (14.15±4.14 vs. 15.98±4.50)	0.045
		DD scores immediately at 6 months	Fluoride varnish vs. not receiving any special treatment; were instructed about the correct dental brushing which must be done 2 times per day (12.35±4.75 vs. 14.75±5.14)	0.004
			MI Paste Plus vs. Normal home care	>0.05

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Huang et al., 2013	USA	Mean improvement of WSLs over 8-week period	PreviDent fluoride varnish vs. Normal home care	>0.05
			MI Paste Plus vs. PreviDent fluoride varnish	>0.05
Restrepo et al., 2015*	Brazil	ΔZ (%vol/μm) in 3 months after the last application	Fluoride varnish vs Control (7459±960.1 vs. 7608±7608)	>0.05
			CHX gel vs. Control (7670±7699.6 vs. 7680±7680)	>0.05
		Lesion depth (μm) 3 months after the last application	Fluoride varnish vs Control (224.43±76.3 vs. 208.9±92.8)	>0.05
			CHX gel vs. Control (266.7±87.2 vs. 208.9±92.8)	>0.05
He et al., 2016	China	ΔQ value [estimate; 95% CI]	Fluoride varnish vs. Control [-11.83; 95% CI, -15.39 to -8.26]	<0.0001
			Fluoride film vs. Control [-7.72; 95% CI, -11.34 to -4.10]	<0.0001
			Fluoride Film vs. Fluoride varnish [4.11; 95% CI, 0.48 to 7.73]	0.0266
Restrepo et al., 2016*	Brazil	Fluorescence values, the end of the intervention (3 months) vs. Baseline	Fluoride varnish (7.2±1.6 vs. 17.2±2.3)	<0.05
			CHX gel (9.2±1.6 vs. 16.8±1.8)	<0.05
			Control (10.5±2 vs. 17±1.7)	<0.05
		Number of WSLs, the end of the intervention (3 months) vs. Baseline	Fluoride varnish (2 active caries vs 17 active caries)	<0.001
			CHX gel (7 active caries vs. 17 active caries)	<0.001
			Control (6 active caries vs. 17 active caries)	<0.001
Singh et al., 2016	India	Description of DD scores at various time intervals of observation (T0 to T4)	Fluoride toothpaste	0.744
			Fluoride toothpaste plus fluoride varnish	0.378
			Fluoride toothpaste plus CPP-ACP	0.614
		Between the group comparisons of visual scores at various time intervals of observation	Fluoride toothpaste	>0.05
			Fluoride toothpaste plus fluoride varnish	>0.05
			Fluoride toothpaste plus CPP-ACP	>0.05
		Between the group comparisons of DD scores at various time intervals of observation	Fluoride toothpaste	>0.05
			Fluoride toothpaste plus fluoride varnish	>0.05
			Fluoride toothpaste plus CPP-ACP	>0.05
Turska-Szybka et al., 2016	Poland	Progression of the treated lesions after 1 year, %	Resin infiltration and fluoride varnish vs. Fluoride varnish (7.9 vs. 29.4)	<0.001

*CHX: Chlorhexidine; ΔQ: Product of ΔF and area, and indicates the volume of the lesion; ΔF: the percentage of fluorescence loss comparing sound enamel with an identified lesion; ΔZ: the integrated mineral loss; T0: prior to application of remineralizing agents; T1: 1 month after the use of remineralizing agents; T2: 3 months after the use of remineralizing agents; T3: 6 months after the use of remineralizing agents; DD: DiagnoDent pen; CPP: casein phosphopeptide; and ACP: amorphous calcium phosphate. *The values were mean±SD. #The WSL scores of baseline between groups in each study were similar (P>0.05).*

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Parameters of WSLs

Decalcification Score

This score was significantly less for fluoride varnish than for control in an *in vitro* study and after 2 years of an *in vivo* study (Adriaens et al., 1990). Another study reported that decalcification depths and maximum decalcification depths were significantly lower in fluoride varnish compared to control (Øgaard et al., 2001). The change in the enamel decalcification index after 12 months vs. baseline was less for fluoride varnish vs. control (P=0.035) (Vivaldi-Rodrigues et al., 2006).

Prevalence and Incidence

Prevalence (debonding) of WSLs on maxillary incisors was significantly less for CHX varnish combined with fluoride varnish, for fluoride varnish compared to control, and also for CHX varnish combined with fluoride varnish compared to fluoride varnish alone (Demito et al., 2004). This prevalence was 11.7% for fluoride varnish versus 29.7% for placebo varnish (P<001) (Stecksén-Blicks et al., 2007). The incidence of WSLs was 7.4% for fluoride varnish vs. 25.7% for placebo varnish (P<0.001) (Stecksén-Blicks et al., 2007). The number of WSLs at the end of the intervention (3 months) versus baseline was less for fluoride varnish compared to control, or for control compared to CHX gel (Restrepo et al., 2016).

Progression score

Increments of WSLs during treatment on maxillary incisors for CHX varnish combined with fluoride varnish was less than the increments for fluoride varnish alone (P<0.05); progression of WSLs was 58% vs. 61% (Øgaard et al., 2001), whereas was it was 0.8% for fluoride varnish vs. 2.6% for placebo varnish (P<0.001) (Stecksén-Blicks et al., 2007). The mean improvement of WSLs over the 8-week period for MI Paste Plus and fluoride varnish were less than that for normal home care; the mean improvement of WSLs for MI Paste Plus was less than for fluoride varnish (P<0.05) (Huang et al., 2013). Progression of the treated lesions after one year was 7.9% in resin infiltration combined with fluoride varnish compared to 29.4% for fluoride varnish alone (P<0.001) (Turska-Szybka et al., 2016).

ΔQ and ΔZ

ΔQ value was significantly less for fluoride varnish and fluoride film compared to control, and also less for fluoride varnish compared to fluoride film (He et al., 2016). Indeed, ΔZ in 3 months after the last application of fluoride varnish and CHX gel was less than for control (P>0.05), ΔZ for fluoride varnish was less than that of CHX gel (P>0.05). However, lesion depth in 3 months after the last application of control was less than that for fluoride varnish and CHX gel (P>0.05); lesion depth for CHX was less than that for fluoride varnish (P>0.05)

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www.bmrat.org

(Restrepo et al., 2015). Demineralization in fluoride varnish was 44.3% less than that for control (Vivaldi-Rodrigues et al., 2006). Fluorescence value at the end of the intervention (3 months) vs. baseline was (7.2±1.6 vs. 17.2±2.3), (9.2±1.6 vs. 16.8±1.8), and (10.5±2 vs. 17±1.7) for fluoride varnish, CHX gel, and control, respectively ($P<0.05$). These values were less than fluoride varnish compared to CHX gel after 3 months, and compared to baseline (Restrepo et al., 2016).

DD Scores

DD scores in 3 months and 6 months (versus baseline) were less for fluoride varnish and placebo, and also less for 6 months compared to 3 months ($P<0.05$) (Restrepo et al., 2015). At these two time points, the DD score of fluoride varnish was less than that of placebo ($P<0.05$) (Restrepo et al., 2015). Additionally, DD scores for 3 months and 6 months (versus baseline) were less for fluoride varnish compared to placebo ($P<0.05$), and less for 6 months compared to 3 months (Jumanca et al., 2012). DD and visual scores at various time intervals of observation (prior to application, 1 month, 3 months and 6 months) for fluoride toothpaste, fluoride toothpaste + fluoride varnish, fluoride toothpaste + *DiagnoDent* pen, casein phosphopeptide (CPP), and amorphous calcium phosphate (CPP-ACP) were not different ($P>0.05$). Moreover, DD scores between treatment groups at various time intervals of observation were not different ($P>0.05$) (Singh et al., 2016).

Other

Roughness height and total surface area of WSLs after fluoride varnish, unfilled sealants and filled sealants (pro-seal varnish) were all less than control ($P<0.001$). Also, roughness height for filled sealant (pro-seal varnish) was less than that for unfilled sealant, while roughness height for unfilled sealant was less than that for fluoride varnish. The total surface area for unfilled sealant was less than that for fluoride varnish; and total surface area for fluoride varnish was less than filled sealant (pro-seal varnish) (Shinaishin et al., 2011).

Discussion

This systematic review evaluated the efficacy of fluoride varnish for preventing WSLs during orthodontic treatment and compared its efficacy to other treatments. The results indicated that fluoride varnish was an effective treatment for orthodontic patients, compared to patients without treatment (control or placebo). By increasing treatment time (of fluoride varnish) to 6 months, one can reduce WSLs; thus, 6 months of fluoride varnish was more effective than a shorter treatment time. Importantly, fluoride varnish combined with CHX was more effective than fluoride varnish alone.

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The prevalence of WSLs in patients that seek orthodontic treatment is in the range of 50% to 96% (Geiger et al., 1992; Øgaard et al., 1996; Vivaldi-Rodrigues et al., 2006). Lucchese and Gherlone (2013) showed that the first 6 months are of particular importance in the development of WSLs because the majority of adolescent patients need to adapt their hygienic practices to the requirements of orthodontic therapy. It is assumed that calcium, fluoride and phosphate will penetrate the deepest areas of lesions (Llena-Puy, 2013).

Fluoride varnishes have been suggested to be safe and feasible for topical application. They include high concentrations of fluoride (not the fluoride used daily in toothpaste and mouth rinse). The varnish may also remain on tooth surfaces for several hours after application, and may be capable of releasing sufficiently high concentrations of fluoride ions to maintain surface fluoridation (Seppä, 1983). One study (Farhadian et al., 2008) revealed a 40% reduction in depth of demineralization around brackets after application of high concentration fluoride varnish. Many clinicians have applied topical fluoride to WLSs as the first step in treatment.

When the pH of oral fluids increases to normal levels, the calcium and phosphate ions of saliva are transmitted through the pellicle into the enamel; according to the laws of chemical equilibrium, this leads to remineralization (de Leeuw, 2004). Certainly, this process is greatly enhanced by fluoride in saliva and plaque. Another study (McNeill et al., 2001) reported that fluoride inhibits mineral loss during the acid dissolution process and enhances remineralization in a similar manner to that which occurs in dental enamel.

The benefits of using antimicrobial agents for the control of gingivitis have been widely discussed in the literature, and at present, CHX is considered the most effective agent for this purpose (Sari and Birinci, 2007). CHX has the capacity to prevent biofilm formation, which is one of the main etiological factors of caries disease. However, CHX affects the prevention and control of WSLs (Twetman, 2004). In a short-term *in vivo* study, a combination of daily mouth rinsing with fluoride and CHX was more effective at decreasing mineral loss and lesion development than fluoride mouth rinsing alone (Ullsfoss et al., 1994). Huizinga et al. (1991) calculated that CHX would be need to be released from the varnish for at least 6 months after a topical application (Huizinga et al., 1991). Some studies have shown the efficacy of CHX varnishes in decreasing the prevalence of caries during orthodontic treatment, yet other studies have not shown the efficacy of a varnish of 40% CHX (Kronenberg et al., 2009; Øgaard et al., 2001). Moreover, the main benefits of CPP-ACP are their ability to localize at the tooth's surface and penetrate into the supragingival plaque to provide bioavailable calcium and phosphate ions where they are most needed (Reynolds et al., 2003).

Turska-Szybka et al. (2016) concluded that resin infiltration in conjunction with fluoride varnish treatment of early facial smooth-surface caries lesions in deciduous teeth is superior to fluoride varnish treatment alone for reducing

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lesion progression (Turska-Szybka et al., 2016). The studies (Hammad et al., 2012; Mueller et al., 2006; Paris and Meyer-Lueckel, 2010) showed a good effect of resin infiltration on WSLs after debonding orthodontic brackets. The studies concluded that treatment with resin infiltration in conjunction with fluoride varnish is promising for controlling proximal lesions (Ekstrand et al., 2010) and in fact, teeth treated with resin infiltration showed higher Vickers hardness values than untreated teeth (Palamara, 2010). Based on our knowledge, there were no study on the efficacy of resin infiltration versus fluoride varnish+ CHX for WSL treatment; therefore, more studies in the future are necessary to follow up on this comparison.

Limitations of this systematic review included: (1) heterogeneity between the studies; (2) difference in age and sex between the studies; (3) few studies reported the efficacy of a type of treatment compared with other treatments; (4) many parameters of WSLs in the studies; and (5) different types of study environment (*in vitro* and *in vivo*). The studies concluded that treatment with resin infiltration in conjunction with fluoride varnish is promising for controlling proximal lesions

Conclusion

While this systematic review has several limitations, it also demonstrates that fluoride varnish combined with CHX could be an effective treatment for WSLs after orthodontic procedure. It is best that fluoride varnish be available for 6-month period of treatment, at least. The study review also demonstrated or concluded that treatment with resin infiltration in conjunction with fluoride varnish is a promising combination for controlling proximal lesions (e.g. WSLs). More studies in the future are needed to explore that.

Abbreviations

WSL: White spot lesion
CHX: Chlorhexidine
ΔQ: Product of ΔF and area
ΔF: The percentage of fluorescence loss comparing sound enamel with an identified lesion
ΔZ: The integrated mineral loss
T: Time
DD: DiagnoDent
CPP: Casein phosphopeptide

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www.bmrat.org

ACP: Amorphous calcium phosphate
SD: Standard deviation

Author Contribution

All authors drafted the first version and approve the final draft.

ISSN: 2198-4093
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