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Dental Science - Review

Antierosive Effect of Topical Fluorides: A Systematic Review and Meta-Analysis of *In Situ* Studies

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Keywords: Erosive tooth wear; Topical fluoride; In situ

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Abstract

BACKGROUND: The effectiveness of the application of topical fluorides in prevention of erosive tooth wear has been an issue of controversy in the literature. The objective of this systematic review was to assess in situ studies investigating the effects of using topical fluorides on prevention of erosive tooth wear

MATERIAL AND METHODS: Two electronic databases PubMed/MEDLINE and Cochrane Central Register of Controlled Trials were searched. Eligibility criteria included in situ-controlled studies that assessed the effect of the erosive process without additional tooth brushing. The search involved English-written articles only. A total of 684 potentially relevant titles and abstracts were found after removal of duplicates, of which 22 full-text articles were selected. Seventeen studies were included in the qualitative synthesis of which 6 studies included in the meta-analysis. The following data were obtained for each study: authors, year of publication, country, study design, periods of study, duration, blinding, interventions (type/concentration/form), tooth substrate, location of the intraoral appliance, number of samples attached to each appliance, type of acidic media used for erosive challenge, duration of erosive challenge, subjects (number/age/sex), reported side effects -if any-, measuring device, amounts of tissue loss.

RESULTS: The risk of bias of the included studies was assessed using the Cochrane Collaboration tool for assessing the risk of bias. A meta-analysis of the present study was performed using Comprehensive Meta-Analysis version 2.2.048 software.

CONCLUSION: The use of oral hygiene products containing AmF/NaF/SnCl2 or NaF may be effective in the prevention of erosive tooth wear.

Introduction

The ever-changing human lifestyle has influenced the pattern of oral diseases [1]. One of these obvious changes during the last decades is the continuous increase in the total amount and frequency of consumption of acidic beverages and foods [2], [3].

While the prevalence of dental caries has declined in many countries, there is some evidence that the prevalence of erosive tooth wear is steadily growing [4], [5], [6], [7]. A systematic epidemiological review and meta-regression analysis estimated the prevalence of erosive tooth wear in permanent teeth of children and adolescents to be 30.4% [8]. Thus, erosive tooth wear has drawn increasing attention in the last decades as an entity having deleterious consequences on oral health. The loss of hard dental tissues might lead to poor appearance and/or dentin hypersensitivity [9], [10]. Therefore, management of erosive tooth wear is becoming an increasingly important issue for the long-term health of the dentition [4].

Erosive tooth wear is defined as the pathologic and irreversible loss of dental hard tissue by acids and/or chelators acting on plaque-free tooth

surfaces [11], [12], [13]. Erosive tooth wear is a multifactorial condition that has a complex aetiology. Various extrinsic or intrinsic factors are involved in the development and progression of erosive tooth wear which may be patient dependent or diet dependent [1], [14], [15]. The Acids responsible for the aetiology of erosive tooth wear can be of intrinsic or extrinsic origin. Acidic foods and beverages among many other extrinsic factors can contribute to the development of erosive lesions [4], [13], [16]

Strategies for prevention and control of erosive tooth wear usually target the assessment of risk factors and applying preventive measures [17]. The preventive measures rest on two major approaches: the first one is the minimisation of the erosive potential of acidic beverages and foods. The second approach is the protection of tooth surfaces against erosive attacks [18]. Although the effectiveness of the application of topical fluorides in caries prevention has been convincingly proven, its effectiveness in the prevention of erosive tooth wear has been an issue of controversy in the scientific literature [2], [19], [20], [21].

In vitro studies have been widely used to investigate the effectiveness of topical fluoride application in the prevention of erosive tooth wear. Although they allow for better standardisation and accurate assessment of mineral loss, their external validity is limited. Clinical studies have greater validity, but they lack adequate standardization and require long follow-up periods [22], [23], [24], [25]. In situ studies seem to be an ideal study design combining the advantages of in vitro and clinical studies [26]. Therefore, this systematic review was done to assess in situ studies investigating the anti-erosive effects of topical fluorides.

Methods

Focused question

The research question was as follows: In adults, what are the anti-erosive effects of topical fluorides?

Electronic searches

The electronic search was conducted, with no date restriction, at 31st March 2018 in the following two databases:

1) PubMed/MEDLINE.

2) Cochrane Central Register of Controlled Trials.

The keywords used in the search strategy are listed in Table 1.

Table 1: Search strategy used in PubMed (MEDLINE)

Search number	Search terms
#1	(((((((fluoride) OR topical fluoride) OR fluoride mouth rinse) OR fluoride mouthrinse) OR fluoride mouthwash) OR fluoride varnish) OR fluoride gel) OR fluoride toothpaste) OR fluoride dentifrice
#2	((((((erosion) OR dental erosion) OR tooth erosion) OR enamel erosion) OR dentin erosion) OR dentine erosion) OR erosive dental wear) OR erosive tooth wear
#3 (#1 and #2)	((((((((((fluoride) OR topical fluoride) OR fluoride mouth rinse) OR fluoride mouthrinse) OR fluoride mouthwash) OR fluoride varnish) OR fluoride gel) OR fluoride toothpaste) OR fluoride dentifrice)) AND ((((((((erosion) OR dental erosion) OR tooth erosion) OR enamel erosion) OR dentin erosion) OR dentine erosion) OR erosive dental wear) OR erosive tooth wear)

Eligibility criteria

This systematic review included the studies: 1) were in situ-controlled trials; 2) assessed the effect of the erosive process without additional tooth brushing; 3) measured the amount of human enamel or dentin loss via profilometer, and 4) were published in English.

Selection process

All retrieved articles were stored in Mendeley® Desktop 1.19.1 Reference Manager to identify and exclude any duplicated studies. Firstly, the screening process of all studies was carried out by two authors (A.G.A and M.M.T.) independently to analyse titles and abstracts. Titles were discarded only if both authors agree that the title is irrelevant. However, if either feels the study may be eligible, the study was retained for the following step where full-text articles were analysed. Disagreements between the two authors were resolved by thoughtful discussion with a third reviewer (F.M.H.)

Data extraction process

Two reviewers (A.G.A and M.M.T.) independently extracted data. For each included study, Excel spreadsheets (Microsoft Corporation, Washington, USA) were used to collect the following data when available: authors, year of publication, country, study design, periods of study, duration, blinding, interventions (type/concentration/form), tooth substrate, location of the intraoral appliance, number of samples attached to each appliance, type of acidic media used for erosive challenge, duration of erosive challenge, subjects (number/age/sex), reported side effects -if any-, measuring device, amounts of tissue loss.

Confidence in data (Assessments of the risk of bias and quality)

Two authors (A.G.A and M.M.T.) analysed quality and the risk of bias of the included studies using the Cochrane Collaboration tool for assessing the risk of bias [27]. Each study was assessed for the following types of bias: selection bias (sequence

generation and allocation concealment), performance bias (blinding of study participants and personnel), detection bias (blinding of outcome assessors), attrition bias and reporting bias. The authors considered the risk of bias to be low if the study met all of the criteria above. The studies that fail to meet one criterion were classified as having a moderate risk of bias while those that failed to meet two or more criteria were deemed to have a high risk of bias.

Statistical analysis

A meta-analysis of the present study was performed using Comprehensive Meta-Analysis version 2.2.048 software. Cochran's Q test and I2 were used to assess heterogeneity. Standardised mean difference was used as the effect measure. The results were graphically presented using Forest plot. Publication bias was assessed using funnel plot. The significance level was set at P-value ≤ 0.05. Meta-analyses for enamel and dentin were performed separately to minimise heterogeneity between studies.

Results

Study selection

The initial electronic search produced 681 titles from MEDLINE/ PubMed, 116 titles from the Cochrane Central Register of Controlled Trials. The authors found 684 potentially relevant titles and abstracts after removal of duplicates. After initial screening, 22 full-text articles were selected. The judicious analysis led to the exclusion of 5 studies because they did not fulfil the eligibility criteria (Table 2). Therefore, this systematic review included 17 published between 2007 and 2017. The details of the study search, selection process and the reasons for exclusion are summarised in Figure 1.

Table 2: Excluded studies with reasons for exclusion

Studies	Reason for exclusion
Lepri et al., 2015 [28]; João-Souza et al., 2017 [29]	Bovine teeth were used
Ganss et al., 2007 [30]; Hara et al., 2014 [31]	Tooth brushing abrasion was evaluated in addition to erosion
Magalhães et al., 2007 [32]	Type of fluoride was not mentioned

Study characteristics

Of the 17 studies selected, 2 were parallel while 15 were cross over studies, 3 of them used split-mouth design. The included studies investigated two to five different fluoride formulations with fluoride concentration ranging from 250 ppm to 1450 ppm. Placebo was used as a control group in 10 studies. All included studies used tooth specimens originating from impacted third molars.

Regarding the tooth substrate, 13 studies used human enamel; one study used human dentin while 3 studies used both human enamel and dentin. The number of specimens carried by each appliance varied from 2 to 8. The acidic challenge in 12 studies was performed extraoral (using citric acid, cola drink, Sprite® or orange juice) while in five studies it was performed intraoral (using orange juice). The number of recruited participants varied from 8 to 36. The age of participating subjects was not mentioned in six studies. Only four studies reported side effects. The reported side effects were astringent feeling on the mucosa and a dull feeling on the teeth. The characteristics and details of the selected studies are presented in Table 3.

Assessments of the risk of bias

The majority of included studies showed a moderate risk of bias. Figure 2 shows the summary and graphical representation of the risk of bias of included studies.

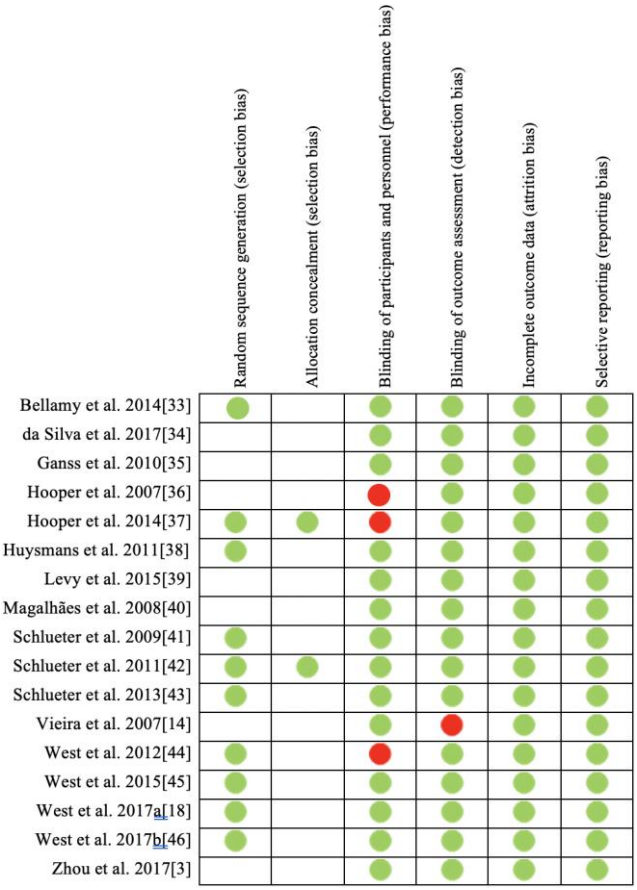

Figure 2: Risk of bias of included studies

Meta-analysis

Two studies [14], [33] were excluded from the analysis because they were parallel group designs while all other studies were cross-over/split mouth

designs. One study [38] was excluded because it reported tissue loss as a percentage and not the amount. Two studies [18], [46] were excluded because they reported estimated median and standard error rather than the actual mean and standard deviation. The following meta-analyses reported all pair-wise comparisons between different agents that met the criteria for performing the meta-analysis. The unreported comparisons were not performed due to: a) absence of studies with both agents; the b) the presence of only one study that compares the agents.

Enamel

Placebo vs NaF Dentifrice

Heterogeneity measures showed non-statistically significant Cochrane Q value (*P*-value = 0.374). I^2 value was 0% indicating no heterogeneity, so the homogeneity hypothesis was not rejected, and the fixed effects model was used. The fixed effects model showed an effect size (standardised difference in means) of -0.358 with a 95% CI (-0.641 – -0.075). The effect size was statistically significantly higher for placebo with *P*-value = 0.013. The relative weight of the studies revealed that study of (Schlueter et al., 2013) had the highest weight (48.77%) while the study of (Magalhães et al., 2008) showed the lowest weight (20.81%). Funnel plot analysis for the included studies showed no publication bias. This was confirmed by Egger's regression intercept which showed the non-statistically significant result (*P*-value = 0.102) (Table 4, Figure 3, and Figure 4).

Table 3: Characteristics of included studies (arranged alphabetically)

Study, Year	Country	Study design	Periods	Duration (days)	Blinding	Interventions	Fluoride concentration	Form	Tooth substrate	Appliance	Number of samples	Erosive challenge	Time per day	Subjects		Age (years)		Sex		Side effects	Measurement	Tissue loss µm	Notes
														Randomized	Completed	range	mean	M	F				
Bellamy et al. 2014 [33]	UK	Parallel	_	15	Double	1-Placebo	-	Dentifrice	E	LB	8	EO/Citric acid	5 min	12	12	NR	NR	NR	NR	NR	contact profilometer	18.94(3.53)	Mean values (SE)
						2-NaF	1450 ppm															15.53(3.53)	
						3-NaF/SnF_2	1450 ppm															2.03(0.57)	
da Silva et al. 2017 [34]	Brazil	Crossover	4	5 x 4	Double	1-Placebo	-	Solution	E	LB	2	EO/Citric acid	12 min	12	12	NR	28±8	NR	NR	None	non-contact profilometer	4.55±2.75	Mean values
						2-NaF	500 ppm															4.59±2.13	
						3-AmF/NaF/$SnCl_2$	500 ppm															2.64±1.55	
Ganss et al. 2010[35]	Germany	Crossover	3	7 x 3	Double	1-Placebo	-	Mouthrinse	E/D	NR	3	EO/Citric acid	30 min	24	24	NR	32±6	6	18	NR	contact profilometer	28.2±6.1 *[43.8±9.2]*	Mean values
						2-AmF/NaF/$SnCl_2$	500 ppm															9.3±4.5 *[23.2±6.8]*	
						3-NaF	500 ppm															22.8±6.0 *[33.7±6.6]*	
Hooper et al. 2007 [36]	UK	Crossover	3	3x5	Single	1-Placebo	-	Toothpaste	E	UP	2	IO/ Orange	10 min	15	15	NR	NR	NR	NR	NR	profilometer	3.233±4.424	Mean values
						2-NaF	NR															2.258±3.628	
						3-SnF_2																0.946±1.413	
Hooper et al. 2014 [37]	UK	Crossover	4	15 x 4	Single	1-NaF/KNO_3	1450 ppm	Dentifrice	E	UP	2	IO/ Orange	10 min	35	32	19-62	41.9	12	23	1 subject (reason not ststed)	contact profilometer	4.39±3.554	Mean values
						2-NaF/$SnCl_2$	1450 ppm															3.009±4.925	
Huysmans et al. 2011 [38]	Netherlands	Crossover / split mouth	3	3x5	Double	1-NaF	1450 ppm	Toothpaste	E	UP	4	EO/Citric acid	5 min	12	12	20-50	NR	1	11	None	non-contact profilometer	7% (24.7)	% erosive reduction compared to the (control sample)
						2-AmF/SnF_2	1400 ppm															34% (23.4)	
						3-NaF/SnF_2	1450 ppm															26% (22.3)	
Levy et al. 2014 [39]	Brazil	Crossover / split mouth	3	5 x 3	Double	1-NaF	2,26%	Varnish	E	UP	2	EO/Cola drink	6 min	12	12	23-35	NR	1	11	None	contact profilometer	1.1±0.5	Mean values
						2-NaF	2,45%	Solution														1.3±0.4	
						3-TiF_4	2,45%	Varnish														1.2±0.5	
						4-TiF_4	2,45%	Solution														1.2±0.7	
						5-Placebo	-	Varnish														1.8±0.8	
Magalhães et al. 2008 [40]	Brazil	Crossover	2	2x7	Double	1-Placebo	-	Toothpaste	E	UP	3	EO/Cola drink	5 min	10	10	19-30	24	NR	NR	NR	profilometer	3.63±1.54	Mean values
						2-NaF	1098 ppm															3.54±0.90	
Schlueter et al. 2009[41]	Germany	Crossover	3	7 x 3	Double	1-Placebo	-	Solution	E/D	LB	3	EO/Citric acid	30 min	20	20	NR	NR	NR	NR	13 (astringent feeling on the mucosa and a dull feeling on the teeth with using AmF/NaF/$SnCl_2$)	contact profilometer	33.6±15.4 *[47.8±15.5]*	Mean values
						2-NaF	1000 mg/kg F															24.2±9.2 *[34.1±9.3]*	
						3-AmF/NaF/$SnCl_2$	500 mg/kg F															9.2±3.4 *[23.9±6.4]*	
Schlueter et al. 2011 [42]	Germany	Crossover	3	7 x 3	Double	1-Placebo	-	Solution	E/D	LB	3	EO/Citric acid	30 min	8	8	NR	NR	NR	NR	3 participants reported astringent feeling on the mucosa + dull feeling on teeth	contact profilometer	54.8±8.6 *[48.5±13.0]*	Mean values
						2-AmF/SnF_2	250 ppm															24.5±14.4 *[32.8±9.6]*	
						3-AmF/NaF/$SnCl_2$	1000 ppm															9.7±4.1 *[26.2±6.7]*	
Schlueter et al. 2013 [43]	Germany	Crossover / split mouth	3	3x 7	Double	1-Placebo	-	Toothpaste	E	LB	6	EO/Citric acid	12 min	27	27	NR	NR	NR	NR	None	non-contact profilometer	12.5±5.9	Mean values
						2-NaF	1400 ppm															9.3±5.6	
						3-F/Sn/Chitosan	1400 ppm															4.9±2.9	
Vieira et al. 2007 [14]	Netherlands	Parallel	_	21	Single	1-Placebo	-	Varnish	E	UP	4	Eo/Sprite®	5 min	11	11	NR	NR	NR	NR	NR	non-contact profilometer	37.81± 11.89	Mean values
						2-Difluorosilane	0.10%															Not measured	
West et al. 2012 [44]	UK	Crossover / split mouth	2	15 x 2	Single	1-NaF	1100 ppm	Toothpaste	*D*	LB	4	EO/ Orange	2 min	28	26	NR	33.7	6	22	11 reported 17 treatment emergent adverse events, 15 non-oral, 2 oral	contact profilometer	*12.42(1.81)* *22.50(1.78)*	Mean values (SE)
						2-SnF_2	1100 ppm																
West et al. 2015 [45]	UK	Crossover	4	10 x 4	Double	1-NaF/$SnCl_2$	1000 ppm	Dentifrice	E	UP	2	IO/ Orange	10 min	34	32	24-65	45.7	9	25	NR	contact profilometer	0.42±1.47	Mean values
						2-NaMFP/triclosan	1000 ppm															2.27±2.50	
West et al. 2017 [18]	UK	Crossover	4	15 x 4	Double	1-NaF/SnF_2	1450 ppm	Dentifrice	E	UP	2	IO/ Orange	10 min	36	33	23-65	44.8	7	29	NR	contact profilometer	1.6	Estimated median
						2-NaF/triclosan	1450 ppm															5.03	
West et al. 2017 [46]	UK	Crossover	4	10 x 4	Double	1-NaF/SnF_2	1450 ppm	Dentifrice	E	UP	2	IO/ Orange	10 min	34	33	NR	44.6	NR	NR	NR	contact profilometer	0.0747(0.008)	estimated median(SE)
						2-SMFP/arginine	1450 ppm															1.2255(0.138)	
Zhou et al. 2017 [3]	China	Crossover	3	10 x 3	Double	1-SnF2	0.45%	Dentifrice	E	LB	8	IO/ Orange	10 min	12	12	25-62	36.3	NR	NR	NR	non-contact profilometer	9.117(2.002)	Mean values (SE)
						2-NaF/KNO_3	0.24%															12.471(2.002)	

NaF = sodium fluoride; NaF/SnF_2 = sodium fluoride/stannous fluoride; AmF/NaF/$SnCl_2$ = amine fluoride/sodium fluoride/stannous chloride; SnF_2 = stannous fluoride; NaF/KNO_3 = sodium fluoride/ potassium nitrate; AmF/SnF_2 = amine fluoride/stannous fluoride; TiF_4 = titanium fluoride; F/Sn/Chitosan = fluoride/tin/chitosan; NaMFP/triclosan = sodium monofluorophosphate/triclosan; SMFP/arginine = sodium monofluorophosphate/arginine; E = enamel, D = dentin; LB = lower buccal; UP = upper palatal; IO = intra oral; EO = extra oral; NR = not reported.

Placebo vs NaF Solution

Heterogeneity measures showed statistically significant Cochrane Q value (*P*-value = 0.046). I^2 value was 67.6% indicating moderate heterogeneity, so the homogeneity hypothesis is rejected, and the random effects model was used.

Table 4: Heterogeneity measures of meta-analysis for the difference between amounts of tissue loss after using placebo and NaF Dentifrice (Enamel)

	Value	df	*P*-value
Cochrane Q	1.968	2	0.374
I^2	0%		

**: Significant at P ≤ 0.05, df: degrees of freedom (n-1).*

The random effects model showed an effect size (standardised difference in means) of -0.546 with a 95% CI (-1.061 – -0.031). The effect size was statistically significantly higher for placebo with *P*-value = 0.038.

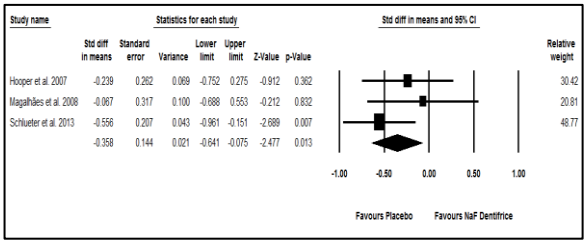

Figure 3: Forest plot of fixed-effect meta-analysis for the amount of tissue loss after using Placebo and NaF Dentifrice (Enamel)

The relative weight of the studies revealed that study of (Ganss et al., 2010) had the highest weight (34.87%) while the study of (da Silva et al., 2017) showed the lowest weight (30.95%).

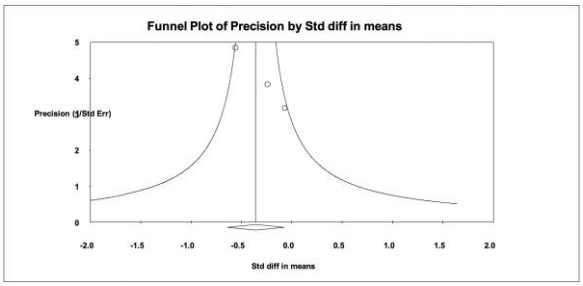

Figure 4: Funnel plot of meta-analysis for the amount of tissue loss after using Placebo and NaF Dentifrice (Enamel)

Funnel plot analysis for the included studies showed publication bias. This was confirmed by Egger's regression intercept which showed a statistically significant result (*P*-value = 0.028) (Table 5, Figure 5, and Figure 6).

Placebo vs. AmF/NaF/$SnCl_2$

Heterogeneity measures showed statistically significant Cochrane Q value (P-value = 0.008). I^2 value was 85.8% indicating high heterogeneity, homogeneity hypothesis was rejected, and the random effects model was used.

Table 5: Heterogeneity measures of meta-analysis for the difference between amounts of tissue loss after using placebo and NaF Solution (Enamel)

	Value	df	*P*-value
Cochrane Q	6.170	2	0.046*
I^2	67.6%		

**: Significant at P ≤ 0.05, df: degrees of freedom (n-1).*

The random effects model showed an effect size (standardised difference in means) of -2.259 with a 95% CI (-2.839 – -1.678). The effect size was statistically significantly higher for placebo with P-value <0.001.

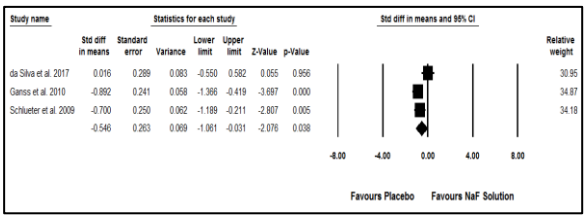

Figure 5: Forest plot of random-effects meta-analysis for the amount of tissue loss after using Placebo and NaF Solution (Enamel)

The relative weight of the studies revealed that the study of (Schlueter et al., 2009) had the highest weight (69.72%) while the study of (Ganss et al., 2010) showed the lowest weight (30.28%). Publication bias was not assessed because there are only two studies (Table 6, and Figure 7).

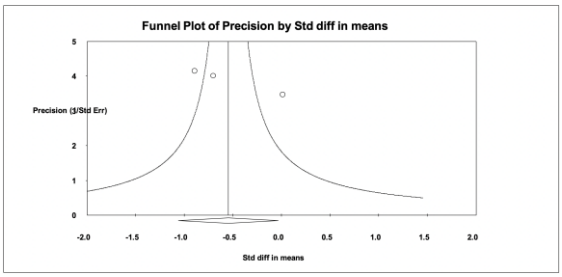

Figure 6: Funnel plot of meta-analysis for the amount of tissue loss after using Placebo and NaF Solution (Enamel)

NaF Solution vs. AmF/NaF/$SnCl_2$

Heterogeneity measures showed non-statistically significant Cochrane Q value (P-value = 0.253). I^2 value was 23.5% indicating weak heterogeneity, so the homogeneity hypothesis was not rejected, and the fixed effects model was used.

Table 6: Heterogeneity measures of meta-analysis for the difference between amounts of tissue loss after using placebo and AmF/NaF/$SnCl_2$ (Enamel)

	Value	df	*P*-value
Cochrane Q	7.029	1	0.008*
I^2	85.8%		

**: Significant at P ≤ 0.05, df: degrees of freedom (n-1).*

The fixed effects model showed an effect size (standardised difference in means) of -2.143 with a 95% CI (-2.684 – -1.603). The effect size was statistically significantly higher for NaF solution with P-value < 0.001.

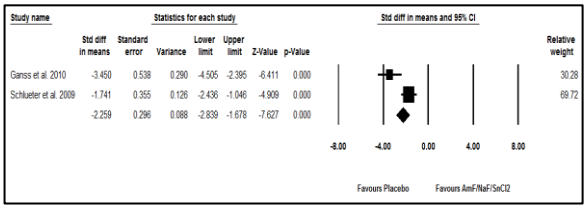

Figure 7: Forest plot of random-effects meta-analysis for the amount of tissue loss after using Placebo and AmF/NaF/$SnCl_2$ (Enamel)

The relative weight of the studies revealed that the study of (Schlueter et al., 2009) had the highest weight (56.65%) while the study of (Ganss et al., 2010) showed the lowest weight (44.35%).

Table 7: Heterogeneity measures of meta-analysis for the difference between amounts of tissue loss after using NaF Solution and AmF/NaF/$SnCl_2$ (Enamel)

	Value	df	*P*-value
Cochrane Q	1.307	1	0.253
I^2	23.5%		

**: Significant at P ≤ 0.05, df: degrees of freedom (n-1).*

Publication bias was not assessed because there are only two studies Table 7, and Figure 8).

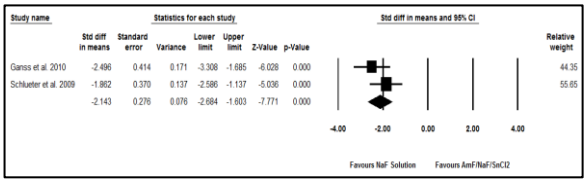

Figure 8: Forest plot of fixed-effect meta-analysis for the amount of tissue loss after using NaF Solution and AmF/NaF/$SnCl_2$ (Enamel)

Dentin

Placebo vs NaF Solution

Heterogeneity measures showed non-statistically significant Cochrane Q value (P-value = 0.576). I^2 value was 0% indicating no heterogeneity, so the homogeneity hypothesis is not rejected, and the fixed effects model was used. The fixed effects model showed an effect size (standardised difference in means) of -1.124 with a 95% CI (-1.502 – -0.745). The effect size was statistically significantly higher for placebo with P-value < 0.001.

Table 8: Heterogeneity measures of meta-analysis for the difference between amounts of tissue loss after using placebo and NaF Solution (Dentin)

	Value	df	*P*-value
Cochrane Q	0.312	1	0.576
I^2	0%		

**: Significant at P ≤ 0.05, df: degrees of freedom (n-1).*

The relative weight of the studies revealed that the study of (Ganss et al., 2010) had the highest weight (50.85%) while the study of (Schlueter et al., 2009) showed the lowest weight (49.15%). Publication bias was not assessed because there are only two studies (Table 8, and Figure 9).

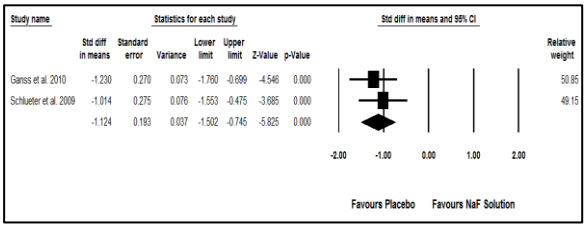

Figure 9: Forest plot of fixed-effect meta-analysis for the amount of tissue loss after using Placebo and NaF Solution (Dentin)

NaF Solution vs. AmF/NaF/$SnCl_2$

Heterogeneity measures showed non-statistically significant Cochrane Q value (P-value = 0.439). I^2 value was 0% indicating no heterogeneity, so the homogeneity hypothesis was not rejected, and the fixed effects model was used. The fixed effects model showed an effect size (standardised difference in means) of -1.398 with a 95% CI (-1.815 – -0.981).

Table 9: Heterogeneity measures of meta-analysis for the difference between amounts of tissue loss after using NaF Solution and AmF/NaF/$SnCl_2$ (Dentin)

	Value	df	*P*-value
Cochrane Q	0.598	1	0.439
I^2	0%		

**: Significant at P ≤ 0.05, df: degrees of freedom (n-1).*

The effect size was statistically significantly higher for NaF solution with P-value < 0.001. The relative weight of the studies revealed that the study of (Schlueter et al., 2009) had the highest weight (51.25%) while the study of (Ganss et al., 2010) showed the lowest weight (48.75%). Publication bias was not assessed because there are only two studies (Table 9, and Figure 10).

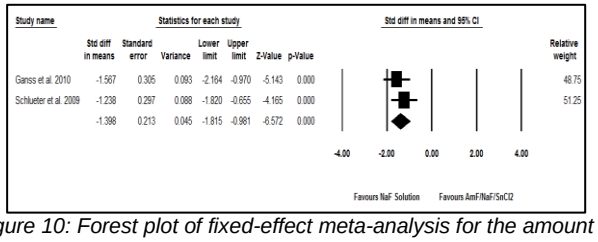

Figure 10: Forest plot of fixed-effect meta-analysis for the amount of tissue loss after using NaF Solution and AmF/NaF/$SnCl_2$ (Dentin)

Discussion

Summary of evidence

Two previous systematic reviews [19], [20] were published regarding the role of topical fluorides

in prevention of erosive tooth wear. Mohammed and Dusara, 2013 [19] investigated the role of topical fluoride application in preventing dental erosion. They found four studies related to the clinical question addressed in their review; three of them showed statistically significant greater remineralisation for all topical fluoride products compared to the placebo. Zini et al., 2014 [20] found an insufficient number of studies fulfilling the standards of evidence-based dentistry to reach any definite conclusions.

The current systematic review and meta-analysis attempted to analyse the anti-erosive effects of topical fluorides, as reported by in situ studies. The in-situ model was chosen because it is suitable for assessing the potential of various topically applied fluorides to provide protection against teeth erosion [36].

In enamel, regardless of the type of intervention (NaF Dentifrice/NaF Solution/AmF/NaF/$SnCl_2$), the results of the meta-analysis showed that placebo groups showed statistically significantly higher mean amount of tissue loss than intervention groups. When NaF Solution was compared with AmF/NaF/$SnCl_2$, NaF Solution showed statistically significantly higher mean amount of tissue loss than AmF/NaF/$SnCl_2$.

In dentin, the use of placebo showed a statistically significantly higher mean amount of tissue loss than NaF Solution. However, NaF Solution showed statistically significantly higher mean amount of tissue loss than AmF/NaF/$SnCl_2$.

NaF was widely used as a positive control because it is the most commonly used compound in oral hygiene products [43]. The difference in efficacy between NaF and AmF/NaF/$SnCl_2$ was associated with the differences in their mechanism of action [34], [35], [41].

Strengths and limitations

The latest published systematic review regarding the clinical question of this review was Zini et al., 2014 [20] who performed their search during 2011. Therefore, the current systematic review may be considered as an updated review for this topic.

Although an adequate number of studies were found to be fulfilling the eligibility criteria of this review, the large number of investigated materials and lack of standardisation of testing protocols make comparisons between studies difficult. Of the 17 studies included in the qualitative analysis, meta-analysis was done for six studies only.

A shortcoming with the present systematic review is that only two major databases were searched. Also, the electronic search was restricted to English written articles only and therefore; relevant studies may have been missed. However, the language restriction was due to the reason that reliable translation of non-English articles was not always possible to obtain.

Conclusion

Based on evaluation of the available evidence from reviewed in situ trials, despite the limited number of included studies, it could be concluded that the use of oral hygiene products containing AmF/NaF/$SnCl_2$ or NaF may be an effective method in protecting dental hard tissues against erosive tooth wear. However, it is highly recommended a standard protocol for in situ erosion studies do exist to making comparisons between different studies difficult possible.

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