Effectiveness of root caries preventive and arresting agents in middle age and older adults: a systematic review

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Abstract

Background: Root caries among adults is a concern and requires special attention. This systematic review aimed to assess the findings on the effectiveness of different agents to treat root caries in middle age and older adults.

Methods: PubMed, Scopus, and Web of Science databases were searched systematically, following PRISMA guidelines. Clinical trials that evaluate the effectiveness of preventive and/or arresting agents for root caries in patients over 50 years old, published from 2011 to 2019 (June). This review has been registered at PROSPERO database (CRD42018104399).

Results: Twelve of 277 studies fully encountered the inclusion criteria and were selected for this review. Eight agents were identified in the studies and their efficacy were assessed by different methods. The agents that presented valuable results on arresting or preventing root caries were 38% SDF, arginine-containing toothpaste and high-fluoride toothpastes.

Conclusion: Based on the selected studies' findings, annual applications of 38% SDF could be the most effective treatment for root caries in older adults. In addition, the daily use of a 1,5% arginine toothpaste or a high fluoride toothpastes could also be recommended. More research on root-caries-specific diagnose methods, especially at very early stages, are necessary.

Background

The population of older adults in the world has increased substantially in the past few years and this growth is expected to accelerate in the next decades [1]. In addition, with the advances in medicine, people are living healthier and longer lives. Most of the health problems in older individuals are related to chronical diseases [2, 3]. In dentistry, ageing may be related to the increase of oral diseases risk [4].

Since people are living longer lives and retaining more teeth, a substantial increase in caries lesions in older population has been reported, particularly the prevalence and incidence of root caries [5]. In the study of Hariyani et al. [5], the incidence and increment of root caries in the population, annually, had values of 18.25% [CI = 13.22%–23.28%] and 0.45 [CI = 0.37–0.53], respectively. It was also observed that the there was an increase of root lesions over time even among healthier older adults. The risk factors for primary root caries, are the exposure of the root surface by gingival recession, reduction of salivary flow, inadequate oral hygiene, sucrose rich diet, and the inadequate use of removable partial dentures [6]. Therefore, prevention, both self-care and professional, is key for these patients [7].

Many agents have been described to be effective in preventing and arresting root caries, especially fluoride-based products, such as low/high fluoride (F) toothpastes [8–11], silver diamine fluoride (SDF) [12, 13] and fluoride varnishes [14]. Other preventive agents reported to have beneficial effects on coronal and root decays are chlorhexidine [15] and xylitol [16, 17].

A previous literature review [18] reported that primary and secondary prevention agents effectively reduced root caries incidence in older adults and vulnerable elderly, when compared to placebo treatments. This review comprised 31 studies, from 1979 to 2010, and concluded that the best choice of prevention for primary root caries in this population is the 38% SDF professionally applied annually. For secondary root caries, the 22,500ppm sodium fluoride (NaF) varnish (applied every 3 months) was selected as the most effective prevention treatment.

Years have passed, root caries are still a concern among adults [5], new studies and new products and agents have been tested to evaluate their efficacy on the prevention of root caries, especially for elderly. Therefore, the aim of this systematic literature review is to assess the recent findings in literature in order to compare and rank the efficacy of the agents to prevent and arrest root caries in older adults.

2 Methods

2.1 Search strategy

PRISMA guidelines for systematic review and meta-analysis have been used for this review manuscript [19]. PubMed, Scopus, and Web of Science databases were searched to identify the most recent scientific articles on the subject (from 2011 to present date). The research took place on 1th June, 2019, and no language restriction was used. The keywords used were: “root caries”; “dental caries”; “humans”; and “aged”. The search strategy for each database are described on Table 1. This review has been registered at PROSPERO database, from the Centre for Reviews and Dissemination of the University of York, UK (CRD42018104399).

Table 1: Search strategies per database.

Database	Strategy
PubMed	((("root caries") AND "dental caries") AND humans) AND aged
Scopus	(ALL ("root caries") AND ALL ("dental caries") AND ALL (humans) AND ALL (aged)) AND PUBYEAR > 2010 AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ip")) AND (LIMIT-TO (SUBJAREA, "DENT")) AND (LIMIT-TO (SRCTYPE, "j"))
Web of Science	TOPIC: ("root caries") AND TOPIC: ("dental caries") AND TOPIC: (humans) AND TOPIC: (aged).

2.2 *Inclusion and exclusion criteria*

In order to identify relevant studies, the following inclusion and exclusion criteria were established. Studies were limited to clinical trials involving human subjects aged over 50 years old. *In vitro*, *in situ*, review articles, short communications were excluded.

2.3 *Risk of bias*

The assessment of the risk of bias in the included studies was made according to the Cochrane Collaboration’s tool for assessing risk of bias for randomized trials [20]. The non-randomized trials risk of bias was assessed by ROBINS-I (“Risk of Bias in Non-Randomized Studies of Interventions”) tool [21].

3 Results

3.1 Study selection

The initial electronic search resulted in 277 studies identified as possibly relevant (Fig. 1). After eliminating duplicated articles (n=35), the title and abstracts of remaining papers were screened and 253 papers were excluded, since they were not relevant to the inclusion criteria. The full text of the remaining 24 relevant studies were read. A consensus between the reviewers (R.C. and N.A.) was reached to determine which studies fully encountered the inclusion criteria and 12 studies were excluded with reasons after full-text appraisal (Table 2). Lastly, 12 studies were included in this review.

Fig. 1 – Flow diagram.

Table 2: Excluded studies with reasons.

Studies	Reasons for exclusion
Blinkhorn and Davies, 2013	Case report with unclear results.
Deutsch, 2016	
Durmusoglu et al., 2012	No assessment of efficacy of preventive agents on root caries prevention or arrest.
Featherstone et al., 2012	
López et al., 2013	
Gil-Montoya et al., 2014	
Rodrigues et al., 2011	Reviews
Hayes et al., 2014[a]	
Hayes et al., 2014[b]	
Gregory and Hyde, 2015	
Jablonski and Barber, 2015	

Risk of bias

A summary of the risk of bias assessment, following the Cochrane Collaboration's tool for risk of bias in randomized trials [20], is represented in Table 3. Ten of the twelve studies were randomized clinical trials and presented low risk of bias for "random sequence generation" and "selective reporting" criteria. Most of these studies had a low risk of bias for "allocation concealment" [10–16], "blinding of participants and personnel" [9, 11–16], "incomplete outcome data" [9–13, 15, 17] and "other source of bias" [8–11, 13–17] criteria. Four studies were considered to have a high risk of bias for only one parameter the "blinding of outcomes" [8, 10, 11, 16] (Table 3).

Table 3: Risk of bias assessment of randomized clinical trials.

	Papas et al. (2012) [15]	Bader et al. (2013) [16]	Ekstrand et al. (2013) [8]	Hu et al. (2013) [9]	Ritter et al. (2013) [17]	Souza et al. (2013) [10]	Zhang et al. (2103) [12]	Srinivasan et al. (2014)[11]	Li et al. (2016) [13]	Xin et al. (2016) [14]
Random sequence generation	P	P	P	P	P	P	P	P	P	P
Allocation concealment	P	P	O	?	O	P	P	P	P	P
Blinding of participants and personnel	P	P	O	P	O	O	P	P	P	P
Blinding of outcomes	P	P	O	P	O	O	P	O	P	P
Incomplete outcome data	P	O	O	P	P	P	P	P	P	O
Selective reporting	P	P	P	P	P	P	P	P	P	P
Other sources of bias	P	P	P	P	P	P	O	P	P	P

P - Low risk of bias.

O - High risk of bias.

? - Unclear risk of bias.

Two non-randomized trials were included [22, 23]. After their risk of bias assessment, using ROBINS-I tool (Table 4), one paper [22] was considered to have a serious risk of bias, especially due to bias of missing data and measurements of outcomes. The second paper [23] was considered to have a low risk of bias, according to the parameters assessed by ROBINS-I tool.

Table 4: Risk of bias assessment of non-randomized clinical trials.

Source	Overall bias	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurements of outcomes	Bias in selection of the report results
Wyatt et al., 2014 [22]	**Serious**	Low	Low	Low	Low	Critical	Critical	No information
Katsura et al. 2016 [23]	**Low**	Low	Low	Low	Low	Low	Moderate	Low

The years of publications were from 2012 to 2016. The preventive agents tested were: 10% chlorhexidine diacetate varnish [15], xylitol [16, 17], 5000ppm F toothpaste [8, 11], 1.5% arginine and 1450ppm F toothpaste [9, 10], 38% SDF [12, 13], 38% SDF followed by application of potassium iodide (KI) [13], 5% sodium fluoride (NaF) varnish [14], and casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) with sodium fluoride [23]. These agents were compared with a placebo [12–17] or a non-fluoridated toothpaste [9] or a regular-fluoridated toothpaste (1350-1450ppmF) [8–11] or a non-intervention group [23]. The mean age of the population, preventive agents (experimental groups) tested, their comparison group(s), sample size (n) and follow-up period are summarized on Table 5.

Table 5: Mean age, experimental and comparison groups, sample size and follow-up periods of the selected studies.

Source	Mean age	Experimental group	Comparison group	Sample size (n)	Final follow-up period
Papas et al. (2012) [15]	42.9±13.3	10% chlorhexidine diacetate varnish	Placebo	983	13 months
Bader et al. (2013) [16]	47.0	Xylitol	Placebo	691	33 months
Ekstrand et al. (2013) [8]	81.7±11.6	5000ppm fluoride toothpaste	1450ppm F toothpaste	176	8 months
Hu et al. (2013) [9]	64±4.1	1.5% arginine and 1450 ppm F toothpaste	1450ppm F toothpaste non-fluoride toothpaste	412	6 months
Ritter et al. (2013) [17]	47.3	Xylitol	Placebo	620	33 months
Souza et al. (2013) [10]	45.7±9,19	1.5% arginine and 1450 ppm F toothpaste	1450ppm F toothpaste	284	6 months
Zhang et al. (2013) [12]	72.5±5.7	38% SDF	Placebo	266	24 months
Srinivasan et al. (2014) [11]	56.9±12.9	5000ppm F toothpaste	1350ppm F toothpaste	130	6 months
Wyatt et al. (2014) [22]	65 – 86	Fluoride toothpaste *(unknown concentration)*	*(no control)*	67	24 months
Katsura et al. (2016) [23]	59.0±8.25 / 66.5±8.13	CPP-ACP paste with NaF	Non-CPP-ACP	19	12 months
Li et al. (2016) [13]	72.2±5.8	38% SDF 38% SDF and KI	Placebo	83	30 months
Xin et al. (2016) [14]	50±9.9	5% NaF varnish	Placebo	78	24 months

The methods used to assess the activity of caries lesions were by measuring tissue color and texture by standard visual-tactile examination [9, 11–13, 23], electrical caries monitoring [9, 10], other scoring systems [8, 15], and by the International caries detection assessment system - ICDAS [14, 16, 17, 22]. Only half of the studies were specific for root caries treatment and showed beneficial effects of the agents applied to prevent and/or arrest root caries lesions [8–10, 12, 13].

Two studies evaluated the efficacy of SDF on arresting and preventing new lesions on root surfaces [12, 13]. Annual application of 38% SDF is highly efficient in arresting root caries lesions, with values of 90% (SDF only) and 93% (SDF and KI) of root caries arrested (versus 45% of caries arrested by the placebo solution) [13]. Moreover, the annual application of SDF in combination with biannual oral hygiene instructions showed statistically significant results in preventing new root caries lesions and arresting active lesions [12].

The daily use of fluoride-based toothpastes for root caries treatment was assessed by two clinical trials [9, 10], and also demonstrated to be efficient on the increase of hardness of the affected dental tissue. The use of 1,5% arginine and monofluorophosphate toothpaste, twice a day, promoted 61.7% increase of hardness after 6 months, compared to 56% of the

positive control toothpaste ($p < 0.001$) and 27.0% of the negative control ($p = 0.006$) [9]. The same experimental toothpaste, under the same experiment conditions, was tested in another study [10] and presented 70.5% of increase of hardness against 58.1% (positive control – $p = 0.038$).

Two studies [8, 11] compared the efficacy of brushing teeth with a high fluoride toothpaste (5000ppm), when compared with a regular fluoride toothpaste (1450ppm). Their finding suggest that the use of 5000ppm F toothpaste daily is significantly more effective in controlling root caries lesions progression and promoting remineralization after 8 months [8]. Likewise, the findings of the second study [11], using 5000ppm F toothpaste, compared to a 1350ppm as control, also demonstrated better performance on arresting dental caries, including root caries lesions.

In the trial presented by Wyatt et al. [22], the daily use of a regular fluoride toothpaste by community-dwelling elderly promoted low rates of progression and reversal of coronal and root caries after 2 years. However, the results of this study have a high variation rate, where the reversal of non-cavitated root caries and the development of new root caries varied from 0% to 23%. As additional results, the authors identified that the progression of caries in root surfaces is correlated with age and the number of medical conditions presented by the patients. As age increases, a higher incidence of root caries lesions was noticed. However, patients with one or no medical conditions developed more root caries (3.0%±5.0) vs. (1.0%±2.5) for patients with two or more health issues.

In patients submitted to red and neck radiotherapy, daily topical applications of CPP-ACP with NaF increased significantly root surface hardness after 12 months, when compared to a non-intervention group ($p=0.001$ and $p<0.001$, respectively) [23]. A minor increase in the number of hard surfaces after 1 year of CPP-ACP applications (from 347 to 350 surfaces) and a decrease in the number of hard surfaces for the control group (from 197 to 173 surfaces) were observed. Moreover, the use of CPP-ACP by these patients promoted a significant reduction of the incidence of soft root surface lesions (0.6%) than the non-CPP-ACP group (6.8%, $p<0.001$).

Four randomized clinical trials [14–17] did not present specific findings for root caries treatment, but for dental caries in general. They all failed to show promising results of the tested agents to prevent or arrest caries lesions, when compared to the control groups. Quarterly applications of 5% NaF varnish showed similar effectiveness in preventing dental caries (coronal and root) in patients with Sjögren's syndrome as a placebo gel ($p > 0.05$) [14]. The use of chlorhexidine varnish had similar results as the placebo used to prevent new dental caries [15], although the authors suggest that it might have a role in preventing root caries in very high-risk populations. The supplementation with 1g xylitol did not show significant results to be considered as an effective preventive agent for dental caries in general [16, 17]. However, it appears to have some caries-preventive effect on root surfaces [17].

4 Discussion

This systematic review aimed to assess clinical findings from the past eight years on the effectiveness of different agents to prevent and treat root caries in older adults. For that, randomized clinical trials, published from 2011 to 2018 (July), with population over 50 years old, were taken into consideration. Different diagnose methods for dental caries activity were applied at baseline and follow-up examinations. Only half of the selected studies [8–10, 12, 13] were performed to evaluate the agents' effect specifically on root surfaces caries. The other half [11, 14–17] took root caries as an inclusion factor, with results related to dental caries in older adults in general.

Different methods were used to diagnose and determine the activity of caries lesions at baseline and after follow-up. The standard visual-tactile method was performed by four studies [9, 11–13]. In this method, the visual examination of the tooth surface aims to identify lesion's color, contour and presence of cavitation, and the tactile examination is performed, with the aid of a probe, to determine if the affected tissue is hard, leathery or soft. A blunt probe, with light force, can easily penetrate an active carious lesion. In contrast, the surface of arrested lesions are hard and smooth [24]. The greatest limitation of this diagnose method is that it can only be useful when the lesion is at an advanced stage, even though inter-examiner reliability has been reported as good to excellent in clinical trials [24].

The second most used method to evaluate caries activity was the ICDAS scoring system, performed by 3 of the selected studies [14, 16, 17]. This method was created in order to standardize caries diagnose method and allow the detect and assess carious lesions in enamel or dentine, coronal and root surfaces, including non-cavitated lesions – which is one of the limitations of other systems [25].

This seems to be a complete method, since the detection of caries in an early stage (non-cavitaded stage) is important for prevention. However, none of the selected studies, that used ICDAS or ICDAS II as a diagnose method, had enough results regarding root surfaces lesions assessment.

Electric caries monitoring assessment (ECM) was used by two studies [9, 10]. ECM is considered a complementary method, and measures the electrical resistance of a site on a tooth during controlled drying, where a sound dentin has higher resistance to electricity [9, 26]. This method allows monitoring the alterations in lesions over time, i.e. monitoring the process of de- or remineralization of the tooth surface, which can be useful (along with a visual-tactile examination), to evaluate the efficacy of preventive or arresting agents that can provide dentin remineralization [9].

Other 3 scoring methods were performed. The first one was proposed by Ekstrand et al. [27], which is a well standard visual-tactile assessment, specific for root caries lesions. This method was used by one of the selected studies [8] and had a good reproducibility level. For the second study [15], a scoring method described previously [28], identifies coronal caries lesions in 3 stages (non-cavitated, cavitated in enamel only, and cavitated involving enamel and dentin). This classification was extended for root surfaces, with 2 stages of lesions: non-cavitated and cavitated. However, the authors were not able to provide sufficient results regarding root caries lesions, due to the lack of exposed root surfaces (7%). The method, described by Pitts and Fyffe [28], uses radiographs as a complement examination of subjects, which was not used by Papas et al. [15]. Perhaps, the use of radiograph images could have helped the authors to identify lesions that were still non-cavitated and/or in hard-to-see locations, like under interproximal contact.

SDF presented the best results in arresting and preventing root caries lesions in patients over 65 years old [12, 13]. The combination of silver and fluorides have the ability to halt caries progression and prevent new caries to develop. SDF has antibacterial properties, remineralization effect on inorganic tooth tissues and can inhibit the degradation of the organic matrix. The amount of fluoride present on 38% SDF solution is 44,800 ppm of fluoride, for that reason, the promotion of remineralization of hydroxyapatite in enamel and dentine can be higher when compared to all other fluoride-based agents [29]. Zhang et al. [12] results show that the control group (placebo solution) developed over a third more new root caries (1.33) when compared to the group that received annual application of 38% SDF (1.00). In addition, the combination of 38% SDF application with biannual oral hygiene education (OHE) provided significantly less number of new caries (0.70). In terms of arresting caries, the benefits of SDF over placebo is also significant, and the addition of OHE promoted the arrest of 18% more active root caries (0.33) than the SDF intervention alone (0.28). Therefore, it is clear the importance and beneficial impact of OHE as a supporting method on the prevention and treatment of caries among elderly. The results of Li et al. [13] corroborates with the previous research [12] in terms of high effectiveness of 38% SDF in arresting root caries, achieving over 90% of lesions arrested. The major side effect of this product is the dark pigmentation of lesion spot after application caused by silver ions. The application of KI immediately after SDF application could prevent this effect by precipitating silver ions. However, according to the same study [13], KI does not reduce blackening of the arrested caries. The use of 38% SDF seems to be a great option for treating root caries in elderly population, especially due to its ease of application and high effectiveness after only one single use. However, the anti-esthetic effect could dissatisfy some patients.

The substitution of a regular toothpaste for daily brushing with a toothpaste that can prevent or treat primary root caries can be a viable and easy treatment method, since brushing teeth daily is a routine for all patients. Hu et al. [9] and Souza et al. [10] evaluated the benefits of a dentifrice containing 1.5% arginine and 1450ppm F in a calcium-base, to manage primary root caries in adults. Their findings suggest that the 6 months use of this arginine-containing dentifrice is able to increase hardness of root surface (61.7% [9] and 70.5% [10]) when compared to the use of dentifrices with fluoride only (56.0% [9] and 58.1% [10]) or without arginine and fluoride (18.2% [9]). The authors attribute the beneficial effect of the non-fluoridated toothpaste (negative control) is by simple plaque control. The inclusion of fluoride (positive control) improves the remineralization effect, due to this well known ability of fluoride. The effect of arginine is related to its capability to modulate plaque metabolism, helping to control acid-producing organisms and reduce pathogenicity [9, 30]. In addition, this arginine-containing dentifrice has an insoluble calcium ratio, which acts as a reservoir of free calcium ions, enhancing the remineralization process [10].

The amount of fluoride in a product composition is an important factor for its effectiveness. The property that fluoride has to control caries development is effective for patients with low risk. However, low concentrations of fluoride might not be enough to decrease caries susceptibility in high-risk patients, like elderly patients (especially those living in community-based residences) [11]. The fluoride concentration in saliva to permit the formation of calcium fluoride needs to be over 100ppm. Throughout brushing,

concentration of fluoride in saliva is around 110 for low-fluoride toothpaste, and 650 for 5000ppm toothpaste. Thus, the high-fluoride toothpaste has a greater advantage on this matter, maintaining a higher concentration of fluoride in oral environment than low-fluoride toothpastes, which allows more formation of calcium fluoride to promote remineralization. Ekstrand et al. [8] and Srinivasan et al. [11], when both compared the efficacy of 5000ppm F toothpaste with low-fluoride toothpastes, found that its use is significantly more effective in arresting coronal and root caries. Particularly for root caries, the preventive effect of the low-fluoride toothpaste was over 2x lower (2.55) than the high fluoride (1.05). In terms of the capability to arrest primary root caries, the daily use of 5000ppm F was 3 times more effective than the low-fluoride toothpaste.

The use of fluoride varnish, chlorhexidine varnish and xylitol were the least effective of the agents found in this review. In Xin et al. [14] clinical trial, the quarterly application of a fluoride varnish provided dental caries prevention ratio of 32,5%, when compared to a placebo application. However, the differences were not statistically significant. The authors attribute this result to a Type II error; where the number of patients recruited were less than estimated, and they do not have enough data to refute or accept their hypothesis. Another limitation of this study could be the selected population (patients with Sjögren's Syndrome). These patients have reduced salivary flow rate that leads to changes in the saliva's composition, reducing its protective effect.

Prevention by chlorhexidine varnish was also not significant. In the selected study [15], this finding may be due to the previously reported [31] inefficiency of CHX in preventing dental caries, to the difficulty in diagnosing caries in the early stages and to the fact that all patients had several procedures done in the dental appointments (restorations at baseline and during the trial, rubber cup prophylaxis, prophy cleaning). Only 7% of the population had root surfaces exposed and the results of this trial represented primarily coronal data. Although their outcomes were not enough to confirm, the authors suggest that CHX varnish might have prevention effect for root caries in very high-risk populations.

Two trials [16, 17] evaluated the potential preventive effect of xylitol lozenges for adults. These studies were related (different sites, same research group – Xylitol for Adults Caries Trial - X-ACT) and did not achieved significant findings to prescribe the supplementation with 1g xylitol for caries prevention. The tooth-surface-specific trial [17] showed no significant effect of xylitol, after 33 months, for smooth-surfaces ($p = 0.100$), occlusal-surfaces ($p = 0.408$) and proximal-surfaces ($p = 0.159$). However, patients of the experimental group developed 40% less root caries than those in the placebo group per year ($p < 0.001$). Which means that more research is required to verify the specific effect of xylitol supplementation for root caries prevention.

For the two non-randomized trials included in this review, there is a need for standardization and details in the methods used. The main concerns regarding Wyatt et al. [22] follow-up study are the absence of a control group, the specifications of the agent used (fluoride concentration and composition of the toothpaste), and the number of patients. These parameters are important to provide validity to the results presented. For example, the statistical significance of the results could be different or not significant if the number of patients were higher. This error is shown in this paper by the high standard deviation value. The lack of control group makes impossible to assess if the use of fluoride toothpaste is in fact effective for this high-risk population or if they should use a better agent to prevent caries. Despite these limitations, the follow-up period of 2 years is enough to show the effect of the toothpaste tested. However, the absence of pertinent details does not allow the authors to provide a reliable conclusion if the use of fluoride toothpaste is effective in reducing the progression or reversal of root caries lesions in elderly after 2 years.

The main limitations of Katsura et al. [23] trial are related to the sample size and its characteristics. The number of patients that concluded the study is small and varies between groups, which could affect the significance of the results. The difference of 10 years (mean age) among the experimental and control groups could also influence the outcome. Regardless of these limitations, this seems to be a well-conducted trial. Their promising results can encourage new research to assess the efficacy of CPP-ACP with sodium fluoride to prevent root caries in patients undergoing head and neck radiotherapy.

Due to the heterogeneity between studies in terms of diagnose methods; it is hard to compare all of them directly. ICDAS scoring system seems to the most complete examination for diagnosing dental caries activity, especially because it allows the scoring of caries in very early stage, which is important to prevent irreversible demineralization by caries progression. However, this method still need more research regarding its application in root caries diagnose, since no studies that used ICDAS had enough findings for root caries. Only one study had a specific diagnose method for root caries [8, 27]. Regardless of this heterogeneity between studies, all methods used had good reproducibility levels and were enough to provide diagnose of dental caries. Nevertheless, more research on methods that can diagnose root caries lesions, especially in very early stages are necessary.

In summary, 38% SDF seems to be the best option to treat and prevent root caries in older adults. Despite the anti-esthetic result, this agent is the fastest and easiest treatment, since it requires only one application per year and demonstrates almost 100% of effectiveness in arresting root caries. If the root lesions are in an aesthetically compromised area and/or prevention is necessary, the use of toothpastes for daily brushing (with 1.5% arginine or 5000ppm F) is also effective and easy to use, since it only requires a simple substitution of the regular toothpaste. Nevertheless, it could be a problem for debilitated patients that are not able to brush their own teeth or do not have someone to do that for them. The use of fluoride varnish, chlorhexidine varnishes and xylitol are not yet proven to be efficient and need more root-caries-specific research.

5 Conclusion

Based on the findings of this systematic review, more research is required in order to define the most effective treatment for root caries in middle age and older adults. At first, more research on methods that can diagnose root caries lesions, especially in very early stages are necessary. The findings of the studies selected for this review shows that annual applications of 38% SDF could be the most effective treatment for root caries in older adults. The greatest advantages of this agent are the easy application and the high effectiveness compared to all other agents mentioned here. Blackening of the lesion is its only disadvantage, which could be stopped by KI, but no evidence of KI efficacy was found in this review. SDF being a good agent to prevent and treat root caries lesions, more research is required in order to reduce its drawback. Additionally, the daily use of a 1.5% arginine toothpaste or a high fluoride toothpaste could also be recommended for prevention and arrest of root caries in the elderly and middle age adults, since both provided good results and only requires the substitution of the regular daily toothpaste.

Clinical Relevance

Root caries among adults are still a concern and requires special attention. The main purpose of this review is to provide a useful analysis of the latest findings on prevention and treatment of root caries in middle age and older adults. These findings could provide researchers with new ideas to improve the characteristics of agents along with the methods used to assess their efficacy; and help clinicians to select the best option for their patients. With the aim of achieving a gold-standard management of root caries.

Declarations

List of abbreviations: F – fluoride; SDF – silver diamine fluoride; NaF - sodium fluoride; ppm – parts per million; CPP-ACP - casein phosphopeptide-amorphous calcium phosphate.

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Consent for publication: Not applicable.

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Authors' contributions: BG and NPP conceived the Study. RC and NA prepared the Study protocol, planned and revised the research Strategy. RC, MAG and NA analyzed risk of bias. RC wrote the first draft. ABCEBC, NA and BG reviewed the final draft. All authors are responsible for the research reported and have seen and approved the manuscript as submitted. All authors have contributed significantly to the work.

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Conflict of interest

There is no conflict of interest.

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Figures

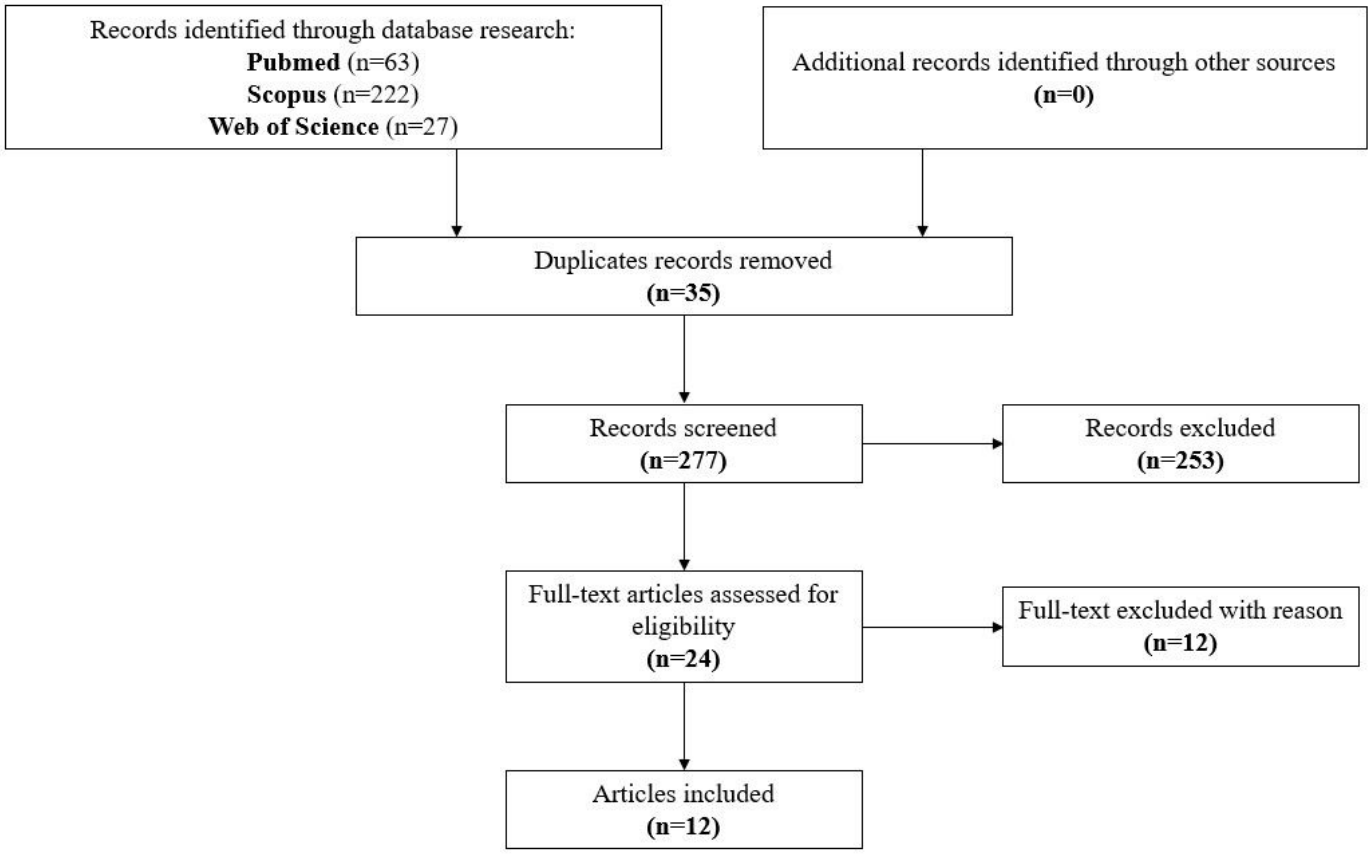

Figure 1

flow diagram

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