White Spot Lesions: Diagnosis and Treatment – a Systematic Review

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Abstract

Background

Dental caries is one of the most prevalent pathologies in the world and its first stage appears as a white spot lesion. It is important to know its activity and the differential diagnoses. There are several ways to diagnose an injury and several clinical approaches to its treatment. The aim of this study is related to a previously established PICO(S) question: “Do new diagnostic tools have the potential to change the conventional treatment of white spots?”.

Methods

A systematic search of available studies in the literature was carried out in Pubmed and Scopus electronic databases and manually to identify relevant articles. This systematic review included trials complying the following inclusion criteria: (1) being in humans, (2) being in English, (3) being about white spot lesions, (4) have been published between 2012 and 2023, (5) having both diagnosis and treatment and (6) having full text available. In this review we excluded other systematic reviews of clinical trials and studies in vitro. The RoB tool was used to assess the risk of bias.

Results

The systematic literature search identified 143 potentially relevant references, which after applying the exclusion criteria, resulted in only 22 articles. Regarding diagnostic methods, most articles found were based on visual examination (10) or fluorescence (7). The least referenced diagnostic techniques were based on the use of clinical photographs (2), cross-sectional microrafiography (1) and computed microtomography (1). The use of DIAGNOdent was reported by 3 studies. With regard to therapies, most studies reported the use of infiltrating resin (7) and fluoride-based products (5). Other studies have reported the use of SAPP11-4 (1), home care (1), CPP-ACP (2) and HCL (1). Combination therapies were also considered: 2 studies reported the use of fluoride varnish, 2 studies used infiltrating resin and fluoride varnish, and one study reported the use of a combination of fluoride varnish and chlorhexidine.

Conclusion

The chosen diagnostic tool does not have the potential to change the form of treatment, whether it is a conventional method or a differentiated one.

Background

Dental caries is the term used to characterize lesions at different stages of development, described by the visible destruction at the tooth´s surface. It is initiated by enamel decalcification, followed by enzymatic lysis of the underlying organic structures leading to the formation of cavities. If not evaluated, the cavities can penetrate the enamel and dentin reaching the pulp [(1)].

This type of oral lesion is the most frequent one in the world, known for its slow development and for having several causes: microorganisms, substrate, host, and time. In addition, socioeconomic and behavioral factors take part in the etiology of the disease [(2)]. The caries’ developmental process is due to the creation of dental plaque on the surface of the teeth, formed by microorganisms such as *Streptococcus mutans*, *Actinomyces* and *Lactobacillus*. These microorganisms decrease pH of the oral cavity, leading to enamel demineralization [(2)].

The equilibrium between the enamel demineralization and remineralization is the ideal environment for oral cavity. This balance is achieved by pH variations due to constantly biofilm changes. Saliva, which has an important role in maintaining the pH and cleaning the environment, will act to prevent the loss of minerals, when the imbalance occurs. Caries occurs when this balance is not observed [(2)].

White spot lesions represent the first stadium of dental caries and their prevalence has been increasing in recent years, particularly in patients undergoing orthodontic treatment [(3)]. Clinically, the appearance of the lesion is opaque white, due to the optical phenomenon caused by mineral loss and the difference in the refractive index of water and air that fill the spaces formed in the enamel [(3, 4, 5, 6)].

In this way, the lesion will be *whitish* and with little translucency since there is an increase in enamel porosity. This surface irregularity then causes a loss of brightness, making the reflection of light diffuse [(7, 8)]. Regarding the time of formation, the lesions develop relatively quickly. However, they are only visible after the tooth surface has dried [(7, 8)]. Thus, the white spot is related to the loss of minerals by the enamel which, when diagnosed in its initial phase, is still partially demineralized and is subject to remineralization [(9)].

White spot lesions are signs of demineralization under a layer of intact, highly mineralized enamel, which may or may not lead to the development of caries. Demineralization is a process that causes mineral loss from the enamel due to the dissolution of hydroxyapatite by the acid environment, thus creating porosities in the enamel [(10)].

A significant correlation can be found between the intensity of white spot lesion color and lesion volume. The intensity of the lesion color can predict the depth of enamel demineralization [(10)].

During orthodontic treatment, there is great difficulty in hygienic care for patients under certain conditions, particularly for those with fixed orthodontic appliances. Now, knowing that orthodontic appliances, due to their inherent characteristics, favor the retention and accumulation of bacterial plaque, hindering

the normal cleaning process, this predicts a high predisposition to caries and associated periodontal problems [11]. One of the most frequent and undesirable sequelae after orthodontic treatment is the white spot lesion without cavitation caused by enamel demineralization [12]. Its formation is caused by several factors, among them we can mention poor oral hygiene, loose bands, dehydration of the tooth during cementation, and isolation of the insufficient area with a mixture of saliva and cement [13, 14]. Moreover, low salivary flow and low buffering capacity do not promote the reduction of microorganisms and food remains in the oral environment, which impairs the neutralization of acids and reduces the tendency to remineralization of the initial lesions of the tooth enamel, leading to caries development [15].

Traditionally, the diagnostic methods for white spot lesions are visual and photographic examination, in order to detect the depth and extent of the lesions. However, in recent years, new techniques have emerged such as fluorescence (the DIAGNOdent mechanism appears within fluorescence), microradiography and microcomputed tomography. These new techniques aim to make a more accurate diagnosis and, thus, make less invasive treatments so as not to weaken the tooth structure.

With the evolution of Dentistry, there are now several treatments for white spot lesions, from more invasive methods to more conservative solutions, which try to preserve the dental structures as much as possible. Within this conservative concept various strategies can be used, such as oral hygiene instructions, prescription of topical fluorides, including fluoride varnish, use of CPP-ACP and infiltrating resin [16]. There are several forms of diagnosis and suitable treatments for white spot lesions, due to different clinical situations. Knowing how to identify a white spot lesion and ensure correct and effective treatment is crucial to promote good care and achieve clinical success. The goal of this study is to understand if the new diagnosis tools can change or improve the white spot´s conventional treatment. For that, a systematic review of the literature was made to answer the PICO(S) question: “Will new diagnosis tools have the potential to change white spots´ conventional treatment?”.

Methods

A systematic search of available studies in literature was conducted in the electronic databases Pubmed and Scopus to identify relevant articles. In addition, the reference list of potentially eligible studies was also screened to verify all relevant articles that may not have been identified during the database searches.

This systematic review will be conducted following the Preferred Reporting Items for Systematic reviews and Meta-analysis (PRISMA) guidelines and will be recorded in the OSF database with the Registration DOI: https://osf.io/9k8fw/.

The search strategies were based on the PICO(S) question “Will new diagnosis tools have the potential to change white spot´s conventional treatment?”, developed for the Pubmed database and adapted for each consulted database. The results of the different bases were crossed to locate and eliminate the duplications.

Below is the defined PICO (S) question:

(Patient/Problem): In patients with white spot lesion, I (intervention): new diagnosis tools, C (comparison): comparison between differential diagnostic tools and conventional ones, O (outcome): the treatment, S (study type): systematic review.

After the literature search, two independent researchers (PL and TC) filter relevant articles that fit the study, analyzing the title and abstract for study selection. Any disagreements between reviewers will be discussed with a third author (ACVMM). Cohen's Kappa test will be performed to assess reviewers' agreement. Rayyan's Intelligent Systematic Review Platform was used to assist in the systematic review process (Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. Syst Rev. 2016 Dec 5;5(1):210).

Reviewers extracted data independently from the articles selected for analysis. The information collected during data collection was as follows: title of the article, year of publication, authors, study design, type of participants, number of participants, age of participants, type of diagnosis and treatment, period of clinical follow-up and the evaluated outcome.

Revised Cochrane risk of bias tool for randomized trials (RoB 2.0)) (Eldridge S, Campbell M, Campbell M, Drahota A, Giraudeau B, Higgins J, Reeves B, Siegfried N. Revised Cochrane risk of bias tool for randomized trials (RoB 2.0): additional considerations for cluster-randomized trials. Cochrane Methods. Cochrane Database Syst Ver. 2016 Out, 10). This analysis is based on five domains: D1 (Bias arising from the randomized process), D2 (Bias due to deviations from intended intervention), D3 (Bias due to missing outcome data), D4 (Bias in measurement of the outcome) and D5 (Bias in selection of the reported result). In each article, the five domains were evaluated and, in each domain, one of the following judgments were applied: low risk, some concerns and high risk. In the end, the most prevalent judgment was the one that determined the final evaluation of each article.

Results

In February 2023 data collection was performed and a systematic literature search identified 143 references potentially relevant, with 99 publications from the

PubMed/Medline database, 33 from Scopus and 11 from manual search. Two duplicates were found and excluded. Based on the information provided in the title and abstract, 90 articles were considered ineligible. The main reasons for non-inclusion were: (1) being a systematic review, (2) being *in vitro* and (3) not being about white spot lesions. Fifty-one articles were analyzed in full to collect more detailed information. Twenty-nine studies were excluded for the following reasons: (1) not having full text available and (2) not having diagnosis and treatment. Finally, 22 studies were included in the following review. The study selection process is shown in Figure 1.

Table 1 in additional files, shows the primary characteristics of the 22 studies selected for this systematic review. Most of the studies selected are RCT (Sedlakova Kondelova et al, 2020; Senestraro et al, 2013; Ciftci et al, 2018; Kirschneck et al, 2016; Huang et al, 2013; Krithikadatta et al, 2013; Bock et al, 2017; Rechmann et al, 2018; Giray et al, 2018; Kucuk et al, 2016; Perrini et al, 2016; Du et al, 2012 and Aykut-Yetkiner et al, 2014). There are also cross-sectional studies (Hadler-Olsen et al, 2012; Roig-Vanaclocha et al, 2020; Marouane et al, 2021; Sezici et al, 2020; Tassery et al, 2013 and Restrepo et al, 2015), longitudinal studies (Hammad et al, 2012 and Kabaktchieva et al, 2014) and only one case report (Marouane et al, 2020). Visual and fluorescence are the most frequent diagnostic techniques, but other techniques such as clinical photographs (Sedlakova Kondelova et al, 2020 and Senestraro et al, 2013), transverse microradiography (Restrepo et al, 2015), microcomputed tomography (Kucuk et al, 2016) and DIAGNOdent (Perrini et al, 2016; Du et al, 2012 and Aykut-Yetkiner et al, 2014) are also used. Interestingly, two studies reported the use of two techniques: visual and fluorescence and fluorescence and transverse microradiography (Giray et al, 2018 and Restrepo et al, 2015 respectively).

Table 1. Characteristics of the 22 studies included in this systematic review

Entry	Article	Study design	Type of participants	Nr of subjects	Age of participants	Diagnostic	Treatment	Outcomes	Interventio time
1	Sedlakova Kondelova et al, 2020	RCT	Patients presenting 2 teeth with WSLs	44	27	Clinical photographs	Self-Assembling Peptide P11-4 (SAP P11-4)	SAP P11-4 lesions showed significant WSL size reduction compared to FV alone	3 months
2	Senestraro et al, 2013	RCT	Orthodontic patients	No information	No information	Clinical photographs	RI	The results for treated teeth showed a mean reduction in WSL area of 61.8 percent immediately after treatment and 60.9 percent eight weeks later	8 weeks
3	Ciftci et al, 2018	RCT	No information	No information	No information	Visual	RI, FV	A significant decrease in DIAGNOdent Pen scores was observed in all the groups	3 months
4	Hadler-Olsen et al, 2012	Cross-sectional	Orthodontic patients	80	12-16	Visual	Home care	23% of treated patients showed good compliance, 68% moderate compliance, and 9% poor compliance. The mean increase in WSL was 1.0, 1.4 and 3.3 in the good, moderate and poor compliance group, respectively	18 months
5	Kirschneck et al, 2016	RCT	Adolescent orthodontic patients	90	No information	Visual	Elmex® fluid and Fluor Protector S	Each treatment group showed a significant increase of the ICDAS index, but not of the gingivitis index	20 weeks
6	Huang, et al 2013	RCT	Orthodontic patients	115	12-20	Visual	MI paste plus, FV	The objective improvements in the affected surface were 16%, 25% and 17% in the MI Paste Plus, fluoride varnish and control groups, respectively	8 weeks
7	Hammad et al, 2012	Longitudinal	Orthodontic patients	18	No information	Visual	RI	Results after Icon application showed that around 65-76% of the surface area of the WSLs was masked	No informatio
8	Krithikadatta et al, 2013	RCT	Patients with occlusal WSLs	45	No information	Visual	CPP-ACP, CCP-ACP with fluoride, NaF mouthwash	All three remineralising agents heal WSL	30 days

9	Bock et al, 2017	RCT	Orthodontic patients	39	No information	Visual	Fluoride gel	No statistically significant group difference existed	24 weeks
10	Rechmann et al, 2018	RCT	Orthodontic patients	37	No information	Visual	MI paste plus, MI varnish	Salivary fluoride levels were significantly higher at 12 months for the experimental than for the control group	12 months
11	Roig-Vanaclocha et al, 2020	Cross-sectional	No information	No information	No information	Visual	HCL	When each application was evaluated with the initial situation of the untreated tooth, we observed that 6.6% HCl removes more enamel than 15% HCl	No informatio
12	Giray et al, 2018	G RCT	WSLs on permanent teeth in children	23	8-14	Visual and fluorescence	RI, FV	The values of the RV group were statistically lower than those of the FV group	6 months
13	Marouane et al, 2021	Cross-sectional	Patients with MIH lesions on permanent anterior teeth	No information	No information	Fluorescence	RI	A non-linear correlation was observed indicating that the IPx was rapid at the beginning of resin application, decreasing over time	No informatio
14	Marouane et al, 2020	Case report	Patients with enamel opacities related to MIH	No information	No information	Fluorescence	RI	The lesions showed a clearly improved esthetic integration and had almost disappeared	1 week
15	Sezici et al, 2020	Cross-sectional	Orthodontic patients	57	No information	Fluorescence	RI	Fluorescence of WSLs improved significantly following infiltration treatment in both groups	No informatio
16	Tassery et al, 2013	Cross-sectional	Patients with carie	No information	No information	Fluorescence	RI	The objectives of preserving the natural tooth structure are achieved	No informatio

17	Kabaktchieva et al, 2014	Longitudinal	Patients with carie	No information	No information	Fluorescence	RI	The lesion progression could be detected very precisely. When the demineralization is slight Icon fi lls all the pores in the body of the lesion and the camera detects sound tissues	1 year
18	Restrepo et al, 2015	Cross-sectional	Orthodontic patients	No information	No information	Fluorescence and transverse microradiography (TMR)	FV, chlorhexidine gel	FV induced faster remineralization than CHX. The correlation between QLF and TMR was significantly moderate	3 months
19	Kucuk et al, 2016	RCT	No information	No information	No information	Microcomputed tomography	GC Tooth Mousse, 50-ppm sodium fluoride solution and Clinpro 5000	GC Tooth Mousse and Clinpro 5000 improved all measurement. The artificial saliva group and the 50-ppm sodium fluoride solution did not show significant effects in the regression of the white spot lesions	30 days
20	Perrini et al, 2016	RCT	Orthodontic patients	24	No information	DIAGNOdent	FV	The varnished anterior teeth showed a statistically significant reduction in demineralization compared with their unvarnished counterparts	No informatio
21	Du et al, 2012	RCT	Orthodontic patients	110	12-22	DIAGNOdent	FV	There was statistically significant differences between the	6 months

								mean DD readings of the two groups at the 3-month ($P < 0.05$) and at the 6-month follow-up visits ($P < 0.01$).	
22	Aykut-Yetkiner et al, 2014	RCT	Children exhibiting at least 1 WSL	60	No information	DIAGNOdent	CPP-ACP	In both groups, the mutans counts were decreased	3 months

Most of the studies reported the use of infiltrating resin and fluoride varnish as treatment techniques (Senestraro et al, 2013; Ciftci et al, 2018; Huang et al, 2013; Hammad et al, 2012; Giray et al, 2018; Marouane et al, 2021; Marouane et al, 2020; Sezici et al, 2020; Tassery et al, 2013; Kabaktchieva et al, 2014; Restrepo et al, 2015; Perrini et al, 2016 and Du et al, 2012). However, the treatment with SAPP11-4 (Sedlakova Kondelova et al, 2020), home care (Hadler-Olsen et al, 2012), Elmex® fluid (Kirschneck et al, 2016), CPP-ACP (Krithikadatta et al, 2013 and Aykut-Yetkiner et al, 2014), fluoride gel (Bock et al, 2017), chlorhexidine (Restrepo et al, 2015), MI paste plus, MI varnish (Rechmann et al, 2018), HCL (Roig-Vanaclocha et al, 2020), GC Tooth Mousse and 50-ppm sodium fluoride solution and Clinpro 5000 (Kucuk et al, 2016) were taken in to account.

In what concerns the intervention time, it is notorious the discrepancy between the studies. The study with lower intervention time reported the use of treatment techniques for 1 week (Marouane et al, 2020). However, more robust studies within 3, 5, 6, 9, 12 or 18 months of using the treatment techniques (Sedlakova Kondelova et al, 2020; Ciftci et al, 2018; Hadler-Olsen et al, 2012; Kirschneck et al, 2016; Bock et al, 2017; Rechmann et al, 2018; Roig-Vanaclocha et al, 2020; Kabaktchieva et al, 2014; Restrepo et al, 2015; Du et al, 2012 and Aykut-Yetkiner et al, 2014) are most of the cases.

The impact of treatment considering diagnostic techniques was evaluated in a range of different cohorts, as children, adolescents, and adults all in good state of general systemic health. The studied population has several characteristics related to orthodontic treatment (Senestraro et al, 2013; Hadler-Olsen et al, 2012; Kirschneck et al, 2016; Huang et al, 2013; Hammad et al, 2012; Bock et al, 2017; Rechmann et al, 2018; Sezici et al, 2020; Restrepo et al, 2015; Perrini et al, 2016 and Du et al, 2012), MIH (Marouane et al, 2021 and Marouane et al, 2020) and carie (Sedlakova Kondelova et al, 2020; Tassery et al, 2013 and Kabaktchieva et al, 2014). The caries identification and evaluation method were mostly accessed by the International Caries Detection and Assessment System (ICDAS II), however other clinical evaluation criteria were also considered.

In the various studies included, different ways of carrying out the diagnosis and treatment were used. Thus, most studies showed positive results, in which the treatment methods used improved or even reversed the white spot lesion on tooth surfaces. Only one study did not show significant statistical differences in treatment with the use of fluoride gel (Bock et al, 2017).

The use of SAPP11-4 was found to be successful compared to the use of fluoride varnish alone in regressing dental caries (Sedlakova Kondelova et al, 2020).

In all studies carried out with infiltrating resin, it presented good clinical results in the aesthetic improvement of the white spot lesion and tooth remineralization (Senestraro et al, 2013; Marouane et al, 2021; Marouane et al, 2020; Sezici et al, 2020; Tassery et al, 2013 and Kabaktchieva et al, 2014). Compared to the use of fluoride varnish, it may even provide better evidence than fluoride varnish (Ciftci et al, 2018), although a study mentioned the opposite (Giray et al, 2018). Some studies report that lesion improvement with infiltrating resin is related to its depth (Hammad et al, 2012).

Another study addressed treatment with chlorhexidine in comparison with fluoride varnish and reported that this varnish induces faster remineralization and therefore assumes better results (Restrepo et al, 2015).

Regarding the use of fluoride varnish, the study that resorted only to this form of treatment show good results, stating that there is a positive change at the mineral level and that it is a good way to prevent the existence of dental caries (Perrini et al, 2016). Although the difference is not very significant when applied to patients with good oral hygiene (Du et al, 2012). This is also reported in another study which refers that the use of fluoride varnish compared to home care does not present major differences in the treatment of white spot lesions (Huang et al, 2013). Likewise, it is reported that an application of fluoride varnish before orthodontic treatment as prevention is not relevant (Kirschneck et al, 2016). Fluoride-based products and home care have proven to be helpful in treating injuries, but compliance by the patients themselves also must be good (Hadler-Olsen et al, 2012; Rechmann et al, 2018 and Kucuk et al, 2016).

The use of CPP-ACP had good remineralization effect in white spot lesions (Krithikadatta et al, 2013 and Aykut-Yetkiner et al, 2014).

The use of HCL also showed good results for the treatment of white spot lesions, despite the percentage of HCL being related to the amount of enamel removal (Giray et al, 2018).

In the following figures, figures 2 and 3, it is possible to observe, through two different graphics, the number of studies that used the different diagnostic methods (figure 2) and treatments (figure 3) in this systematic review. So that in this way, you can have a better perception of the number of studies that refer to each type of method of diagnosis and treatment.

Regarding diagnostic methods, 2 of the 22 used clinical photographs as a diagnostic method, 9 of the 22 used visual examination, 5 of the 22 used fluorescence, 1 used microcomputed tomography and 3 used DIAGNOdent. One used visual examination and fluorescence and another used fluorescence and microradiography.

Regarding treatment methods, 7 out of 22 used infiltrating resin, 5 used fluoride-based products, 1 out of 22 used SAPP11-4, 1 used home care, 2 out of 22 used CPP-ACP and 1 used HCL. Combination therapies were also considered: 2 out of 22 used fluoride varnish, 2 used infiltrating resin and fluoride varnish and 1 used fluoride varnish and chlorhexidine.

Risk of bias analysis

Table 2 shows the risk of bias analysis using the RoB tool. This tool consists of evaluating articles in five different domains.

Table 2. Risk of bias analysis according to the RoB tool (Cochrane Library).

The first domain evaluates Bias arising from the randomized process. In this domain, 13 articles have a low risk, 5 articles have some concerns and 4 articles have a high risk of bias. Domain two refers to Bias due to deviations from intended intervention. In this domain, all articles have a low risk of bias. Regarding the third, Bias due to missing outcome data, 16 articles have low risk and 6 articles have some concerns about risk of bias. Domain four is about Bias in measurement of the outcome. In this domain, 16 articles present some concerns and 12 low risk. In the last domain, which addresses Bias in selection of the reported result, 9 articles present low risk, 12 present some concerns and only 1 presents high risk.

Overall, this analysis resulted in 16 of the 22 articles with low risk of bias and the remaining 6 articles with some problems.

Discussion

It is known that dental caries is a very common pathology, of bacterial origin and that can be noticed, at an early stage, in the form of a white spot lesion. It is known that it is the most common oral pathology, which can affect all individuals of different ages and from different populations, particularly the most socioeconomically vulnerable [17].

Thus, since the high worldwide prevalence of this pathology, this study is very important and relevant. In an attempt to reduce its existence, it is important to study and know both the diagnosis and treatment of caries and, particularly, of the white spot lesion. In this way, we will be able to timely identify and therefore act against this pathology still in an early stage. As well as knowing how to act in the intervention area in order to reduce the prevalence rate of caries and white spot lesions.

In this way, a large number of clinical studies was obtained after searching the various databases [18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31]. This shows the usefulness and relevance of carrying out a systematic review of this subject. Also, because there are variations in the types of white spot lesions and, therefore, it is important to understand the longevity of the appropriate treatment for each clinical situation.

Thus, to allow a better discussion of this topic, the study was based on a PICO question and the PRISMA model. The Rayyan and RoB tools were also used in order to help visualize and operationalize the selection and quality of articles since they are both well accepted in systematic reviews. With this, it was verified that most of the studies had good quality.

In order to be able to discuss and analyze the results obtained and to answer the PICO question, were created two groups (visual and clinical photographs vs fluorescence, Diagnodent, microcomputed tomography and microradiography) considering that the visual and clinical photographs group corresponds to the conventional method and the other group to the new diagnostic techniques.

The choice of diagnostic technique to be used for detecting caries and white spot lesions is important and depends on the clinical case. It is important to understand whether these tools have enough scientific evidence to be chosen over conventional diagnostic techniques and that allow the treatment method to be also differentiated and less invasive than the current one.

Several treatments were reported in studies in which conventional diagnoses such as: SAPP11-4, infiltrating resin, fluoride varnish, hygiene care at home, CPP-ACP, HCL and even chlorhexidine varnish. Therefore, there was no consensus in all articles concerning the treatment associated with conventional diagnostic techniques, although the results were satisfactory in all studies.

The result considered good and satisfactory may have a subjective character since the parameters for evaluating the results are not the same for all articles, which means that the results cannot be evaluated and perceived in exactly the same way.

On the other hand, the treatments reported in the studies in which the diagnoses were differentiated consisted of infiltrative resin, fluor varnish, hygiene care at home with fluoride products, CPP-ACP and even chlorhexidine gel.

The choice of treatments applied after using different diagnostic techniques was also not consensual, as there was variation in the choice of treatment and the results were also all positive.

Thus, all means of treatment promote good evidence in the teeth of patients.

Resin is a more immediate means of treatment that improves esthetics, leads to short- and long-term improvements in tooth decay and white lesions, and does not limit other dental treatments.

Fluorine, whether applied in the form of varnish or in the form of other fluoride products, helps prevent caries and can reverse initial lesions, strengthening the enamel structure and reducing tooth sensitivity. Unlike resin, this mineral product ends up being a less immediate means of treatment, as results are not

observed right after its application.

CPP-ACP products also have advantages such as enamel remineralization, the ability to treat and prevent the occurrence of white spots. These products are easy to apply and help with tooth sensitivity, being compatible with the use of fluoride.

The use of HCL in the treatment of white spot lesions is related to its ability to decontaminate and demineralize the injured areas so that the consequent restorative treatment is possible and more effective.

Chlorhexidine is an antiseptic and antimicrobial agent used against white spot lesions in conjunction with other materials such as fluoride or resins. This will help prevent decay, facilitating its treatment and helping to control lesions.

SAPP11-4 is also a product that can be used in combination with fluorine, not limiting its action and promoting enamel remineralization. This monomeric self-assembling peptide solution can diffuse into carious lesions and promote hydroxyapatite formation, significantly reducing the size of buccal white spot lesions [19].

All these products must be used with expertise and training as they can cause other injuries if misused, as is the case with HCL and chlorhexidine.

According to several studies, both infiltrating resin and the application of fluoride varnishes are effective in the treatment of white spot lesions. The result of treatment with resin is immediate, while fluoride must be applied for a certain period of time for its effect to be noticed. If the continuous release of fluoride manages to combat enamel demineralization, its application will be enough to treat the lesion. Therefore, intervention with infiltrating resin is not necessary. This makes the use of fluoride a non-invasive method. Some studies also consider infiltrating resin to be a less invasive method with many advantages. One of the great advantages refers to the ICON material, which can improve the aesthetics of deciduous and permanent teeth. Thus, immediate resin treatment may be a good option in patients whose level of hygiene is poor, with little likelihood of remineralization [20, 21, 22, 23].

In this way, the application of fluoride varnish has more benefits in uncooperative patients and with a greater lack of hygiene. That is, in patients with good oral hygiene and a low risk of dental caries, the application of fluoride varnish may not show noticeable improvements compared to home hygiene care [24, 25].

Restrepo states that the effects of chlorhexidine compared to fluor turn out to be similar, although chlorhexidine has a slower action.

It was also found that CPP-ACP products combined or not with fluoride are effective in the treatment of white spots, being better than just mouthwashes with fluoride products. Although fluoride products are also effective for tooth remineralization [18, 26].

Studies demonstrate that SAPP11-4 is effective for treating lesions. Since the product does not inhibit the action of fluorine, it can even be applied together with fluorine. Especially because SAPP11-4 ends up having better results than fluor individually. This is a minimally invasive and innovative technique capable of inducing the formation of hydroxyapatite in the lesion itself [19].

Regarding the use of HCL, it is known to be useful in the treatment of white spot lesions. Thus, the application of acid prior to restoration with infiltrative resin allows the surface layer of the lesion to weaken and shrink. However, the use of this product causes corrosion of the enamel surface and, therefore, its application must be careful so that, subsequently, the adhesion and the performance of the restoration are not compromised. Just as care is needed not to compromise the gum, leading to the occurrence of ulcers [27, 28].

Regarding the diagnosis, it is essential that the dentist does not lose the ability to detect a carious lesion or a white spot through visual or photographic examination, as is the most conventional way. However, other forms of diagnosis have emerged, such as fluorescence and DIAGNOdent, as well as microradiography and microcomputed tomography to facilitate and accelerate the diagnostic process.

Fluorescence is useful because it allows more precise and intuitive detection of lesions since it is done through the emission of light. Then, the DIAGNOdent appears, which is a device that uses fluorescence and is minimally invasive and painless, using a quantitative method to assess the severity of the lesion. Fluorescence should not be used individually, but as an aid to the visual diagnosis made by the dentist.

Transverse microradiography is a diagnostic technique used, comparing photographs at different points, also to quantitatively assess the mineral content and perceive the state of remineralization/demineralization of the teeth.

Microcomputed tomography is a high-quality, three-dimensional technique that allows the evaluation of dental structures in high detail.

Regarding diagnostic methods, in general, lesion values decreased, and lesions improved when DIAGNOdent was used [20].

Fluorescence was useful in detecting demineralization and remineralization of lesions. This method has shown, in several studies, to be favorable in assessing the size of the lesion and in evaluating its progression throughout the treatment. The use of fluorescence is quite accurate and ends up surpassing the visual examination. However, it is important to maintain visual inspection skills so that the clinician does not lose his diagnostic sensitivity when inspecting and detecting a lesion [22, 29, 30, 31].

Kucuk et al. state that microcomputed tomography is an excellent method to observe and evaluate the mineral behavior of the white spot lesion [18].

All studies were carried out on individuals of different ages and from different socioeconomic backgrounds, with some reporting the use of orthodontic appliances. In this way, we can observe that the results will be more comprehensive and real.

In general, the studies addressed less invasive techniques, as they considered that acceptance by patients would be better and that the treatment itself would also have advantages the more conservative it was.

Hence, it is not possible to reach a rigorous conclusion. Therefore, in order to draw more conclusions from this study, it would be convenient to follow up on the cases in order to see if the treatments carried out with the differentiated methods have better durability than the treatments carried out with conventional diagnostic methods.

Thus, several conflicting results regarding the type of diagnosis and treatment applied to white spot lesions exist. Although all forms of treatment improve the lesion, some are more invasive than others.

Therefore, both through a conventional diagnosis and through a differentiated diagnosis, the form of treatment does not present great differences and may be the same. This means that there is no scientific evidence of less invasive treatment techniques than the current ones in the face of a differentiated diagnosis. Thereby, the chosen diagnosis type will not change the clinical approach to a white spot lesion.

Conclusion

There are several options for the diagnosis, as well as for the appropriate treatment of white spot lesions, with a positive prognosis and good treatment longevity.

With this systematic review, it is possible to conclude that the diagnostic tool chosen does not have the potential to change the treatment option, whether it is a conventional tool or a different one.

Therefore, there are no differences in the therapeutic approach for the treatment of white spot lesions, regardless of the type of diagnosis used.

Abbreviations

WSL – White Spot Lesion

MIH – Molar-incisor hypomineralization

ICDAS – International Caries Detection and Assessment System

CPP-ACP – Casein phosphopeptide-Amorphous calcium phosphate casein

TEGDMA – Triethylene Glycol Dimethacrylate

SAPP11-4 – Self-assembling peptide P11-4

IR – Resin Infiltration

FV – Fluoride Varnish

HCL - Hydrochloric acid

MI – Minimally invasive

NaF – Sodium fluoride

MIV - Minimally invasive varnish

MIPP - Minimally invasive paste plus

IPx – Infiltration proportion

DD - DIAGNOdent

LIF – Light-Induced Fluorescence

QLF- D - Quantitative Light-induced Fluorescence: Digital System

RCT- Randomized clinical trial

TMR – Transverse microradiography

Declarations

Ethics approval and consent to participate

Not applicable to a systematic review.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article.

Competing interests

Authors declare no competing interests.

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Authors' contributions

PCLopes designed the study, collected and processed the data and drafted the manuscript.

TCarvalho- collected and processed the data and drafted the manuscript.

ATPCGomes collected and processed the data and drafted the manuscript.

NVeiga- revised the final document.

LBlanco revised the final document.

MJCorreia collected and processed the data and drafted the manuscript and revised the final document

AMoura collected and processed the data and drafted the manuscript and revised the final document.

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Table

Table 2 is available in the Supplementary Files section.

Figures

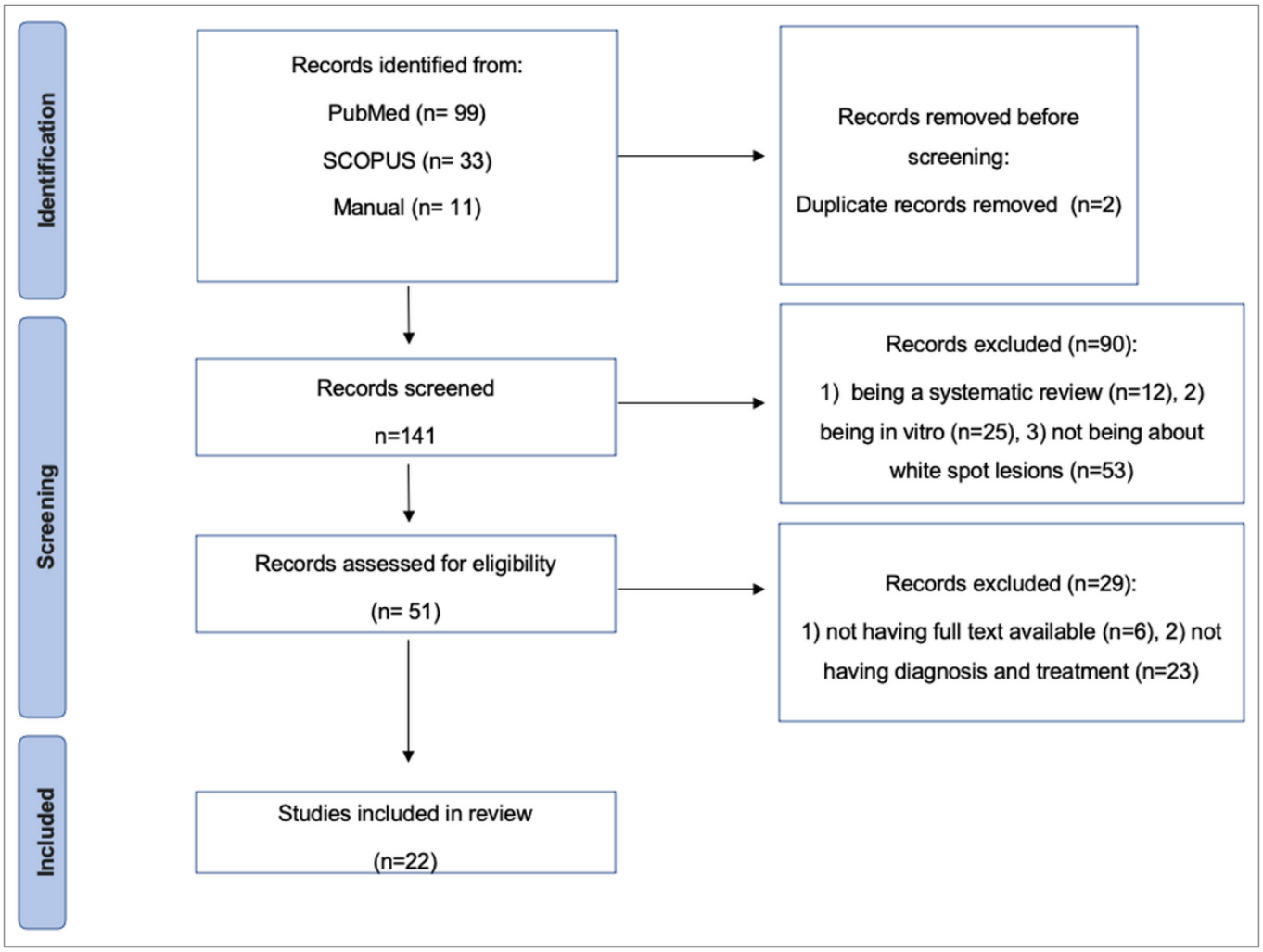

Figure 1

Overview of article selection procedure according to PRISMA guidelines

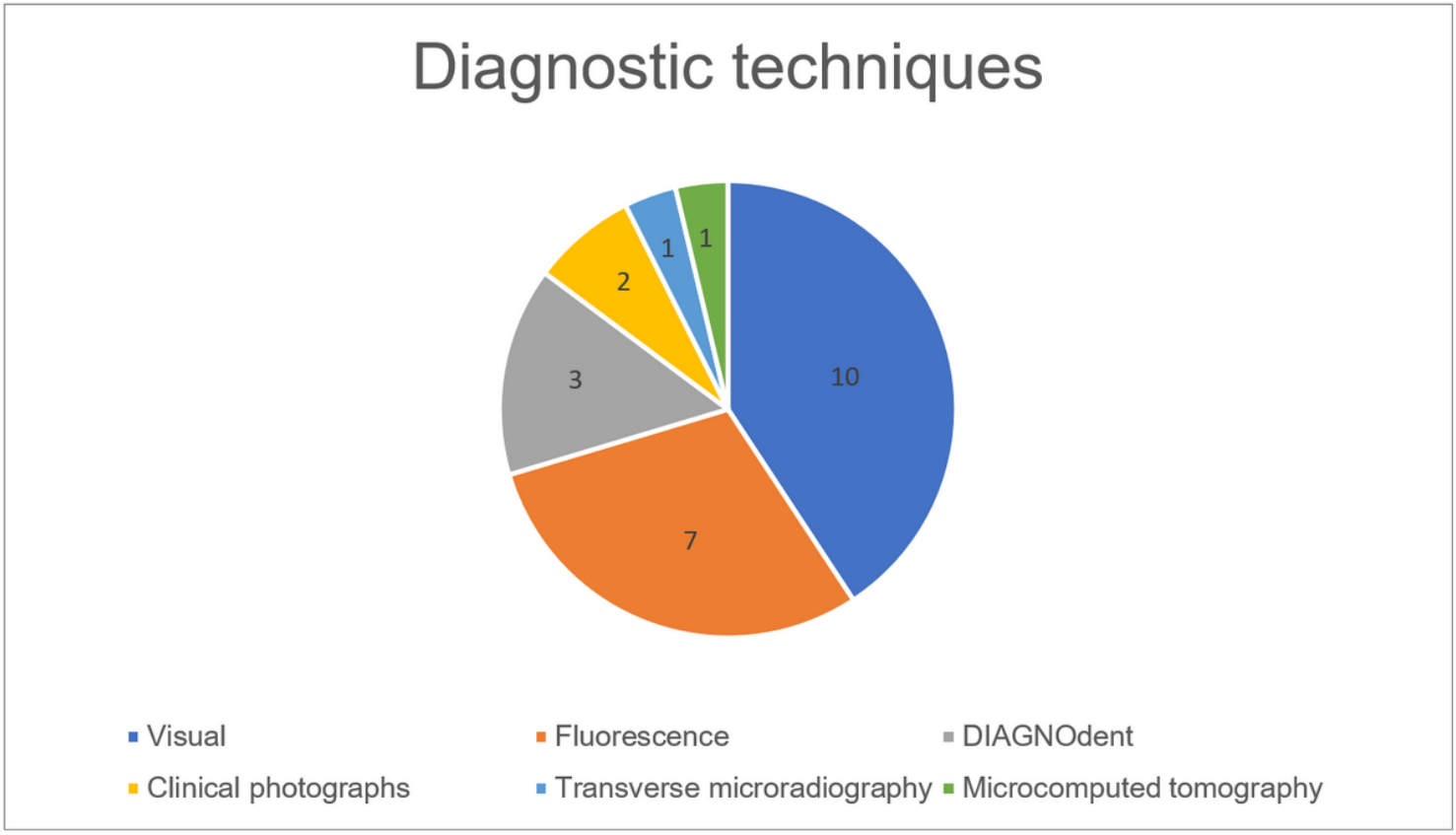

Figure 2

Diagnostic techniques included in this systematic review

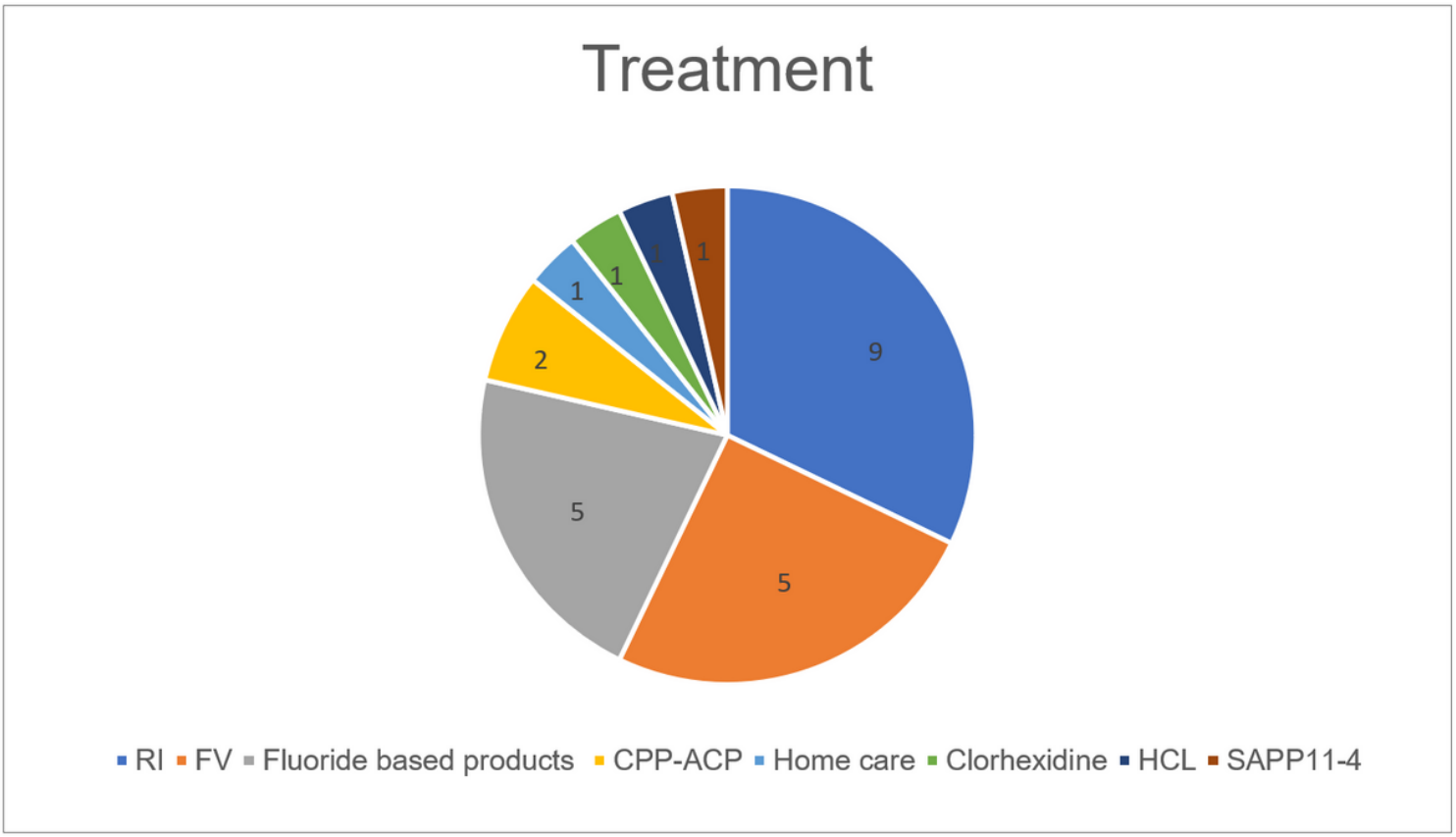

Figure 3

Assessment treatment techniques included in this systematic review

Supplementary Files

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- Table2.docx