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Incidence of white spot lesions following fixed orthodontic treatment: A scoping review

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Abstract

White spot lesions (WSLs) rank as one of the most commonly witnessed undesirable sequelae associated with fixed orthodontic treatment. The present scoping review aims to consolidate the findings of the previous studies to determine the incidence of WSLs among orthodontic patients. The literature search was carried out on MEDLINE/PubMed, Google scholar, Electronic open general access, Science direct, Grey literature database from 1970 till September 2020. Relevant articles were selected based on specified inclusion and exclusion criteria. The study sample, teeth examined, method of evaluation, percentage of patients and teeth surfaces who developed WSLs obtained in the selected studies were tabulated and evaluated. The results suggested wide variation in reporting the incidence of WSLs during fixed orthodontic treatment ranging from 26% to 72.9% in individuals and 6.7% to 24.9% across tooth surfaces. It can be concluded that the risk of developing white spot lesions during orthodontic treatment should not be underestimated by orthodontists and be properly assessed before starting the treatment.

Keywords: white spot lesions, enamel lesions, orthodontic treatment, demineralization, prevalence, incidence

Introduction

Orthodontic treatment is widely popular for its beneficial results, which often mask the underlying potential risks and restraints in terms of tissue damage. The treatment is commonly associated with numerous types of perils such as soft and hard tissue damage which include enamel decalcification, soft tissue lacerations and ulcerations or temporomandibular joint disorders alongside the most commonly seen condition i.e. orthodontic treatment

relapse. White spot lesions (WSLs) rank as one of the most commonly witnessed undesirable sequelae associated with fixed orthodontic treatment.[1] These lesions are defined as demineralization of the enamel surface and subsurface without any cavitation and are known to develop subsequent to prolonged plaque accumulation on the affected surface due to inadequate oral hygiene.[2] The placement of fixed orthodontic appliances naturally limit the self-cleansing mechanisms and hinder effective teeth cleaning contributing to additional plaque retention.[3–5] Consequentially, it enhances the risk of enamel demineralization leading to the development of WSL's on smooth enamel surfaces. WSLs can be differentiated from dental caries as they are mostly present without cavitation and commonly present on the smooth surfaces of enamel surrounding the orthodontic bracket area.

The clinical characteristics of these lesions often vary from mild loss of normal enamel translucency to the presence of pits and fissures. [3] The severity of the appearance of these lesions depends on various factors which have been researched previously.[3] Co-existence of the four factors namely, bacterial plaque, fermentable carbohydrates, a susceptible tooth surface and a sufficient period of time are necessary for WSL to develop.[3] The detection of WSL's has been performed by several approaches such as direct and indirect visualization, fiber-optic transillumination, ultraviolet-light application, fluorescent-dye uptake, and laser fluorescence. Photographic images persist to be routinely used in orthodontic clinics as they are the simplest and most clinically relevant approach for detection of WSL's. More sensitive methods such as quantitative laser techniques provide higher prevalence rate than the conventional methods like simple visual technique.

The prevalence of WSLs has been reported by researchers in different populations across the world.[4,5] However, there exists a wide variation in the percentages, which can be accounted for various factors such as small sample size or the method used for detection. The present scoping review aims to consolidate the findings of the previous studies to assess the incidence of white spot lesions following fixed orthodontic treatment.

Methodology

The scoping review has been registered with Open Science Frameworks.[6] The source search was carried out on MEDLINE/PubMed, electronic general open access, Science direct, Google scholar and grey literature from 1970 till September 2020. The keywords used were white spot lesions, enamel lesions, orthodontic treatment, demineralization, prevalence, incidence. The search strategy has been described for one database has been elaborated in Table 2.The titles and abstracts of the articles found were assessed to meet the inclusion criteria.

The inclusion criteria were (a) Patients who have been treated with fixed orthodontic appliances, (b) Only those articles which longitudinally evaluated both pre and post treatment prevalence of WSLs irrespective of method of diagnosis either in the form of percentage of patients or number of teeth/tooth surfaces were included (c) Treatment time of 18-36 months (d) No fluoride supplementation used during the treatment. The exclusion criteria were (a) History of retreatment; (b) Patients with systemic disease, cysts, clefts or any congenital malformations; (c) Ongoing medication for a chronic disease; (d) Articles in languages other than English ; (e) Case report, Case –series or case-control studies. The methodology flowchart has been shown in Figure1. The source search resulted in a total of 1006 articles which was followed by removal of duplicates and matching of articles for the specific inclusion and exclusion criteria.

This resulted in selection of 8 articles which were later assessed in detail. Out of 8 studies, 6 studies have followed routine use of fluoride toothpaste and oral hygiene measures without any specific preventive fluoride program.[7-11] Use of weekly fluoride gel in addition to routine oral hygiene measures was prescribed in one study by Lovrov et al. whereas no information on fluoride application or other oral hygiene measures was provided in one study by Akin et al. [8,12]

Results

The initial search resulted in 1006 articles. The titles of the 1006 articles were read, duplicates removed and 8 articles were selected. The full text of these 8 articles was retrieved and they were assessed in details in table no 1.

All the 8 studies were longitudinal.[6-13] There was no segregation made according to population type or countries among all the included studies. The method of diagnosis was direct or indirect visual inspection (clinical or photographic). Out of all, 2 studies diagnosed with direct inspection and the rest 6 used indirect visual inspection. Both the studies with direct visual inspection evaluated with WSL index (Gorelick index). Among the 6 studies with indirect inspection, 5 studies used WSL index (Gorelick index) and only one used ICDAS (International Caries Detection and assessment System). Out of these, 3 studies reported the incidence as percentage of patients as well as percentage of teeth affected by WSL.[6,9,13] whereas 4 studies reported only percentage of patients affected [7,8,10,11] and the remaining one study reported only the percentage of teeth affected.[12] The methodology comprising of different groups of teeth assessed, method of diagnosis, method of evaluation, treatment duration, assessment of age of the patients or teeth/ teeth surfaces affected were the variables in different studies.[6-13] Various studies have shown wide variation in reporting the incidence of WSLs during fixed orthodontic treatment ranging from 26% to 72.9% of patients and 6.7% to 24.9% of teeth/tooth surfaces.[6-13]

Discussion

WSLs continue to subsist as the most common corollaries of fixed orthodontic treatment, encountered by orthodontists after treatment completion. Despite of magnitudes of research in this direction, preventing their occurrence still endures to be a huge challenge. A white spot lesion (WSL) is defined as “subsurface enamel porosity from carious demineralization that presents itself as a milky white opacity when located on smooth surfaces”.[14] WSLs can involve any tooth or any surface of teeth.[5] The presence of fixed appliances on tooth surfaces such as brackets and bands contributes to the build of plaque on the tooth surface, hindering effective cleaning and thus, leading to the formation of WSL’s. The presence of WSLs on visible surfaces of the teeth often results in an unacceptable esthetic presentation post-orthodontic treatment thus, nullifying the entire purpose of enduring the treatment.

Various extrinsic and intrinsic risk factors also play an important role in development of WSLs. Extrinsic factors include gender, treatment time, method of evaluation, use of fluorides, poor oral hygiene , carbohydrates, salivary flow volume, teeth involved and intrinsic factors consist of fluorosed teeth, enamel hypoplasia etc, all of which promote the proliferation and bacterial activity of dental plaque.[15] Fixed orthodontic appliances contribute to the adhesion of oral bacteria due to their complex design, which prevents proper cleaning around orthodontic brackets and may result in enamel demineralization.[16] The scoping review compiled information regarding incidence from 8 studies which were selected on the basis of specified inclusion and exclusion criteria. Many factors influence the prevalence of WSLs which are method of evaluation, treatment time and sample size.

Risk Factors

Age and gender

According to Akin et al. and Richter et al., age at the start of treatment was significant factor in WSL development.[8,10] Richter et al. found the decrease in white spot lesions on increasing the age factor.[10] Julien et al. reported that males were more prone to develop WSLs than females though the difference was statistically insignificant.[5] Similarly, in a study by Enaia, it was found that severity of WSLs was more in males when compared to females.[11] while Gorelick et al. reported incidence to be higher in girls.[1] On the other hand, Akin et al. and Lovrov et al. did not report any gender predilection in in WSL development.[8,12]

Oral hygiene

Poor oral hygiene is known to be an important risk factor in WSL formation. Similar findings were reported by Julien et al. [5] i.e. WSLs were found more in poor hygiene group than other fair/good hygiene groups. Similarly, Buschang et al., Akin et al. and Richter et al. also found that quality of oral hygiene maintained by patient played a significant role in WSL development.[7,8,10] According to Oslen et al., WSLs occurred less in good compliance group in comparison to moderate compliance and with poor compliance group. [9] Lovrov et al. found that improved tooth brushing helped in less increase in WSL incidence.[12]

Teeth involved

According to Julien et al., maxillary teeth contribute 2.5 times more to WSLs than mandibular teeth and that they were most commonly found on maxillary lateral incisors followed by maxillary canines, mandibular canines and central incisors.[5] Similar findings were reported by Enaia et al. and Buschang et al.[7,11] Lovrov et al.[12] found WSLs were more commonly present on premolars and incisors than on molars whereas maxillary lateral incisors were found to be the main contributing factor to highest incidence of WSLs as per Gorelick et al.[13]

Fluorosis

Fluorosis has a protective role during fixed treatment against WSLs. In a study by Julien et al., it was found that WSLs development was less in the presence of fluorosis (15%) in comparison to non-fluorosis group(26%).[5]

Lovrov et al. also found decrease in the risk of WSLs on increasing fluoridation.[12]

Treatment time

Julien et al.[5] showed that prevalence of WSLs increased with rise in treatment duration i.e. more WSLs were reported in study group of >36 months than study group of 24-36 months, Similar findings were reported by Richter et al. and Buschang et al.[7,10] On the contrary, treatment time did not contribute to WSLs development as per various studies.[8,12]

Preexisting WSL's

WSLs which are present before orthodontic treatment may contribute more to the development of new lesions. According to Julien et al., new lesions were more in the patients with preexisting WSLs(87%) in comparison to total patients (23%).[5] Buschang et al. also found that worsening of oral hygiene during treatment significantly increased the risk of developing WSLs during treatment.[7] No significant difference was found in WSL incidence due to preexisting WSLs by Lovrov et al.[12]

Salivary flow volume

Decalcification of enamel decalcification on lingual surface of incisors is mainly prevented due to free salivary flow. As a result of this, Gorelick et al. did not found the presence of WSLs when lingual surface was bonded with fixed reatainer.[13] Similarly, Oslen et al. found that the incidence of WSL in the whole dentition was 6.7 percent, the incidence of WSL for the upper anterior teeth was 16.7

per cent which can be due to low salivary clearance in upper incisors leading to reduced poor hygiene.[9]

Method of evaluation

White spot lesions have been classified in the literature using several indices such as Gorelick index, ICDAS system etc.[13,17] The methods of evaluation vary across the decades with evolution and developments in science and technology. The traditional methods of detecting early lesions included visual inspection and conventional imaging while more recent methods are diagnodent, quantitative light-induced fluorescence (QLF), and digital image fiber-optic transillumination (DIFOTI).

The visual observation method utilizes the reflected light to detect changes in color, texture, and translucency of the tooth substance. In the photographic visual inspection of upper and lower teeth till 1st molar using WSL index(Gorelick index), Akin et al. and Lovrov et al. found that 65 % of the patients developed atleast one lesion and 24.9% of the teeth surfaces developed WSLs at the end of treatment respectively.[8,12] Julien et al. and Buschang et al. examined upper and lower canine to canine teeth surfaces using WSL index and found that 61% and 26% of the patients developed WSLs at the end of treatment respectively whereas Enaia et al. examined upper incisors (2-2) and found that 60.9% of the patients had WSL just after debonding and 57.1 % of the patients showed improvement in WSLs 1 year post retention.[5,7,11]

On photographic visual evaluation with ICDAS, Richter et al. found 72.9% of patients were affected at the end of treatment.[10]

On direct visual inspection of upper and lower teeth till 1st molar using WSL index (Gorelick index), Oslen et al. found 60 % patients affected with WSLs at the end of treatment.[9] Gorelick et al. examined upper and lower teeth till 2nd premolar using WSL index and found 49.6% of the patients develop lesion at the end of treatment.[13]

However, due to high levels of inaccuracy and insensitivity of these traditional methods, they are seldom preferred in the current scenario for early caries diagnosis. As the recent method using quantitative laser technique such as QLF which is found to be more sensitive resulting in increased prevalence rate than the conventional technique, certain studies have been done using these methods. In the QLF evaluation, Boersma et al. evaluated the prevalence on the buccal surfaces of teeth in 62 orthodontic patients as determined with QLF immediately after removal of fixed appliances and found that 97% of the patients developed atleast one lesion during full treatment duration and 30% of the teeth surfaces were affected with WSLs at the time of debonding and 31% of teeth surfaces were affected 6 months after retention whereas Beerens et al. found 41.8% of teeth surfaces developed WSLs at the end of treatment and 47.2 % of teeth surfaces were having WSLs one year post retention.[18,19]

There are many recent modalities used to assess caries in various studies like ECM (based on electrical resistance), digital radiographs and other diagnostic aids like DIFOTI devices, transillumination, diagnodent etc.[20,21,22,23] Bakhsh et al. used cross-polarization optical coherence tomography(CP-OCT) to assess the effect of 45S5-bioglass in remineralizing WSLs which is a novel method to assess sites of WSLs and its depth. [24] Polarization-sensitive optical coherence tomography (PSOCT) system is another tool that has been used for in-vitro dental caries assessment of remineralized lesions.[25] Other modalities like Frequency-Domain Photothermal Radiometry (FD-PTR or PTR) and modulated luminescence are also used to assess early surface and interproximal lesions.[26]

In summary, it is important to restate that patient compliance in terms of tooth brushing and prophylactic fluoridation are the most important factors in preventing WSLs during fixed orthodontic treatment. So, proper reinforcement of good oral hygiene and motivation for the measures should be considered by orthodontists.

Conclusion

The results from the review suggest that incidence of WSLs varies widely from 26% to 72.9% in patients and 6.7% to 24.9% of teeth/tooth surfaces. It can be concluded that various factors leading to development of WSLs and associated risk factors should be well understood by orthodontists and decision for fixed orthodontic treatment should be made accordingly as effects of WSLs cannot be underestimated. This scoping review enables clinicians to assess the patients clinically before initiation of treatment so that patients who are at more risk to develop WSLs can be identified and preventive measures can be considered for them.

Future scope

More studies with standardized method of diagnosis, evaluation criteria and if possible, population specific can be conducted. Future clinical research is needed to establish the role of preventive oral hygiene measures in controlling the incidence of WSLs. More longitudinal studies can be performed to establish a relationship between various risk factors and WSLs.

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Legend Tables

Table 1. Summary of studies

S.No.	Reference	Type of study	Year	Sample	Age group	Teeth examined	Treatment duration	Method of evaluation	WSL evaluation time after treatment	% of patients with WSLs	% of teeth /tooth surfaces with WSLs
1	Buschang et al.	Longitudinal study	2019	206	29	3-3(U/L)	24 mo	Photographic inspection (WSL index)	At the time of debonding	26%	
2	Akin et al.	Longitudinal study	2013	150(72 males, 78 females)	10-18	6-6(U/L)	12-24 mo	Photographic inspection (WSL index)	At the time of debonding	55%	
3	Julien et al.	Longitudinal study	2013	885	14-20	3-3(U/L)	24-36 mo	Photographic inspection (WSL index)	At the time of debonding	61%	23.4%
4	Oslen et al.	Longitudinal study	2012	80	12-16	6-6(U/L)	18 mo	Direct visual inspection(WSL Index)	At the time of debonding	60%	6.7%
5	Richter et al.	Longitudinal study	2011	350	14-20	6-6(U/L)	22-33 mo	Photographic visual inspection (ICDAS)	At the time of debonding	72.9%	
6	Enaia et al.	Longitudinal study	2011	400(168 males, 232 females)	13-17	2-2(U)	1.9 yr	Photographic inspection (WSL index)	At the time of debonding/ 1week after debonding	60.9%, 57.1%	
7	Lovrov et al.	Longitudinal study	2007	53(26 males, 27 females)	12-16	6-6(U/L)	12-18 mo	Photographic inspection (WSL index)	At the time of debonding		24.9%
8	Gorelick et al.	Prospective study	1982	121	≥18	5-5(U/L)	23.4 mo	Direct visual inspection(WSL Index)	At the time of debonding	49.6%	11%

Table 2: Search strategy of a database

Data base	Search strategy
PubMed	white spot lesions[Title/Abstract]) OR (enamel lesions[Title/Abstract])) OR (demineralization[Title/Abstract])) AND (orthodontic treatment[Title/Abstract])) AND (prevalence[Title/Abstract])) OR (incidence[Title/Abstract])

Figure 1: Methodology flowchart