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RESEARCH ARTICLE

QUANTIFICATION OF WHITE SPOT LESIONS USING IMAGE ANALYSIS DURING ORTHODONTIC TREATMENT WITH FIXED APPLIANCES – AN INVITRO STUDY

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ABSTRACT

Aim: To use image analysis to compare the pre and post treatment photographs and measure the incidence and severity of white spot lesions in patients who underwent fixed orthodontic treatment. ***Materials and Methods:*** The orthodontic pre treatment and post treatment intra oral (frontal view) digital photographs taken immediately after debonding are analysed by using Image J software version 1.50i. The facial surfaces of the anterior 6 maxillary teeth (canine to canine) are evaluated for WSLs. Teeth identified as having WSLs had their total facial surfaces and the lesion areas outlined with the free hand tool in the Image J 1.50i software and the respective areas are calculated using the same software. The area of the WSL was divided by the area of the total facial surface of the tooth to calculate the percentage of the facial surface affected. Teeth without WSLs are recorded as a zero percentage. The percentage of WSL per total facial tooth surface provided a relative value that controlled for differences in magnification of the digital photos. ***Results:*** Comparison of WSLs in pre and post treatment photographs showed incidence of WSLs were more in right canine. The decreasing order of incidence of WSLs (comparison between WSLs in pre and post group) was right canine, left canine, right lateral, left central, left lateral, right central. The decreasing order of severity of WSLs in pre treatment group was right lateral right canine, left canine, left lateral, left central and right central. In post treatment group was left lateral, right lateral, left central, right canine, left canine and right central. The WSLs were developed more in lateral incisor (24%) when compared with other teeth. Among all the patients 73% developed WSLs on the labiogingival areas of the teeth included in this study. On average 54.5% develop WSLs and 45.5% did not develop WSLs. Among 20 patients 51% of patients develop WSLs on right canine, 46% on right lateral, 55.6% on right central, 42.4% on left central, 49.2% on left lateral, 40.1% on left canine. ***Conclusion:*** Comparison between pre and post treatment photographs showed more incidence of WSLs on right canine. In post treatment group the increase in WSLs was highest in lateral incisors. 73% of patients develop WSLs on the labio gingival areas of the teeth.

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INTRODUCTION

Enamel demineralization is a significant risk associated with orthodontic treatment when oral hygiene is poor. The development of white spot lesions is attributed to prolonged plaque accumulation around brackets. Not only do fixed orthodontic appliances make conventional oral hygiene procedures more difficult, they also increase the number of plaque retention sites on the surfaces of the teeth that are normally less susceptible to caries. The term white spot lesion was defined as "the first sign of caries like lesion on enamel that can be detected with the naked eye[1]." The white spot lesion has also been defined as "subsurface enamel porosity from carious demineralization" that presents itself as "a milky white opacity when located on smooth surfaces[1]."

WSLs can become noticeable around the brackets within one month of bracket placement, although formation of regular caries usually takes at least six months. These lesions are commonly seen on the buccal surfaces of teeth around the brackets, especially in the gingival region. The white appearance of initial carious lesions is due to an optical phenomenon caused by mineral loss in the surface or subsurface enamel. There is substantial evidence that the initial step in development of a carious lesion is mineral loss at the very surface of the enamel. Such lesions are called surface softened lesions and may, in the presence of fluoride in the oral environment, develop into subsurface lesions. Some recent studies have demonstrated an increased prevalence of white spot lesions (initial enamel lesions) after orthodontic treatment with banded and bonded appliances. Remaining white spots may represent an esthetic problem, counteracting the beneficial effect of such treatment.

A classic WSL study demonstrated that 49.6% of orthodontic patients exhibited enamel opacities on at least one tooth after orthodontic treatment[1]. Post prevalence values of individual teeth with white spot lesions were 10.8% for bonded teeth and 12.03% for banded teeth. Significant increases in both prevalence and severity of enamel opacities following orthodontic treatment were reported[2,3]. The prevalence of post treatment WSL in orthodontic patients was reported to be 84%, compared with 72.3% at pre treatment[3]. The need for a systematic method of caries recording in epidemiologic studies led to the development of a visually ranked caries scoring system such as: Initial Caries Detection and Assessment System II (ICDAS II)[4]. This was found to be reliable and accurate. Compared with later stage caries detection by radiographs, the ICDAS II allows for ready detection of small differences in caries lesions. In the absence of clinical observation, colour photographs can be used as a proper alternative. Colour photography as a means of recording enamel opacity is a powerful method. Assessment of enamel demineralization from colour images appeared to be more reproducible than direct clinical observation with only the naked eye[5].

Since intra oral photographs are routinely taken for orthodontic patients before and after treatment, in this study both the pre and post treatment photographs of patients are taken and assessed for the distribution of enamel white spot lesion on the labial surfaces of upper anterior teeth form canine to canine using Image J software, version 1.50i, so that the incidence and severity of WSLs can be assessed by using this software. Until now only the incidence of WSLs was known and studied by using various means, but the distribution and severity of the same is lacking in the literature.

MATERIALS AND METHODS

A sample of 120 patients who underwent fixed orthodontic treatment in the Department of Orthodontics & Dentofacial Orthopaedics at FDS, RUAS are included in this study. All records of the finished patients are collected as per the rules of American Board of Orthodontics. Both intraoral and extraoral photographs, dental casts, orthopantamogram, lateral cephalograms are collected and preserved both prior to and after completion of treatment. All the patients who completed orthodontic therapy in the department are included except for those with poor quality or inadequately angled digital photographs, incomplete records, limited treatment or retreatment, lingual fixed orthodontic treatment, clear aligner treatment, missing teeth, facial restorations on the crowns of teeth being evaluated. At appliance removal, adhesive was removed with a carbide finishing bur and complete removal was verified by air drying the teeth.

Inclusion criteria:

- Standard oral hygiene procedures are being followed.
- DMF score of less than 1 at the start of treatment.
- Patients at the age group of 13 – 25 years.
- Patients who underwent fixed orthodontic mechanotherapy with labial appliances (PAE metal brackets).
- Patients with any type of malocclusion and whose treatment would be more than 12 months.
- Patients with both extraction and non extraction plans of treatment.

Exclusion criteria

- Patients on long term medication for systemic illness.
- Patients with tooth abnormalities like enamel hypoplasia, dental fluorosis etc.
- Patients undergoing re orthodontic treatment.
- Patients with missing teeth or facial restorations on the crowns of teeth being evaluated.

METHODOLOGY

The Orthodontic pre treatment and post treatment intra oral (frontal view) digital photographs will be analysed by using Image J software version 1.50i. The facial surfaces of the anterior 6 maxillary teeth (canine to canine) are evaluated for WSLs. Teeth identified as having WSLs had their total facial surfaces and the lesion areas outlined with the free hand tool in the Image J 1.50i software and the respective areas are calculated using the same software. The area of the WSL was divided by the area of the total facial surface of the tooth to calculate the percentage of the facial surface affected. Teeth without WSLs are recorded as a zero percentage. The percentage of WSL per total facial tooth surface provided a relative value that controlled for differences in magnification of the digital photos.

Armamentarium:

- Both pre and post orthodontic intraoral frontal view photographs of 120 patients.
- Image J software 1.50i(Java).
- The purpose of the study is to compare the incidence and severity of WSLs in pretreatment and post treatment intraoral photographs of orthodontic patients. The photographs were analyzed by using SPSS statistics 17.0 software.

RESULTS

STATISTICAL ANALYSIS: Descriptive statistics, including the mean, standard deviation, minimum and maximum values were calculated for both pre and post treatment photographs and the obtained values were subjected to student t -test to statistically compare the means of WSLs in pre and post treatment photographs. Statistically significant if P value < 0.01.

Table 1. Descriptive statistics for Pre group. Comparison of means of WSLs and total tooth surface of anterior teeth from right canine to left canine in pre treatment intraoral photographs

Parameters	Minimum	Maximum	Mean	SD
13.0	0.0	13554.0	292.4	1385.8
Total	803.0	711003.0	50152.3	79799.5
12.0	0.0	17625.0	363.5	1968.7
Total	1021.0	364608.0	58844.7	67342.0
11.0	0.0	10786.0	276.1	1173.1
Total	1021.0	528697.0	107240.3	108417.2
21.0	0.0	19474.0	373.8	1889.2
Total	1077.0	507011.0	107093.1	106749.0
22.0	0.0	8172.0	302.3	1105.3
Total	742.0	280410.0	55617.2	57169.1
23.0	0.0	10538.0	239.2	1322.0
Total	668.0	215400.0	41772.9	43224.2

Table 2. Descriptive statistics for Post group. Comparison of means of WSLs and total tooth surface of anterior teeth from right canine to left canine in post treatment intraoral photographs

Parameters	Minimum	Maximum	Mean	SD
13.0	0.0	26488.0	1406.2	3054.6
Total	534.0	208095.0	47001.1	45781.6
12.0	0.0	62115.0	1939.3	5412.2
Total	786.0	284037.0	61660.3	57093.8
11.0	0.0	89548.0	2692.4	8981.5
Total	1308.0	463512.0	112200.1	105175.2
21.0	0.0	134313.0	3546.4	12254.8
Total	1095.0	494021.0	114599.3	105894.6
22.0	0.0	99593.0	2872.8	8304.0
Total	598.0	280410.0	60384.0	57184.2
23.0	0.0	40151.0	1252.5	3663.1
Total	397.0	215400.0	45114.1	44378.4

Table 3. Comparison of tooth 13 mean between Pre & Post in WSL by using Paired t-test

WSL	Mean	SD	P-value	Inference
Pre13	292.4	1385.8	<0.01	HS
Post13	1406.2	3054.6		

Table 4. Comparison of tooth 12 mean between Pre & Post in WSL by using Paired t-test

WSL	Mean	SD	P-value	Inference
Pre12	363.5	1968.7	<0.01	HS
Post12	1939.3	5412.2		

Table 5. Comparison of tooth 11 mean between Pre & Post in WSL by using Paired t-test.

WSL	Mean	SD	P-value	Inference
Pre11	276.1	1173.1	<0.01	HS
Post11	2692.4	8981.5		

Table 6. Comparison of tooth 21 mean between Pre & Post in WSL by using Paired t-test

WSL	Mean	SD	P-value	Inference
Pre21	373.8	1889.2	<0.01	HS
Post21	3546.4	12254.8		

Table 7. Comparison of tooth 22 mean between Pre & Post in WSL by using Paired t-test

WSL	Mean	SD	P-value	Inference
Pre22	302.3	1105.3	<0.01	HS
Post22	2872.8	8304.0		

Table 8. Comparison of tooth 23 mean between Pre & Post in WSL by using Paired t-test

WSL	Mean	SD	P-value	Inference
Pre23	239.2	1322.0	<0.01	HS
Post23	1252.5	3663.1		

Table 3 to table 8: shows the difference in means of WSLs in pre and post treatment for 13 to 23. There is HS difference between pre and post groups. Among all the anterior teeth, the most affected tooth was right canine (13) followed by left canine (23), right lateral(12), left central(21), left lateral(22), right central (11). Most severely affected tooth was right canine (13).

Table 9. Comparison of mean between WSL & Total in Tooth 13 (Pre Group) by using t-test

Tooth Type	Pre	Mean	SD	P-value	Inference
13.0	WSL	292.4	1385.8	<0.01	HS
	Total	50152.3	79799.5		

Table 9. Comparison of mean between WSL & Total in Tooth 13 (Pre Group) by using t-test

Tooth Type	Pre	Mean	SD	P-value	Inference
12.0	WSL	363.5	1968.7	<0.01	HS
	Total	58844.7	67342.0		

Table 11. Comparison of mean between WSL & Total in Tooth 11 (Pre Group) by using t-test

Tooth Type	Pre	Mean	SD	P-value	Inference
11.0	WSL	276.1	1173.1	<0.01	HS
	Total	107240.3	108417.2		

Table 12: Comparison of mean between WSL & Total in Tooth 21 (Pre Group) by using t-test

Tooth Type	Pre	Mean	SD	P-value	Inference
21.0	WSL	373.8	1889.2	<0.01	HS
	Total	107093.1	106749.0		

Table 13. Comparison of mean between WSL & Total in Tooth 22 (Pre Group) by using t-test

Tooth Type	Pre	Mean	SD	P-value	Inference
22.0	WSL	302.3	1105.3	<0.01	HS
	Total	55617.2	57169.2		

Table 14. Comparison of mean between WSL & Total in Tooth 23 (Pre Group) by using t-test

Tooth Type	Pre	Mean	SD	P-value	Inference
23.0	WSL	239.2	1322.0	<0.01	HS
	Total	41772.9	43224.2		

Table 9 to table 14: shows the means between WSLs and total tooth surface (area) in pre treatment photographs. All the teeth from 13 to 23 were affected with WSLs, but among all the teeth the most severely affected was right lateral (12), followed by right canine(13), left canine(23),left lateral(22), left central (21) and right central (11).

Table 15: Comparison of mean between WSL & Total (tooth surface area) in Tooth 13 (Post Group) by using t-test

Tooth Type	Post	Mean	SD	P-value	Inference
13.0	WSL	1406.2	3054.6	<0.01	HS
	Total	47001.1	45781.6		

Table 16. Comparison of mean between WSL & Total in Tooth 12 (Post Group) by using t-test

Tooth Type	Post	Mean	SD	P-value	Inference
12.0	WSL	1939.3	5412.2	<0.01	HS
	Total	61660.3	57093.9		

Table 17. Comparison of mean between WSL & Total in Tooth 11 (Post Group) by using t-test

Tooth Type	Post	Mean	SD	P-value	Inference
11.0	WSL	2692.4	8981.5	<0.01	HS
	Total	112200.1	105175.2		

Table 18. Comparison of mean between WSL & Total in Tooth 21 (Post Group) by using t-test

Tooth Type	Post	Mean	SD	P-value	Inference
21.0	WSL	3546.4	12254.8	<0.01	HS
	Total	114599.4	105894.6		

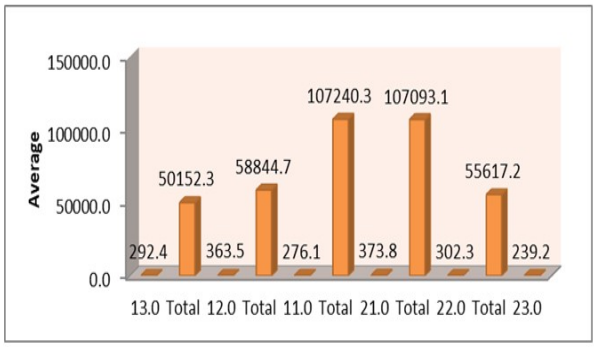
Table 19. Comparison of mean between WSL & Total in Tooth 22 (Post Group) by using t-test

Tooth Type	Post	Mean	SD	P-value	Inference
22.0	WSL	2872.8	8304.0	<0.01	HS
	Total	60384.0	57184.3		

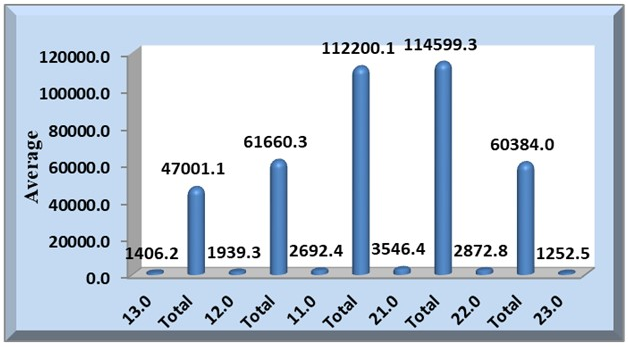
Table 20. Comparison of mean between WSL & Total in Tooth 23 (Post Group) by using t-test

Tooth Type	Post	Mean	SD	P-value	Inference
23.0	WSL	1252.5	3663.1	<0.01	HS
	Total	45114.1	44378.4		

Table 15 to table 20: shows the means between WSLs and total tooth surface in post treatment photographs. These show incidence of WSLs in all the teeth included in this study, but among all the teeth the most severely affected was left lateral (22), followed by right lateral(12), left central(21), right canine (13), left canine (23) and right central(11). Comparison of means of WSLs and total tooth surface between the pre and post treatment photographs showed lateral incisor as the severely affected tooth.



Graph 1. Comparison of means of WSLs and total tooth surface of anterior teeth from right canine to left canine in pre treatment intraoral photographs



Graph 2. comparison of means of WSLs and total tooth surface of anterior teeth from right canine to left canine in post treatment intraoral photographs

The means of WSLs between pre and post groups showed right canine (13) as the most severely affected tooth.

DISCUSSION

The term "white spot lesion" is defined by Fejerskov et al[43] as "the first sign of caries lesion on enamel that can be detected with the naked eye" and used along side with terms "initial" or "incipient" lesions.

Although these terms are meant to deal with description of caries as a dynamic process or, in other words, described one of the first stages of caries development, such lesions may stay stable for many years. In this case they are called "arrested lesions" and are usually not treated and in majority of cases "healing" of these spots happens in form of natural abrasion of superficial enamel during tooth brushing and eating. High prevalence of white spot lesions after orthodontic treatment is explained by difficulties in performing oral hygiene procedures on teeth with braces and arch wires[44]. Caries lesions develop in sites where microbial associations have possibility to form plaque that is not taken away or disrupted by mechanical forces (abrasion) during routine tooth brushing or flossing. There are many methods and instruments for assessing and analysing the presence and severity of enamel WSLs. Commonly used methods are non destructive method, Opacity index, micro-radiographic and SEM examinations, CCD camera with diffuse laser light, clinical photography, direct clinical examination, quantitative laser fluorescence, Diagnodent. In this study digital intraoral photographic method was selected for assessing enamel WSLs, because this was considered as more reliable by some authors[34,36]. But QLF, Diagnodent and CCD camera can also be used for assessing the lesions, but they are expensive[34,36] and cumbersome to use. In a study done by Chapman J, Roberts WE[34] et al concluded that the photographic method was reliable for assessing enamel lesions. They compared the results of photographs and direct clinical examination and observed that 99.2% correlation between these two methods. Amy E. Richter et al[36] also used digital photographs successfully for assessing the lesions. In contrast, Jina Lee Linton[18] concluded that clinical photography is not an adequate method of monitoring the remineralization of white spots with large lesion depths. Hence photographic method was chosen as it is simple, easy and taking photographs of patients is a must in orthodontic treatment plan, so no need for extra time and effort for collecting the photographs[34,36].

There are several factors which are associated to the formation of WSLs. Microorganisms from dental plaque associations near or/and on elements of fixed orthodontic appliance trigger the process of lesion formation[43]. The process starts with dissolution of the crystals in the enamel, resulting into changes of its optical characteristics. As a result enamel becomes opaque (visible for naked eye or "white"), as far as sound enamel disperses the light less than porous enamel[45]. Due to differences in the refractive index of air (stated as 1.00), water (1.33) and enamels crystals (1.66), it is possible to make a deduction that those lesions that require air-drying to become visible (opaque) has lost less amount of minerals than a lesion which is visible without being air-dried. This fact is confirmed by histological studies, that detected a lower level of porosities and less deep penetration of the lesion into the enamel in lesions visible only after being air-dried in comparison to lesions which are visible without being air-dried[43].

The following factors contribute to the formation of white spot lesions

- Microbial factors
- Salivary factors
- Oral hygiene and diet
- Fluoride supplementation during orthodontic treatment
- Patient compliance during orthodontic treatment

Microbial factors: A bacterial plaque that forms near elements of fixed orthodontic appliance is an example of microbial biofilm[46] where associations of microorganisms form three-dimensional structures in matrix of environmental remnants (food, saliva, extacellular material). Among various bacteria, constituting microflora of the dental plaque, mutans streptococci are shown to have significant role in the initiation and progression of dental lesions[47,48]. Several studies also reported an increase in proliferation of lactobacilli in patients undergoing fixed appliance therapy[49].

Salivary factors: Saliva is shown to be an important factor that contribute to the process of loosing and gaining minerals within the enamel-biofilm system[43]. In general, saliva contains sufficient amounts of calcium and phosphate and is supersaturated with respect to components of enamel, making demineralization impossible under normal conditions (provided that saliva is not enriched with acids of diet, gastric or medicinal origins). The bacterial plaque, which is present on or/and near elements of fixed orthodontic appliance, restricts access of saliva to tooth surface. As a result properties of plaque fluid differ from those of saliva. The most important difference is ability of plaque fluid for numerous short time (approximately one minute) pH fluctuations at the border between enamel surface and biofilm, usually initiated by sugar intake. These fluctuations lead to constant multiple short time increase and decrease of concentration of calcium resulting into multiple de- and remineralization processes. Cumulative result of such changes is dissolution of the enamel minerals (hydroxyapatites and fluorhydroxyapatite). Salivary flow rate is also important for WSL formation[45]. It is shown that level of super saturation of saliva with respect to mineral enamel component increases during stimulation of saliva's flow rate, for example during chewing. Due to anatomical position of salivary glands, lower front regions of dental arches experience higher amount of flow resulting into smaller pH drop after exposure to substrates compared with plaque[45]. Gorelick et all[2], described higher incidence of white spot lesions after orthodontic treatment with fixed appliance in maxillary anterior teeth, which also can be attributed to salivary flow.

Oral hygiene and diet: Presence of orthodontic appliance in the mouth makes tooth brushing much more difficult, enhancing the process of plaque attachment[50] on the elements of orthodontic appliance as well as[51] in areas between teeth that brush cannot reach[44]. In addition, fixed elements can prevent tongue and cheeks from removing small pieces of food from interdentally and supply those areas with saliva. As a result, process of multiple plaque formation takes place in the mouth increasing risk of caries initiation process, which was described earlier. That is why proper oral hygiene is crucial during orthodontic treatment with fixed appliance as well as diet. Both frequency and the amount of sugary food intake have etiological importance for caries initiation process, especially the presence of fixed appliance where there is a possibility for easier adhesion to the inaccessible tooth surface areas which results in the enhancement of caries process.

Fluoride supplementation during orthodontic treatment: Along side with proper patient motivation for standard tooth brushing and dietary recommendations, different kinds of fluoride therapy are introduced and shown to be effective in reducing incidence of white spots lesions during fixed orthodontic treatment[44,52]. Fluoride supplement in form of mouthwashes or rinses turned out to be successful, but patients compliance is usually not satisfactory[44]. Fluoride-releasing electrometric ligatures were also tested as a potential solution to the problem of iatrogenic demineralization[53].

As the smile esthetics move up the priority list of a patient's anticipation after appliance removal it can only be threatened by unsightly damaged enamel during debonding. Poor oral hygiene may well destroy a great esthetic result otherwise by way of white spot lesions. This damaged enamel shows up most frequently as a white, opaque area outlining the site of bracket bonding[54]. Prevalence of enamel demineralization in orthodontic patients: Numerous studies regarding enamel demineralization report varied frequencies within the general and orthodontic populations. The reported prevalence of white spots after fixed appliance treatment varies between 2 and 96 per cent[2]. These differences can be attributed to factors, such as diverse demographics, banding versus bonding, emphasis on oral hygiene, use of fluoridated water and other methods of fluoride delivery, and varying methods of analysis. However, several trends can be drawn from these studies.

First, it is generally reported that white spot lesions can occur in as many as 50 percent of teeth with orthodontic appliances and in up to 50 percent of treated patients.[2] Second, white spot lesions are more pronounced at the gingival third of the crown of the tooth, where plaque accumulates[55.] Finally, fixed orthodontic therapy with braces tends to increase the prevalence of white spot lesions when compared to untreated control groups[13]. Orthodontically treated patients show significant numbers of new areas of enamel opacities when compared to controls. Gorelick et al. reported 49.6 per cent of de-bonded patients showed white spot formation on at least one tooth compared with only 24 percent of non-orthodontically-treated controls[2]. Similar to these findings, decalcifications in the control groups of orthodontic patients were found to be 58 percent. Artun et al. concluded that with proper oral hygiene instructions, reinforcement, fluoride prescription usage, and removal of excess adhesive from multi-bonded appliances, there is no significant difference between treated and untreated individuals with respect to white spot lesion formation[56.]

There is certain diversity in locations for white spot lesions. The distribution of lesions is different between treated and control populations, with buccal and lingual surfaces being more susceptible in treated patients. Gorelick et al. reported control teeth most frequently affected by enamel demineralization are maxillary central and lateral incisors, followed closely by mandibular molars[2]. However, during orthodontic treatment, maxillary lateral incisors tended to be most susceptible to decalcification, followed by mandibular canines and premolars[2]. Ogaard found that first molars showed the highest prevalence of decalcification in both control and treated groups. The small area of tooth structure located between the bracket and gingival margin is conducive to plaque retention and with decreased accessibility to oral hygiene measures which allow for white spot lesion formation. Interestingly, white spot formation does not tend to differ significantly with respect to banded versus bonded appliances. In addition, white spot formation with incisors and canines adjacent to bonded lingual retainers has not proven to be more susceptible[12.] Patient compliance during orthodontic treatment:

With all the preventive protocols at the disposal of the orthodontist, the major problem seen is lack of patient compliance. There are numerous reports demonstrating the benefits of proper oral hygiene and fluoride treatment on inhibiting dental caries and re-mineralizing enamel lesions, but patients fail to follow dental professionals' advice.

Compliance is of great concern because the data demonstrate that more severe white spot formation occurs in fixed appliance therapy of over 24 months duration. In these situations, orthodontists are obligated at times to prematurely terminate therapy with noncompliant patients. In a clinical investigation of 101 patients designed to study compliance with home fluoride therapy, Geiger et al. demonstrated a significant association between reduced decalcification with compliance. Patients with poor compliance developed white spot lesions in 64.7 percent of cases, while only 11.8 percent of those with excellent compliance developed decalcification. The same study reported greater than 50 percent of patients had poor compliance, while only 26.7 percent had excellent compliance[44]. A similar study exhibited a compliance rate of only 13 percent with patients asked to decrease their caries risk with daily fluoride mouth rinse[15.] Stratemann and Shannon also had disappointing compliance rates in a study involving daily fluoride usage. Only 2 percent of compliant patients developed white spot lesions, compared to 66 percent of noncompliant patients. Unfortunately only 48 percent of patients were compliant[57]. The slow progression of enamel caries offers the opportunity for dental professional to diagnose and manage caries before there is irreversible destruction of the tooth[58]. Therefore, decalcification can be reduced greatly if clinicians can establish motivational methods for instilling compliance. Unfortunately, patients with poor oral hygiene are the group least likely to comply with proper oral hygiene and fluoride regimens, despite motivational efforts. This is why it is advised to have fluoride-releasing bonding materials that are not dependent upon patient compliance are essential to the orthodontic specialty. In this clinical study the incidence and severity of WSLs on upper anterior teeth (from right canine to left canine) were evaluated by assessing both pre and post orthodontic treatment intraoral photographs of all 220 patients. By using Image J 1.50i software the area of WSLs were calculated on individual tooth surfaces.

In this clinical study comparison of WSLs in pre and post treatment photographs showed incidence of WSLs were more in right canine (from table 3 to 8). In a study done by Bjorn Ogaard[13] the orthodontic group showed mandibular canines as the most affected tooth. In a study done by Leonard Gorelick, Arnold M. Geiger, and A. John Gwinnett, the labiogingival area of the maxillary lateral incisors had the highest incidence of white spots[2]. In a study done by Eliakim Mizrahi, there was a significant increase in the prevalence and severity of enamel opacities on the maxillary and mandibular first molars[8]. Out of 220 patients 51% of patients in the present study showed WSLs on right canine, 46% on right lateral, 45.6% on right central, 42.4% on left central, 49.2% on left lateral, 40.1% on left canine. Out of 220 patients, comparison between pre and post treatment photographs, 4 patients showed decrease in WSLs on right canine, 6 patients on right lateral, 2 patients on right central, 4 patients on left central, 7 patients on left lateral, 3 patients on left canine. On an average in the current study 54.5% developed WSLs, Only 45.5% did not develop WSLs.

Comparison between WSLs in pre and post group showed decreasing order of incidence of WSLs as right canine (13), left canine (23), right lateral (12), left central (21), left lateral (22), right central(11). The decreasing order of severity of WSLs in pre treatment group (Table 9 to 14) was right lateral (12), right canine (13), left canine(23),left lateral(22), left central(21) and right central (11). In post treatment group the decreasing order of severity was left lateral (22), right lateral(12), left central (21), right canine (13), left canine(23) and right central(11) (table15 to 20). The WSLs were developed more in lateral incisors when compared with other teeth.

Lateral incisors were affected by 20% in the current study, which is almost similar to the study done by Chapman J, Roberts WE, Eckert GJ, Kula KS, Gonzalez Cabezas C[34] (lateral incisors24%). A cross-sectional study carried by Eliakim Mizrahi, showed significant increase in the prevalence and severity of enamel opacities on the maxillary and mandibular first molars, the maxillary lateral incisors, and the mandibular lateral incisors and canines[8]. In the current clinical study 73% of patients developed WSLs on the labiogingival areas of the teeth. This is almost similar to the research study done by Leonard Gorelick, Arnold M. Geiger, and A. John Gwinnett concluded that labiogingival area of the maxillary lateral incisors had the highest incidence of white spots[2]. This clinical study did not include all these above explained factors. So it is advised to have a further study and analyze the formation of WSLs including all these factors in to account. The photographs analyzed here are intraoral frontal view images. Owing to the single tooth or multiple teeth in the malocclusion, like crowding, rotations, cross bites, the crown cannot be seen completely because of various angulations. So, in that type of cases photographs with different angulations to focus the tooth completely should be taken for correct results. So all these limitations should be considered if further study has to be performed in future.

CONCLUSION

At the end of fixed orthodontic treatment besides improving the patients profile, some unesthetic appearance of the teeth due to the development of WSLs on the anteriors. The development of these enamel lesions depends upon plaque accumulation, oral hygiene measures, patient compliance etc.
The present clinical study is carried out to compare the presence of WSLs before treatment and at the end of orthodontic treatment on the maxillary anterior teeth from right canine to left canine using pre and post intra oral digital photographs. From the results of the current study the following conclusions can be drawn:

- Incidence of WSLs was more in the maxillary right canine in post treatment group.
- The decreasing order of severity of WSLs in pre treatment group was right lateral, right canine, left canine, left lateral, left central and right central.
- In post treatment group, the decreasing order of severity of WSLs was left lateral, right lateral, left central, right canine, left canine and right central. The WSLs were developed more in lateral incisor (24%) when compared with other teeth.
- Among all the patients 73% developed WSLs on the labiogingival areas of the teeth included in this study.

Suggestions for future directions should include

Future investigations can be directed towards:

- Diagnosis of white spot lesions using image analysis in the posterior teeth
- Clinical application of image analysis for diagnosis of white spot lesions, recording presence of white spot lesions prior to treatment, patient motivation towards oral hygiene maintenance.
- Image analysis can be used to study the efficacy of methods used in the prevention or management of white spot lesions

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