Visual Assessment of Extent of White Spot Lesions in Subjects treated with Fixed Orthodontic Appliances: A Retrospective Study

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ABSTRACT
Aim: White spot lesions (WSLs) are invariably found in patients undergoing orthodontic treatment. The aim of this study was to assess the extent of WSLs in subjects treated with fixed orthodontic appliances for variable time duration.

Materials and methods: In this retrospective evaluation, photographic records of 205 subjects were assessed for extent of WSL using a surface area analysis app. The subjects were split into three groups based on duration of orthodontic treatment: Group A (n = 62): Patients who completed their treatment in 10–12 months; Group B (n = 68): Patients in whom orthodontic treatment was completed in 13–24 months, and Group C (n = 75): Patient with total treatment duration of 25–36 months. The measurements were made at two time points: T0, that is, pretreatment and T1, that is, postdebonding. Total dental area of maxillary teeth was calculated and areas involved with WSLs were calculated for each tooth. Extent of area involved was calculated using the formula: Area of WSL (T1)–Area of WSL (T0). Intragroup comparison was done using paired t-test, intergroup comparison was performed using one-way ANOVA.

Results: Intragroup comparison revealed significant difference in extent of WSL at T0 and T1 in all three groups (p-value < 0.05). Intergroup comparison at T1 revealed a significant difference amongst three groups for the extent of WSLs.

Conclusion: The extent of WSLs depends on the duration of orthodontic treatment. Increased duration of orthodontic treatment was associated with increased extent of WSLs as assessed on digital photographs using an application.

Clinical significance: Longer orthodontic treatment duration is associated with increase in progression of WSLs. Patients undergoing orthodontic treatment, especially for longer duration, must undergo regular oral prophylaxis and should be instructed and motivated to maintain good oral hygiene. Fluoridated mouthwash and remineralizing dentifrices must be incorporated in the daily oral hygiene regime of such patients.

Keywords: Fixed orthodontic appliance, Orthodontic treatment, White spot lesion.

INTRODUCTION
White spot lesions (WSLs) are subsurface enamel porosities resulting from demineralization presenting clinically as milky white opaque areas located on smooth surfaces.¹ Orthodontic appliances including brackets, bands, molar tubes, and wires are niche for plaque accumulation, leading ultimately to demineralization of enamel.² Patients undergoing orthodontic treatment have reported significantly more WSLs when compared to the untreated controls.³⁻⁴ Previous studies have reported that the prevalence of at least one WSL in orthodontic patients was 49.6% compared to the untreated control group where the prevalence was 24%.⁵ The overall incidence of WSL varies from 2–97% in patients undergoing orthodontic treatment.⁶⁻⁸ Orthodontic appliances make regular oral hygiene demanding, even the areas that are usually less susceptible to caries involvement, that is, smooth labial surfaces of teeth are at higher risk to develop WSL. A quick switch in the configuration of the bacterial flora of the plaque is observed following the placement or insertion of orthodontic appliances. The numbers of acidogenic bacteria like S. mutans are noted to be higher in orthodontic patients. Exogenous sugars act as a catalyst for such bacteria. They ferment sugars to products of lactic acid along with other organic acids. The homeostasis of salivary pH is imbalanced, and once it drops below the critical pH, carious decalcification of enamel begins. WSLs are induced clinically in a duration of 4 weeks, which also accounts for the time duration between two orthodontic appointments. Frank cavitations might be noted following 6 months into orthodontic treatment.⁹⁻¹⁰

Apart from thorough clinical inspection, various sophisticated approaches such as fiber-optic transillumination,¹¹ UV light application,¹² fluorescent dye uptake, and laser fluorescence can be used to detect WSLs.¹³⁻¹⁴ However, a more elementary and clinically simple approach such as assessment of photographic images is a routinely used tool in orthodontic clinics for mapping WSL.

Literature on the reports of formation and the prevalence of WSLs at different times during orthodontic treatment at a usual follow up duration of 6 months to 1 year into treatment. However, active orthodontic treatment in many cases extends beyond that

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time period. Fixed orthodontic appliances makes maintenance of oral hygiene challenging, and in subjects requiring extended orthodontic care, progression of WSLs can compromise overall longevity of the tooth. The need of the present study was to assess if extended orthodontic treatment duration can affect the extent of WSLs in subjects undergoing orthodontic treatment with fixed metal brackets. Metal brackets are most commonly used fixed orthodontic appliances and therefore in the current study, photographic records up to 3 years post-treatment of patients who had metal bracket appliances were analyzed using a novel reliable digital application to assess extent of WSLs in pre- and post-treatment photographs.

The objective of this retrospective study was to assess and compare the effect of duration of orthodontic treatment on the extent of WSLs using digital photographs analyzed using an application.

**Materials and Methods**

This retrospective study was conducted at the Department of Orthodontics in a private university in Chennai city, India and was approved by the Institutional review Board (SRB/SDC/MDS/115/001). Digital photographs of 300 patients who finished orthodontic treatment on or before November, 2020 were collected.

**Inclusion Criteria**

Records of the patient who satisfied the following inclusion criteria were included for assessment: (1) Patients with 0.022 MBT prescription metal brackets (3M, Unitek), (2) Patients in the age range of 16–30 years.

**Exclusion Criteria**

Any records were excluded if (1) Images of low-quality standards, (2) Photographs taken at odd and poor angulations, (3) Insufficient records, (4) Retreatment cases, (5) Lingual fixed brackets, (6) Subjects with hypodontia, (7) Subjects with any aesthetic restorations on the labial/buccal surfaces of teeth, and (8) Patients having enamel hypoplasia, white spots, fluorosis of any grade or severity on teeth before orthodontic treatment were not included for the assessment. Frontal, right, and left side intraoral photographs were pooled separately to identify involvement of buccal and labial surfaces.

All the photographs were taken using the digital SLR camera 15–88 mm lens (Canon, Tokyo, Japan) with a Meike FC-100 flashlight.

**Methodology**

Sample size calculation was done at a significance of 0.05 and 95% power. A total of 205 records were eligible to be included in the study. The data was split into three groups on the basis of total treatment duration required to complete ortho treatment. The three groups were as follows: Group A (n = 62; males = 30, females = 32): Patients in whom orthodontic treatment was completed in 10–12 months; Group B (n = 68; males = 33, females = 35): Patients in whom orthodontic treatment was completed in 13–24 months; and Group C (n = 75; males = 37, females = 38): Patients in whom orthodontic treatment was completed in 25–36 months. The mean age of patients was 25.5 ± 3.4 years.

Initial stage and final stage photographs were for the presence of WSLs. Area of the tooth affected by WSL was calculated using the Sketch & Cal App. Following measurements were made: (1) Total dental area (in mm²): The area of labial surfaces of all maxillary teeth. If patients had undergone upper first/second premolar extraction those teeth were eliminated and their area was not included in the total dental area (Fig. 1). (2) Area of WSL at T0 (in mm²): The area involved by white spot lesion before commencing orthodontic treatment, that is, baseline measurement (Fig. 2). (3) Area of WSL at T1 (in mm²): The area involved by WSLs following treatment completion.

Area of WSL was calculated in percentage of total area involved:

- Percentage of Area of WSL (T0) = Area of WSL at T0/Total dental area*100
- Percentage of Area of WSL (T1) = Area of WSL at T1/Total dental area*100

The increase in the extent of WSL was determined by subtracting T1 values from T0.

Increase in the area of WSL = Area of WSL(T1) − Area of WSL(T0)

Assessment, scoring, and image standardization were done by 1 examiner (PV) overseen by the principal investigator (R.K.J). All the measurements were repeated 1 week later to check for repeatability.

**Statistical Analysis**

Statistics were performed using IBM SPSS Statistics Software (Version 23.0, CA, IL, USA). Intercorrelation coefficient was used to assess repeatability for a set of readings obtained at two time points. Normality of data distribution was assessed using the Shapiro Wilk test. Intragroup comparison at two time points was done using paired t-test, whereas intergroup comparison was done using One-way Analysis of Variance (ANOVA). Independent t-test was used to compare prevalence of WSLs amongst males and females in all three groups.
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**Results**

ICC was 0.85 and showed a good repeatability of the measurements made. The results of the current study shows that the percentage of WSLs significantly increased in all the three groups after completion of orthodontic treatment (Table 1).

**Intragroup Comparison**

On intragroup comparison a significant increase was seen in the extent of WSLs involvement from baseline level at T0 to T1 in all the three groups, that is, WSLs increased following orthodontic treatment of any duration. From a baseline percentage of 0.63 ± 0.04 % in Group A the extent of WSLs increased to 13.87 ± 2.89 % after 1 year of treatment completion. (p-value < 0.05) The extent of WSL was significantly higher in Group B and Group C when compared to Group A. In Group B the percentage of WSL involvement increased from 0.87 ± 0.10 % to 21.34 ± 3.21% and in Group C it increased from 0.85 ± 0.08 % at baseline to 24.43 ± 3.87% at T1 (p-value < 0.05) (Table 1).

**Intergroup Comparison**

Three groups had no difference in terms of extent of WSLs before the start of treatment(T0). (p-value > 0.05) Significant difference was noted at T1 amongst the three groups. (p-value < 0.05) Group B and Group C had longer duration of orthodontic treatment and showed an increase in percentage of WSLs higher than compared to Group A where treatment duration was 1 year. The extent of WSLs was 13.87 ± 2.89 %, 21.34 ± 3.21 %, and 24.43 ± 3.87% in Group A, Group B, and Group C, respectively at T1 (Table 1).

In comparison amongst the genders, no significant difference was found in percentage of WSLs in Group A and Group B (p-value < 0.05). However, Group C a significant difference was noted amongst males and females, with the extent of WSLs more in male subjects (p-value < 0.05) (Table 2).

**Discussion**

Several studies have been conducted to assess extent of WSLs in orthodontic patients and compared that to nonorthodontic patients, maximum follow-up being 1 year. However, in actual clinical scenarios the average treatment time may range from 12 months to beyond 36 months, depending on complexity of treatment, treatment mechanics and patient compliance. WSLs are an inevitable sequel to orthodontic treatment, which in mild form may only lead to white discoloration of tooth surface, but if untreated can lead to severe cavitations and will warrant extensive treatment approach. This was the basis of the current research, to evaluate the effect of duration of treatment with the extent of WSLs in patients undergoing orthodontic treatment.

Fixed orthodontic appliances are either metallic or ceramic. Studies have demonstrated a difference in enamel demineralization with two appliances. Therefore, the type of brackets was standardized in the present study. Also, metal brackets are commonly used orthodontic appliances as they are more economic.

Several methods for diagnosis of WSLs exist; however clinical photographs taken at different time points make up for a simple and efficient method for assessing changes in the extent of WSL. However, this method has its own drawback, lack of subjectivity and lack of reproducibility. Despite the availability of other advanced techniques, digital photographic assessment was considered appropriate for a retrospective evaluation of WSL in 205 study participants.

The prevalence of WSLs in the current study was 13.87%, 21.34%, and 24.43% in Group A, Group B, and Group C, respectively. The values of the current studies are lower than those reported previously by Lucchese al. who reported a prevalence of 43% in subjects treated for duration of 6months and 12 months. Studies by Chapman et.al, and Boersma et.al also report higher prevalence of WSL, that is, 46%, 50%, and 97%, respectively, where treatment duration was nearly 2 years. No studies reporting on WSLs prevalence in patients treated for 3 years or more is deficient have been reported so far in existing literature.

A study by Brown et al. assessed prevalence of WSLs in a private practice and concluded that incidence of WSL increased with extended treatment time. The results are in consensus with the results of current study. Extent of WSLs increased significantly as treatment time increased. Patients who underwent treatment for a duration of 32–36 months had 1.7 times more WSLs as compared

### Table 1: Extent of WSLs within the three groups at two different time points. Paired t-test was employed for intragroup comparison and intergroup comparison was evaluated by one-way ANOVA. (p < 0.05 = Statistically significant)

| Extent of white spot lesions (in %) | Group A (Mean ± S.D) | Group B (Mean ± S.D) | Group C (Mean ± S.D) | Intergroup comparison (p-value, ANOVA) |
|----------------------------------|-------------------|-------------------|-------------------|-----------------------------------|
| T0 (pretreatment)                | 0.63 ± 0.04       | 0.87 ± 0.10       | 0.85 ± 0.08       | 0.12                              |
| T1 (posttreatment)               | 13.87 ± 2.89      | 21.34 ± 3.21      | 24.43 ± 3.87      | 0.03**                            |
| Intragroup significance          | **0.05**          | **0.02**          | **0.01**          |                                   |
| (p-value, paired t-test)         |                   |                   |                   |                                   |

**Statistically significant**

### Table 2: Comparison of extent of WSLs amongst males and females of three groups performed using paired t-test (p-value < 0.05 = statistically significant)

| Extent of white spot lesions (in %) | Males (Mean ± S.D) | Females (Mean ± S.D) | Comparison amongst gender (p-value, independent t-test) |
|-----------------------------------|--------------------|----------------------|--------------------------------------------------------|
| Group A                           | 13.41 ± 2.57       | 14.33 ± 3.21         | 0.7                                                    |
| Group B                           | 20.31 ± 3.11       | 22.37 ± 3.31         | 0.5                                                    |
| Group C                           | 26.45 ± 3.84       | 22.41 ± 3.90         | 0.05**                                                 |

**Statistically significant**
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to patients whose treatment was completed within 12 months. Similar findings were reported in the study by Jiang et al. where they concluded that an extended treatment duration (i.e., beyond 17 months) has increased prevalence for WSLs. The findings of these studies are in line with the present study. However, in the abovementioned studies the evaluation was not done for a period as long as 3 years.

No significant difference was found in percentage of WSLs amongst males and females of Group A and Group However, in Group C a significant difference in percentage of WSLs was found amongst males and females. Previous studies have also reported an increased prevalence of WSLs in males in a follow-up period of 12 months. No sexual predilection of WSLs was noted in the current study till a follow-up of even 24 months. The probable reason for this could be that female patients are more amenable and ardent orthodontic patients.

The results of the present study revealed an increase in prevalence of WSLs with an extended orthodontic treatment. Considering that an increased number of WSLs occurred in patients whose treatment took 2–3 years for completion, it is critical to assess the oral health condition of patients every appointment and implement thoroughly the prevention protocols to prevent demineralization of enamel.

Limitations of the current study was that it was a retrospective evaluation, it was not possible to assess factors that could have confounded the results of the study such as dietary intake of all patients which would have altered the progression of WSL. Also, oral hygiene measures adopted by each patient would have been different, and also couldn't be assessed. In the future, long-term prospective studies can be planned with standardized oral hygiene protocols, age groups, genders and duration of orthodontic treatment. A direct clinical evaluation and correlation with digital records can provide for better understanding of depth of WSLs along with the extent of lesion.

Several measures can be adopted by the clinician and patient to limit the progression of WSLs. Foremost being a detailed advisory by the clinician to patients prior starting the orthodontic treatment. Patients must be informed about enamel demineralization associated with orthodontic treatment and therefore oral hygiene instructions must be reinforced at each appointment. Orthodontists must recommend regular oral prophylaxis, once every 6 months, more or less depending upon patients oral hygiene status. Fluoridated mouth rinses should be prescribed along with remineralizing dentifrices containing either novamin, arginine, CPP-ACP, probiotic agents, fluoride, or nano hydroxyapatite that helps in restoring demineralized enamel surface and prevents further progression of WSLs. Application of fluoride varnishes and use of fluoride releasing composites, primers, and e-chains can also be employed, especially in high-risk patients.

WSLs are likely to occur in orthodontic patients and therefore, upon treatment completion their management is crucial. No gold standard procedure exists, however sealants, resin infiltration, micro abrasion, and laser therapy can be used for management of postorthodontic WSLs.

**Conclusion**

The results of the present study show that the prevalence of WSLs increases significantly with duration in patients undergoing orthodontic treatment. Extended orthodontic treatment also increases progression of WSLs. Oral prophylactic measures must be incorporated as a part of routine orthodontic treatment. Patients expected to have a longer treatment duration must be repeatedly instructed to maintain good oral hygiene, fluoridated mouth rinse, and remineralizing dentifrices must be incorporated in the daily oral hygiene regime of the patients.

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