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Prevalence of White Spot Lesion Formation (WSL) During Orthodontic Treatment in Patients Reporting at Orthodontic Department SPH Quetta

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ABSTRACT

Background: White spot lesions (WSLs) are a common complication of fixed orthodontic treatment, resulting from prolonged plaque accumulation around brackets, leading to enamel demineralization. Early detection and intervention are critical to preventing permanent damage and maintaining dental aesthetics.

Objective: To determine the prevalence of WSL formation during orthodontic treatment at different time intervals and to analyze gender differences in susceptibility.

Methods: A cross-sectional study was conducted on 200 patients undergoing fixed orthodontic treatment at Sandeman Provincial Hospital Quetta. Participants were divided into three groups: control (n=56, immediately post-bonding), six-month (n=74), and twelve-month (n=70). WSLs were assessed visually on the maxillary anterior teeth using a standardized scoring system. Data were analyzed using chi-square and logistic regression in SPSS version 25.

Results: WSL prevalence was significantly higher in the six-month (38%, P=0.021) and twelve-month groups (46%, P=0.005) compared to the control (11%). Males had a significantly higher WSL prevalence (76%) than females (24%, P=0.009).

Conclusion: WSLs increased significantly within the first six months of treatment. Early intervention and strict oral hygiene protocols are essential to minimize enamel demineralization.

INTRODUCTION

The development of white spot lesions (WSLs) remains a significant challenge in orthodontic treatment, primarily due to the inherent difficulty in maintaining optimal oral hygiene with fixed orthodontic appliances. The placement of brackets, bands, and archwires creates multiple plaque retention sites that facilitate bacterial colonization, predominantly by acidogenic microorganisms such as Streptococcus mutans and Lactobacilli. These bacteria lower the plaque pH, leading to the demineralization of enamel and the subsequent formation of WSLs, which can appear as early as one month after bracket placement, whereas the progression to cavitated caries usually requires a longer duration (1,5,9). The increased accumulation of plaque around orthodontic appliances poses a considerable challenge, as it alters the bacterial composition of the oral environment, predisposing the enamel to demineralization (7,8).

The prevalence of WSLs varies significantly based on the method of detection and the duration of orthodontic treatment. Visual examination studies have reported that nearly half of the patients completing orthodontic treatment exhibit at least one WSL, while more sensitive techniques, such as quantitative light-induced fluorescence, have identified WSLs in up to 97% of cases (11). The incidence of WSLs has been widely studied, with research highlighting that these lesions predominantly develop on the buccal surfaces of maxillary anterior teeth, particularly in the gingival region adjacent to brackets (1,5,10). Despite advancements in preventive strategies, the management of WSLs remains complex, and clinicians must emphasize early detection and intervention to minimize enamel damage. Studies have consistently reported that without effective preventive measures, demineralization progresses rapidly during the initial months of orthodontic treatment, emphasizing the need for regular monitoring and reinforcement of oral hygiene protocols (6,9).

The literature extensively discusses the prevalence of WSLs post-treatment; however, limited data exist on their progression at different treatment stages. Understanding the temporal pattern of WSL formation is crucial, as early identification may enable orthodontists to implement preventive strategies before lesions become irreversible. While prior studies have primarily focused on WSL prevalence at the end of treatment, there remains a gap in evaluating lesion development at multiple time points during active therapy. Since demineralization occurs rapidly after bracket placement, it is imperative to assess the incidence of WSLs during active orthodontic treatment to

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provide timely intervention. The influence of gender on WSL development has also been debated, with some studies suggesting that male patients exhibit a higher prevalence of WSLs, potentially due to poorer oral hygiene compliance compared to females (1,11,14,15).

Given the aesthetic and functional concerns associated with WSLs, their prevention remains a fundamental aspect of orthodontic care. The current study aims to assess the prevalence of WSL formation in orthodontic patients undergoing fixed appliance therapy at different time points—prior to treatment initiation, at six months, and at twelve months—to better understand the temporal development of these lesions. By investigating the progression of WSLs over time and their association with patient demographics, this research seeks to provide valuable insights into preventive strategies that can mitigate the risks of enamel demineralization during orthodontic therapy (7, 8).

MATERIAL AND METHODS

This cross-sectional clinical study was conducted at the Orthodontic Department of Sandeman Provincial Hospital (SPH) Quetta, affiliated with Bolan Medical College, between October 21, 2021, and April 22, 2022. Ethical approval was obtained from the Research Review Board of Bolan Medical College, and the study adhered to the ethical principles outlined in the Declaration of Helsinki for research involving human subjects. Informed consent was obtained from all participants or their legal guardians before their inclusion in the study.

The study population comprised patients undergoing fixed orthodontic treatment who were aged 12 years or older and had complete initial orthodontic records. Patients with pre-existing enamel hypoplasia, fluorosis, or active carious lesions at the time of bonding were excluded to ensure that only demineralization occurring after treatment initiation was assessed. Additionally, individuals receiving daily fluoride supplementation or using remineralizing agents were excluded to eliminate confounding factors influencing WSL development.

Participants were divided into three groups: a control group consisting of individuals examined immediately after bonding, a six-month group assessed after six months of treatment, and a twelve-month group evaluated after twelve months of active orthodontic therapy. Patient recruitment was carried out through a systematic review of clinical schedules at the orthodontic clinic. Eligible patients were identified weekly, and those meeting the inclusion criteria were approached for voluntary participation. The research assistant recorded demographic details, including age and gender, and assigned participants to their respective groups while ensuring blinding of the examiner to prevent bias in clinical assessments.

White spot lesion assessment was performed through direct visual examination under adequate lighting conditions following the removal of archwires and auxiliary attachments by an orthodontic assistant. The maxillary anterior teeth, from the right second premolar to the left second premolar, were isolated with cotton rolls and air-dried for five seconds to enhance lesion visibility. WSLs were evaluated only on the buccal surfaces gingival to the archwire, as these areas are most susceptible to plaque accumulation and demineralization. The degree of demineralization was categorized using a standardized visual scoring system: Score 0 indicated no demineralization, Score 1 represented mild demineralization, Score 2 signified moderate demineralization, and Score 3 denoted severe demineralization. Clinical assessments were conducted by a single calibrated examiner who remained blinded to patient treatment duration to minimize observer bias.

Statistical analysis was performed using SPSS version 25 (IBM Corp., Armonk, NY, USA). The prevalence of WSLs across the three groups was compared using the chi-square test, followed by Fisher's exact test where necessary. Logistic regression analysis was employed to assess the combined effects of treatment duration and gender on WSL occurrence. The mean number of WSLs per patient was analyzed using analysis of variance (ANOVA), while logistic regression was further applied to evaluate the distribution of WSLs among different tooth types. A significance threshold of $P < 0.05$ was established for all statistical tests.

To ensure the reliability of the clinical examination, intra-examiner consistency was assessed by re-evaluating a random subset of patients one week after the initial assessment. The intra-examiner agreement was calculated using Cohen's kappa coefficient, with a value of ≥0.80 considered indicative of excellent reliability. Data collection and analysis were conducted with strict adherence to ethical guidelines and research integrity standards.

RESULTS

The results of this study indicate a significant prevalence of white spot lesions (WSLs) among patients undergoing orthodontic treatment. The analysis included three groups: the control group assessed immediately after bonding, the six-month group, and the twelve-month group. The findings demonstrated a progressive increase in WSL occurrence with treatment duration, reinforcing the need for early preventive interventions.

In the control group, only 11% of individuals exhibited at least one WSL, whereas the prevalence increased to 38% in the six-month group and further to 46% in the twelve-month group. The statistical analysis confirmed a significant difference between the control group and both the six-month ($P = 0.021$) and twelve-month groups ($P = 0.005$), highlighting the role of fixed orthodontic appliances in promoting enamel demineralization. However, no statistically significant difference was observed between the six-month and twelve-month groups ($P = 0.50$), suggesting that the risk of developing WSLs is highest during the initial months of treatment and then stabilizes over time.

The distribution of WSLs per individual was analyzed further. In the control group, 89% of participants had no WSLs, while 11% had between one and three lesions. In contrast, in the six-month group, 62% of participants had no detectable WSLs, 22% had between one and three lesions, and 16% exhibited four or more lesions. The twelve-month group

followed a similar trend, with 54% free from WSLs, 34% having between one and three lesions, and 12% presenting with four or more lesions. The mean number of WSLs per patient was 0.14 ± 0.24 in the control group, 0.92 ± 0.22 in the six-month group, and 1.13 ± 0.22 in the twelve-month group, with a statistically significant difference observed among these groups (P = 0.01).

A gender-based analysis revealed a substantial disparity in WSL prevalence between male and female patients. Among individuals who developed at least one WSL, 76% were male and 24% were female. In the six-month group, 52% of male patients exhibited WSLs compared to only 19% of females, while in the twelve-month group, 71% of males developed WSLs compared to 22% of females. These differences were statistically significant (P = 0.009), suggesting that male patients are at a higher risk of developing WSLs, possibly due to differences in oral hygiene habits and compliance with preventive measures.

Table 1 Prevalence of White Spot Lesions

Group	Males with WSLs (n, %)	Females with WSLs (n, %)	P-value (Male vs. Female)
Control	2 (7%)	4 (15%)	-
6-Month	22 (52%)	6 (19%)	0.009
12-Month	24 (71%)	8 (22%)	0.009

Table 2 Prevalence of White Spot Lesions

Group	Total Patients (n)	Patients with WSLs (n, %)	P-value (vs. Control)
Control	56	6 (11%)	-
6-Month	74	28 (38%)	0.021
12-Month	70	32 (46%)	0.005

Table 3 Mean WSLs per Patient

Group	(Â±SD)	No WSLs (n, %)	1-3 WSLs (n, %)	â‰¥4 WSLs (n, %)	P-value
Control	0.14 Â± 0.24	50 (89%)	6 (11%)	0 (0%)	-
6-Month	0.92 Â± 0.22	46 (62%)	16 (22%)	12 (16%)	0.01
12-Month	1.13 Â± 0.22	38 (54%)	24 (34%)	8 (12%)	0.01

Table 4 Adverse Events

Group	No Adverse Events (Count)	Yes Adverse Events (Count)	Total (Count)	No Adverse Events (%)	Yes Adverse Events (%)	Chi-Square	p
Lumbar Roll Manipulation	37	8	45	82.20%	17.80%	0.073	0.788
Modified SIMS Manipulation	36	9	45	80.00%	20.00%		
Total	73	17	90	81.10%	18.90%		

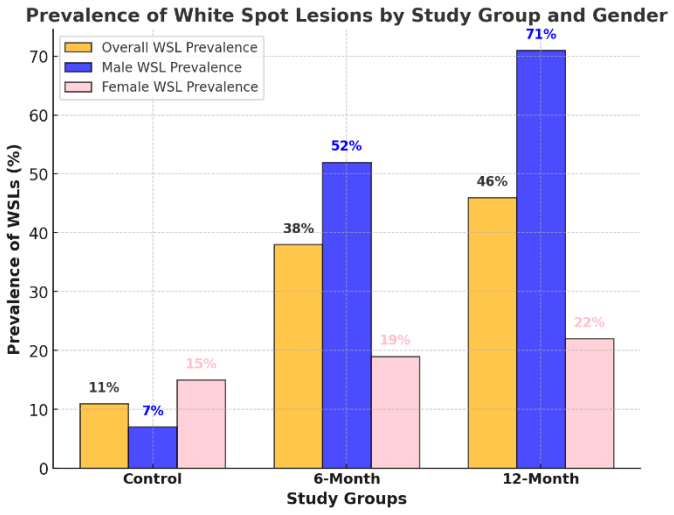

Figure 1 Prevalence of White Spot Lesions

DISCUSSION

The findings of this study proved a significant increase in the prevalence of white spot lesions (WSLs) among orthodontic patients over time, emphasizing the detrimental effects of fixed orthodontic appliances on enamel demineralization. The control group exhibited a considerably lower prevalence of WSLs compared to the six-month and twelve-month groups, confirming that prolonged treatment with fixed appliances exacerbated the risk of enamel demineralization (16-21). This trend was consistent with previous research, which reported a progressive increase in WSLs as treatment duration extended due to the accumulation of plaque and the proliferation of acidogenic bacteria in plaque-retentive areas around brackets (1,5,9). The initial months of treatment appeared to be particularly critical, as a sharp rise in WSL prevalence was observed by six months, followed by a relatively stable rate at twelve months. This finding aligned with earlier studies, which indicated that WSLs could develop as early as one-month post-bonding,

with the most rapid demineralization occurring in the initial phase of treatment (22-29).

The gender-based analysis revealed a significantly higher prevalence of WSLs in male patients compared to females, a finding that suggested behavioral and compliance differences in oral hygiene practices. Prior studies also reported that male orthodontic patients exhibited poorer oral hygiene compliance and a higher incidence of WSLs, likely due to less adherence to preventive measures such as fluoride use and dietary restrictions (11,14,15). The disparity in WSL occurrence between genders underscored the importance of individualized patient education and reinforcement of oral hygiene measures, particularly among male patients. While previous studies had conflicting findings regarding the influence of gender on WSL development, the present results supported the notion that males were more susceptible to demineralization due to less meticulous oral hygiene practices during orthodontic treatment (1,11).

A notable strength of this study was the use of a standardized visual assessment protocol to evaluate WSLs under controlled conditions, ensuring consistency in lesion detection. The single-examiner assessment minimized observer variability, and the inclusion of multiple time points allowed for a clearer understanding of lesion progression over time. Additionally, by excluding individuals with pre-existing enamel defects or those using fluoride supplementation, the study effectively isolated the impact of orthodontic treatment on WSL formation. However, certain limitations should be acknowledged. The reliance on visual examination, while clinically relevant, may have underestimated the true prevalence of WSLs, as early lesions that were not yet visually detectable could have been missed. More advanced diagnostic methods, such as quantitative light-induced fluorescence or optical coherence tomography, may have provided a more precise assessment of enamel demineralization (11). The study also focused exclusively on maxillary anterior teeth, as gingival hyperplasia and plaque accumulation made WSL assessment challenging in posterior teeth. Future research incorporating a broader range of teeth and assessment methods could provide a more comprehensive understanding of WSL development (30-32).

Given the high prevalence of WSLs observed in the early months of treatment, preventive interventions should be emphasized from the outset of orthodontic therapy. Routine monitoring, early detection, and the implementation of remineralization strategies such as fluoride varnishes, casein phosphopeptide-amorphous calcium phosphate applications, and improved oral hygiene instruction could significantly reduce the risk of enamel demineralization. The findings reinforced the necessity of patient-specific preventive plans, especially for individuals identified as high-risk, such as male patients. Further investigations are needed to explore the effectiveness of various preventive strategies and their long-term impact on reducing WSL prevalence. Future studies should also assess patient compliance with different oral hygiene measures to determine the most effective strategies for mitigating the adverse effects of orthodontic treatment on enamel integrity.

CONCLUSION

The findings of this study underscored the significant risk of enamel demineralization associated with fixed orthodontic treatment, with the highest prevalence of white spot lesions (WSLs) occurring within the first six months and persisting at twelve months. The pronounced disparity in WSL occurrence between male and female patients highlighted the role of behavioral factors in oral hygiene maintenance. Given the irreversible nature of advanced demineralization, early preventive measures, including fluoride application, patient education, and strict oral hygiene protocols, are essential to mitigate WSL formation. These results reinforced the need for orthodontists to implement proactive strategies to preserve enamel integrity, ultimately improving long-term dental health outcomes for patients undergoing orthodontic therapy.

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