Innovative Research Journal of **Dentistry** (IRJD)
2024; 2(1):1-8
DOI: https://doi.org/10.62497/irjd.101

Research Article

Prevalence of White Spot Lesions in Fixed Orthodontic Patients and the Role of Fluoride Varnishes in Prevention

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Citation: Ahmad H, Rafaqat MS, Nasir H, Mukkaram M, Naina SA. Prevalence of White Spot Lesions in Fixed Orthodontic Patients and the Role of Fluoride Varnishes in Prevention. IRJD. 2024; 2(1):1-8. DOI: https://doi.org/10.62497/irjd.101 Available from: https://irjpl.org/irjd/article/view/101

Article Info

Received: March 19, 2024
Revised: April 28, 2024
Accepted: May 4, 2024

Keywords

White spot lesions, fluoride varnish, fixed orthodontics, enamel demineralization, preventive dentistry.

Abstract

Introduction: Patients receiving fixed orthodontic treatment often develop White spot lesions (WSLs) are early signs of enamel demineralization. Brackets and wires make it more difficult to practice good oral hygiene, which raises the risk of plaque buildup and the development of WSL. Fluoride varnishes promote enamel remineralization and have been shown to reduce the risk of "WSLs" formation.

Methodology: This cross-sectional study was conducted at the Orthodontics Department of Khyber College of Dentistry, Peshawar, over one year. A total of 132 patients receiving fixed orthodontic treatment for at least six months were included. Participants were divided into two groups: Group A received 5% sodium fluoride varnish at three-month intervals, while Group B received no fluoride treatment. Clinical evaluation was conducted using modified ICDAS criteria. Data were analyzed using SPSS version 26, applying chi-square and t-tests, with logistic regression to identify associated risk factors.

Results: The overall prevalence of "WSLs" was 48.5%. Group A had significantly fewer lesions (28.8%) compared to Group B (68.2%) ($p < 0.001$). The mean number of lesions per patient was also significantly lower in the varnish group (1.21 ± 1.38) than in the control group (3.05 ± 2.41). Logistic regression confirmed fluoride varnish as a protective factor (OR = 0.28, $p < 0.001$).

Conclusion: Fluoride varnish significantly reduces the prevalence and severity of "WSLs" in orthodontic patients. Routine application should be considered as a preventive strategy during fixed orthodontic treatment.

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Introduction

In order to improve oral function and appearance and rectify dental malocclusions, fixed orthodontic therapy is essential. Nevertheless, despite all of its advantages, fixed appliances create an environment conducive to plaque accumulation and bacterial growth [1, 2]. The presence of brackets, wires, and other orthodontic components can make maintaining oral hygiene especially difficult, increasing the risk of enamel demineralization next to these appliances [3]. When these biofilms are not properly controlled, they cause demineralization of the enamel surface, which frequently shows up as "WSLs", the earliest visible signs of dental caries [4].

The loss of calcium and phosphate ions causes subsurface enamel porosity in "WSLs" which gives the enamel a chalky white look [5]. If not detected and treated promptly, these lesions may develop into cavitated carious lesions in addition to being unsightly [6]. It has been observed that the incidence of "WSLs" in orthodontic patients varies greatly, ranging from 25% to over 90%, depending on variables including eating patterns, saliva composition, dental hygiene habits, and preventative measures [7]. Most often impacted are the maxillary incisors and canines, particularly in the cervical and interproximal areas [8].

Preventive strategies are critical in minimizing the risk of WSL development during orthodontic therapy. Among these, the use of fluoride-based agents has gained widespread acceptance due to their ability to enhance enamel remineralization and inhibit demineralization [9]. Particularly fluoride varnishes have been proven to be very successful in creating a protective coating over the enamel, releasing fluoride over time, and reaching the enamel subsurface to encourage mineral deposit [10, 11]. Their effectiveness in lowering the incidence and degree of "WSLs" has been validated by many clinical and in vitro investigations. Simple, safe, and well accepted by patients, fluoride varnish treatments are a sensible preventative action in clinical orthodontic practice [12].

Apart from fluoride varnishes, patient education, dietary advice, and regular oral hygiene reinforcement, a thorough WSL preventive program depends critically on this elements [13]. Patients' adherence to preventive measures varies, leading to inconsistent outcomes. Furthermore affecting its efficacy are time, frequency, and technique of application of fluoride varnish, thereby stressing the requirement of consistent procedures. Understanding both the local prevalence of WSLs and the practical effectiveness of fluoride varnish in clinical settings is essential for optimizing preventive strategies.

Although many research assess the efficacy of fluoride in caries prevention, there is no region-specific data on the real frequency of "WSLs" in orthodontic patients in clinical settings and how often fluoride varnishes are used or effective in such group. The purpose of this research is to assess the frequency of "WSLs" among patients under fixed orthodontic treatment and investigate the preventative effect of fluoride varnishes in their occurrence.

Materials and Methods

Study Design and Setting

This cross-sectional study was conducted in the Department of Orthodontics, Khyber College of Dentistry (KCD), Peshawar. It aimed to assess the frequency of "WSLs" in patients undergoing fixed orthodontic treatment and to evaluate the preventive effect of fluoride varnish in their development.

Study Duration

The study was carried out over a period of 12 months, from January 2023 to December 2023.

Sample Size Calculation

The sample size was calculated using the formula for estimating a proportion in a cross-sectional study.

$$\boldsymbol{n = \frac{Z^2 \,.\, p \,.\, (1 - p)}{d^2}}$$

Under a 95% confidence level (Z = 1.96), an anticipated prevalence (p) of 50%, and a margin of

error (d) of 9%, the computed sample size was 119. The ultimate sample size was raised to 132 to accommodate for non-responses or missing data.

Sampling Technique

Non-probability sequential sampling was used. Up until the necessary sample size was reached, all qualified patients attending the orthodontic department were asked to take part.

Inclusion and Exclusion Criteria

Patients between the ages of 12 and 35 who had been under at least six months of fixed orthodontic treatment and were ready to provide informed permission constituted the study's inclusion criteria. Patients with pre-existing enamel defects or fluorosis, those utilizing detachable orthodontic equipment, those with systemic disorders impacting oral health, and patients undergoing external fluoride treatment outside of the research were excluded.

Data Collection Tools and Procedures

Demographic information, oral hygiene routines, food habits, and treatment history were gathered using a standardized questionnaire. Clinical examinations were performed by trained dentists under standardized conditions. Data entered into a pre-made proforma.

Assessment of White Spot Lesions

"WSLs" were evaluated by modified International Caries Detection and Assessment System (ICDAS) criteria. We noted WSL number, degree, and location as well as their all tests were done by a calibrated examiner in order to be consistent and lower inter-observer variability.

Fluoride Varnish Protocol

Group A, the intervention group, had 5% sodium fluoride varnish applications at 3-month intervals during the course of therapy; Group B, the control group, did not have any professional fluoride treatments. Using manufacturer recommendations, the fluoride varnish was expertly applied to every tooth surface. Furthermore strengthened for all groups was oral hygiene advice to guarantee continuous treatment and maintenance all through the trial.

Data Analysis

IBM SPSS Statistics version 26 was used for statistical analysis. Descriptive statistics were used to compile demographic traits including age, gender, dental hygiene practices, and orthodontic treatment length. "WSLs" were reported as percentages; the mean number of lesions per patient was computed for both groups—fluoride varnish and non-varnish. Mean lesion counts between the two groups were compared using the independent t-test; the chi-square test was performed to evaluate the relationship between fluoride varnish treatment and the existence of WSLs. Furthermore, logistic regression analysis was done to adjust for any confounding factors like treatment length and dental hygiene behaviors. Considered statistically significant, a p-value of less than 0.05 indicated a significant correlation between application of fluoride varnish and decreased prevalence of "WSLs".

Ethical Considerations

The College's institutional review board (IRB) granted ethical clearance. Every participant or parent when appropriate acquired informed permission. Strictly maintained throughout the research were participant anonymity and confidentiality.

Results

Participants were split evenly into two groups, Group A (Fluoride Varnish Group) and Group B (Control Group, No Varnish), each of which included 66 patients. The research comprised 132 patients receiving fixed orthodontic treatment. With 76 patients (57.6%) being female and 56 patients (42.4%) being male, the participants' mean age was 19.8 ± 4.3 years, with a small female preponderance. The orthodontic therapy lasted 10.7 ± 2.9 months on average. In terms of dental hygiene practices, 26% of patients cleaned their teeth once a day or sporadically, while 74% of patients reported brushing twice a day. The mean age of Group B was 19.5 ± 4.1 years, while the mean age of Group A was 20.1 ± 4.4 years. There was no statistically significant difference between the two groups ($p = 0.39$). There were 38 females and 28 men in each group, indicating a comparable gender distribution ($p = 1.00$). With a mean of 10.8 ± 3.0 months for Group A

and 10.5 ± 2.8 months for Group B, the two groups' orthodontic treatment durations were also comparable and did not vary significantly (p = 0.62). Regarding brushing behaviors, there was no significant difference between the groups (p = 0.11); 80.3% of patients in Group A and 68.2% of patients in Group B reported brushing twice daily (Table 1).

Table 1: Demographic and Clinical Characteristics of Participants

Characteristic	Group A (n=66)	Group B (n=66)	Total (N=132)	p-value
Mean Age (years)	20.1 ± 4.4	19.5 ± 4.1	19.8 ± 4.3	0.39
Gender (Male/Female)	28 / 38	28 / 38	56 / 76	1.00
Duration of Treatment (months)	10.8 ± 3.0	10.5 ± 2.8	10.7 ± 2.9	0.62
Brushing Twice Daily (%)	80.3% (53)	68.2% (45)	74.2% (98)	0.11

The overall prevalence of "WSLs" in the study population was 48.5% (n=64). A significant difference was observed between the two groups, with Group B (control group) exhibiting a much higher prevalence of "WSLs" at 68.2% (n=45) compared to Group A (fluoride varnish group), which had a prevalence of 28.8% (n=19). This stark contrast highlights the strong preventive effect of fluoride varnish. In Group A, 47 patients did not show any "WSLs", while 19 patients had "WSLs", whereas in Group B, only 21 patients were free of "WSLs", with 45 patients presenting with "WSLs". The efficacy of fluoride varnish in lowering the incidence of "WSLs" among patients receiving fixed orthodontic treatment was confirmed by the statistically significant difference between the groups (p < 0.001), as illustrated in figure 1.

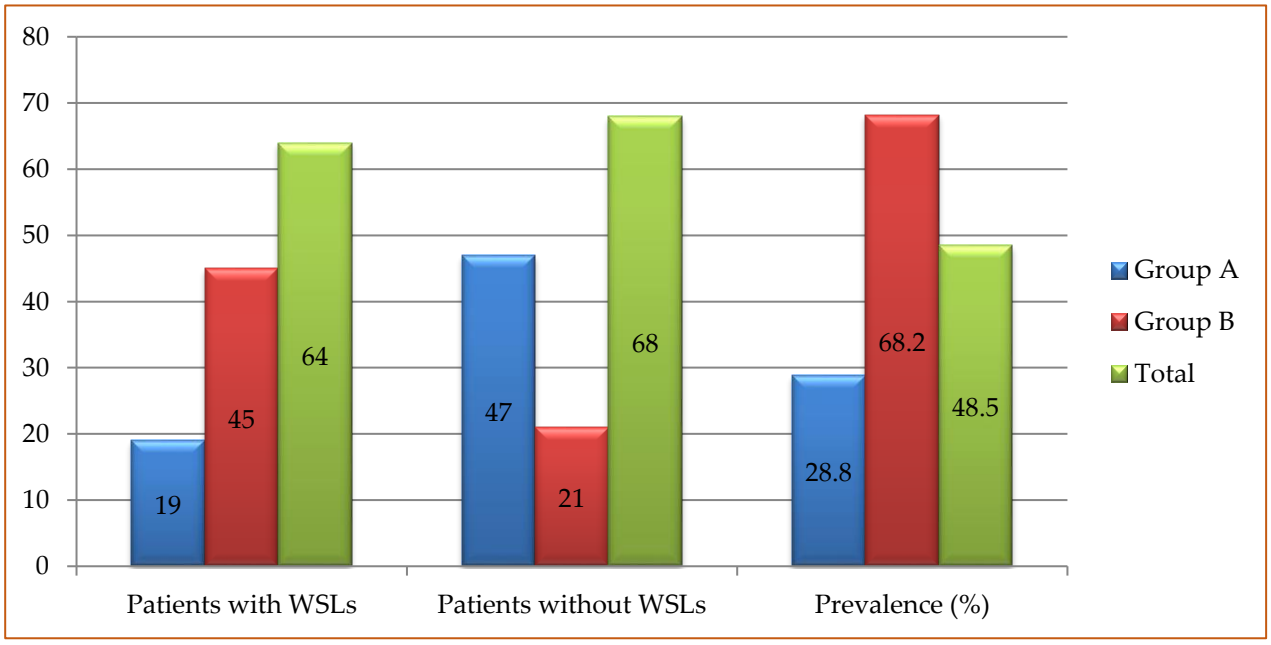

Figure 1: Prevalence of White Spot Lesions by Group

With an average of 3.48 ± 1.87 "WSLs" per patient, patients in Group B (control group) had a substantially larger mean number of "WSLs" than those in Group A (fluoride varnish group), which had an average of 1.21 ± 0.97 lesions. Group A's "WSLs" ranged from 0 to 4, whilst Group B's ranged from 1 to 8. With a p-value of less than 0.001, the group differences were statistically significant, confirming the effectiveness of fluoride varnish in lowering the incidence of "WSLs" during fixed orthodontic treatment (Table 2).

Table 2: Mean Number of "WSLs" per Patient

Group	Mean Number of WSLs ± SD	Minimum	Maximum
Group A	1.21 ± 0.97	0	4
Group B	3.48 ± 1.87	1	8
p-value (t-test)	< 0.001		

The distribution of "WSLs" by tooth type and location revealed that maxillary incisors were the most frequently affected teeth in both groups, accounting for 67.2% (n=43) of all WSL cases 57.9% (n=11) in Group A and 71.1% (n=32) in Group B. Maxillary canines were the next most commonly affected, with 46.9% (n=30) overall 31.6% (n=6) in Group A and 53.3% (n=24) in Group B. Mandibular incisors showed the lowest involvement, noted in 23.4% (n=15) of cases. In terms of lesion location, the cervical region exhibited the highest frequency of "WSLs", present in 85.9% (n=55) of patients 78.9% (n=15) in Group A and 88.9% (n=40) in Group B. The interproximal region was also commonly affected, with 53.1% (n=34) of patients showing "WSLs" in this area 42.1% (n=8) in Group A and 57.8% (n=26) in Group B. These findings indicate a higher susceptibility of maxillary anterior teeth and cervical areas to demineralization during orthodontic treatment (figure 2).

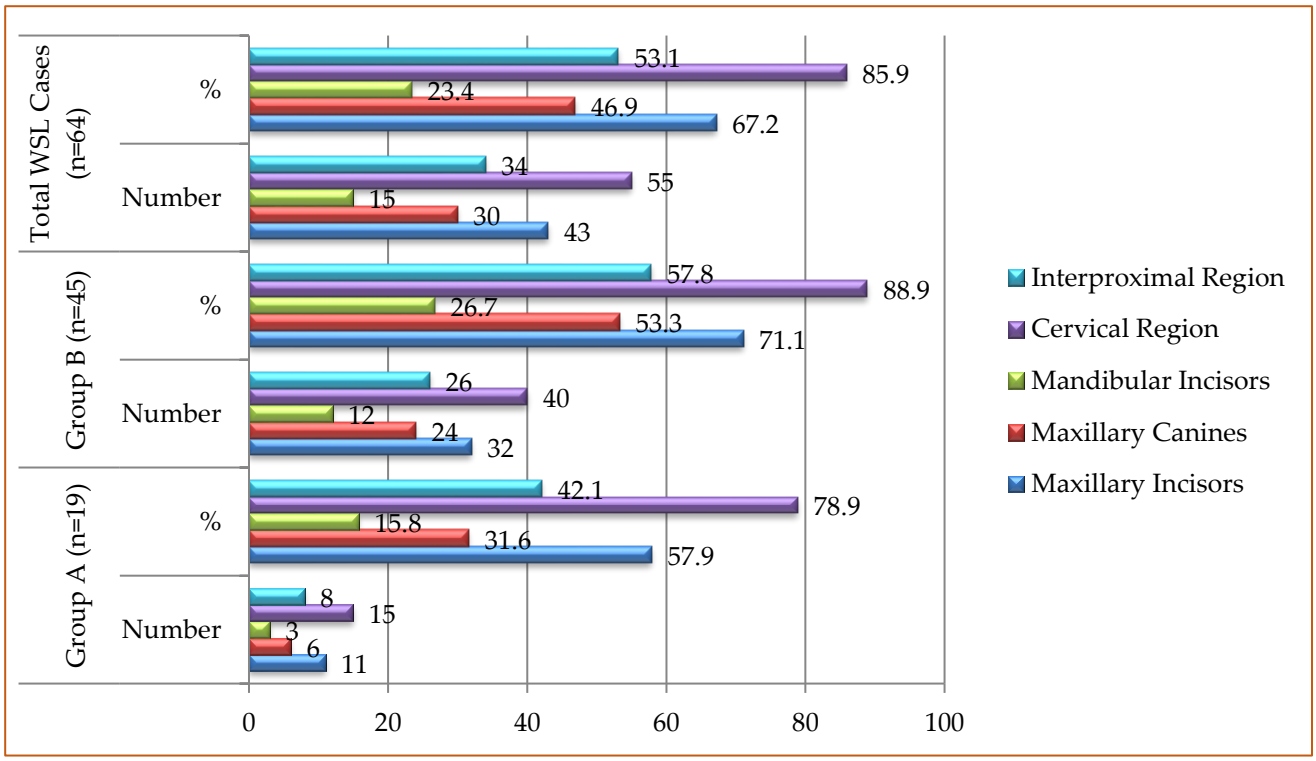

Figure 2: Distribution of "WSLs" by Tooth Type and Location

Important variables linked to the emergence of "WSLs" were found by the multivariate logistic regression analysis. Applying fluoride varnish had a considerable protective effect, as shown by the odds ratio (OR) of 0.19 (95% CI: 0.09–0.40, p < 0.001), which considerably decreased the chance of developing "WSLs". Conversely, brushing less than twice a day was linked to a more than two-fold higher chance of developing WSL (OR = 2.38; 95% CI: 1.20–4.72, p = 0.013). Although not statistically significant (p = 0.091), a tendency toward higher risk was also seen for lengthier treatment durations beyond 12 months (OR = 1.74; 95% CI: 0.91–3.34). WSL development did not significantly correlate with other factors such female gender (OR = 1.04; 95% CI: 0.53–2.01, p = 0.910) or age over 20 years (OR = 1.12; 95% CI: 0.58–

2.18, p = 0.732). These results highlight how crucial regular dental hygiene and the use of fluoride varnish are in reducing the chance of enamel demineralization during orthodontic treatment (Table 3).

Table 3: Logistic Regression Analysis for Risk Factors of "WSLs"

Variable	Odds Ratio (OR)	95% CI	p-value
Fluoride varnish application	0.19	0.09 – 0.40	<0.001
Brushing < 2 times/day	2.38	1.20 – 4.72	0.013
Treatment duration >12 months	1.74	0.91 – 3.34	0.091
Age (>20 years)	1.12	0.58 – 2.18	0.732
Gender (female)	1.04	0.53 – 2.01	0.910

Discussion

This study demonstrated a significantly lower prevalence and severity of "WSLs" among patients receiving fluoride varnish during fixed orthodontic treatment. Patients in the fluoride group had both a lower incidence (28.8%) and a lower mean number of lesions per patient compared to the control group (68.2%). Additionally, the logistic regression analysis confirmed that fluoride varnish application was a strong protective factor against WSL development. Other contributing risk factors included inadequate oral hygiene and prolonged treatment duration.

The findings align with previous evidence suggesting that fluoride plays a critical role in the prevention of demineralization during orthodontic therapy [14]. Fluoride varnishes create a reservoir of fluoride on enamel surfaces, enhancing remineralization and inhibiting enamel dissolution even in the presence of plaque and food debris. The significant difference in lesion development between the varnish and non-varnish groups confirms this mechanism.

When comparing these results to existing studies in the literature, similar trends have been observed where patients not using fluoride-based interventions experienced higher rates of "WSLs" during orthodontic treatment [15]. Studies have also consistently found the highest lesion occurrence in maxillary incisors and the cervical areas of teeth, matching the anatomical pattern observed in this research [16]. Furthermore, prior studies have highlighted poor oral hygiene and longer appliance duration as risk factors, both of which were reflected in our findings [17].

However, this study reported a slightly lower prevalence of "WSLs" in the control group than some literature reports [18]. This may be attributed to better overall oral hygiene education and awareness among our study population. Additionally, while most literature supports the use of fluoride varnish, some reports suggest that the frequency of application and patient compliance play a significant role in its effectiveness factors that were well-controlled in this study [19].

Limitations and Future Suggestions

Despite the valuable insights gained, this study had several limitations. The sample size, although adequate, was limited to a single center, which may affect the generalizability of the results. Additionally, the follow-up period was relatively short, and long-term outcomes post-treatment were not assessed. The study also relied on visual-tactile examination, which, while clinically relevant, may be less sensitive than digital imaging techniques. Future research should include multi-center trials with larger and more diverse populations. Incorporating long-term follow-up post-orthodontic treatment would provide insights into lesion progression or remineralization. Advanced imaging methods such as quantitative light-induced fluorescence or digital subtraction radiography could also improve diagnostic accuracy. Lastly, evaluating patient compliance and frequency of fluoride application may offer a more comprehensive understanding of varnish effectiveness.

Conclusion

This research illustrates the substantial preventative benefit of fluoride varnish and draws attention to the

high incidence of "WSLs" among patients receiving fixed orthodontic treatment. Compared to patients who did not get frequent fluoride varnish treatments, those who did had much fewer and milder lesions. These findings support the integration of fluoride varnish into routine orthodontic care as an effective and practical preventive measure. Early intervention, patient education, and consistent monitoring are essential to minimize the risk of enamel demineralization during orthodontic therapy.

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