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Original Research Article

Effect of fluoride releasing materials on white spot lesions during orthodontic treatment assessed using QLF device – An in-vivo study

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Abstract

Introduction and objectives: One of the pitfalls of orthodontic therapy is the appearance of white spot lesions (WSL's) around brackets within 4 weeks of bracket placement while, regular caries formation usually takes 6 months. Hence, the present study was designed to assess the effect of different fluoride-releasing materials on white spot lesions using Quantitative light-induced florescence (QLF) device.

Materials and Methods: 120 patients who were eligible for this in vivo study were categorized into four groups (30 patients per group) depending on the use of different fluoride remineralizing agents as Group A: Control Baseline Group, Group B: Sodium fluoride 0.2% (Dr Reddy's Senquel AD mouthwash), Group C: Sodium monoflurophosphate 0.7% (Dr Reddy's Senquel F toothpaste) and Group D: Sodium fluoride 5% GC MI Varnish TM (Casein phospho peptide amorphous calcium phosphate). WSLs were evaluated at T0, T1 (1 week), T2 (2 week) and T3 (4 weeks) time intervals. MANOVA and Post hoc tests were used for the analysis of data.

Result All material showed significant results in all time intervals compared with group A, when compared within the fluoride-releasing groups, fluoride varnish was found to be more effective and superior in its ability to remineralize white spot lesions at T1 to T2 time intervals.

Conclusion All the materials in the present study helped in the prevention of WSLs depending upon patients' compliance. Order of prevention of WSLs was fluoride varnish ≥ fluoride toothpaste > mouthwash. Clinical significance Fluoride releasing materials such as fluoride varnish and toothpaste have similar remineralizing effect on WSLs till 2 weeks and fluoride varnish effect deteriorated after 3 weeks. Hence, repeated applications for maximum benefit are recommended

Keywords: Orthodontic treatment, Quantitative light-induced fluorescence (QLF), White spot lesions (WSL's), sodium fluoride, Casein phospho peptide (CPP), amorphous calcium phosphate (ACP)

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1. Introduction

One of the major pitfalls of orthodontic therapy is the increased risk of enamel demineralization or white spot lesions. The term white spot lesion (WSL), as explained by Fejerskov et al., is the first sign of a carious lesion presenting as milky white opacity on smooth facial surfaces of enamel that can be detected with the naked eye". White spot lesions begin to appear around the brackets in 4 weeks of bracket placement, although the formation of regular carious lesion can take at least six months.[1]

These lesions are more common around the gingival region of orthodontic brackets.[1])2 The prevalence rate of white spot lesions in orthodontically treated individuals can range from 2% to 96%.[1])3 Methods using quantitative laser techniques for the detection of WSLs are more accurate and sensitive, yielding a higher prevalence rate than the traditional visual method. On an average, such decalcifications are found in 15.5%–40% no orthodontic patients and 30%–70% during the orthodontic treatment.[1)4-6]

The recent non-invasive methods used for caries detection have greatly improved the accuracy of diagnosis. These methods include quantitative light-induced fluorescence (QLF) of teeth, electrical resistance (such as ECM), and imaging techniques like conventional and digital radiographic imaging techniques.[7] Microcomputer

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tomography, transverse microradiography, transillumination, DIAGNOdent, and DIFOTI devices comprise the other supplemental methods to aid in the diagnosis. QLF measures enamel autofluorescence and can differentiate between the remineralization of early enamel caries.[8] Laser fluorescence devices such as DIAGNOdent and QLF have been shown more sensitivity and specificity than radiographic examinations.

WSLs if left untreated, can evolve into caries which are unesthetic and may require restorations.[9] The incidence of WSLs is directly proportional to oral hygiene maintenance and require prompt diagnosis and management at early stages. Moreover, pandemics like Covid-19 have a significant impact on dental appointments thus increasing the chances of such lesions.[10]

Fluoride ions can be integrated into the hydroxyapatite structure of enamel by the replacement of hydroxy groups or by the redeposition of dissolved hydroxyapatite as more resistant fluorapatite or fluorhydroxyapatite.[9]

The fluoride ions present within the fluid phase of the caries process render an impeding effect on tooth demineralization and an enhancing effect on remineralization. When a topical fluoride is applied, a calcium fluoride-like material (CaF2) is formed on the initial lesions. This Calcium fluoride acts as a reservoir of fluoride ions which are released when the pH falls during a bacterial attack. The dissolution rate of CaF2 at different pH is controlled by phosphate and proteins.[7]

Therefore, an Orthodontist should focus on reducing the incidence of WSLs by preventive Fluoride delivery methods. These methods which reduce the demineralization of enamel surrounding orthodontic brackets include the daily use of toothpastes and/or gels with a high fluoride concentration (1500–5000ppm) or fluoride toothpaste in combination with chlorhexidine mouthwash. Fluoride varnish adheres to the enamel surface longer than other topical fluoride products and has been shown to be superior to the other fluoride delivery methods.[9-11]

Various studies have evaluated the effect of fluoride releasing materials on WSLs using visual methods.[2,4,5] However, WSLs are better visualized using light induced fluorescence as these methods are more sensitive and specific with quantitative measurement than other examination methods. Therefore, the aim of the present study was to evaluate the effect of different fluoride releasing methods on WSLs during orthodontic treatment assessed using Quantitative light induced fluorescence (QLF).

2. Materials and Methods

Ethical approval was obtained from the Institutional Ethics Committee No.IEC/PA-08/2021.120 subjects who were being treated with fixed orthodontic appliances at the Department of Orthodontics, and those who agreed to participate were enrolled in the study. The participants and their legal guardians were informed about the purpose of the research and informed consent was obtained for the same. Patients aged 12 years or above with permanent dentition who did not use extensive fluoride regimes within the past 6 months and were on orthodontic therapy for at least one month were included in the study. While Patients with any medical or dental condition and were using any investigational drug, planned to relocate or move within 6 months of enrolment were excluded from the study. Additionally, patients who had or were currently undergoing fluoride treatment for WSLs, IgE Casein allergy or known allergies to fluoride or other components of the test materials and Pregnant or lactating women were also excluded from the study.

A total of 120 patients who were eligible for this in vivo study were randomly categorized using envelope method into four groups (30 patients per group) depending on the use of different fluoride remineralizing agents. Control group did not receive any specific preventive method apart from regular oral hygiene maintenance instructions.

1. Group A: Control Baseline Group
2. Group B: Sodium fluoride 0.2% mouthwash (Dr Reddy's Senquel AD)
3. Group C: Sodium monoflurophosphate 0.7% toothpaste (Dr Reddy's Senquel F)
4. Group D: Sodium fluoride 5% GC MI Varnish ™ (Casein phospho peptide amorphous calcium phosphate GC corporation, Tokyo corporation Japan)

Figure 1: Qray pen C (QLF)

Figure 2: Fluoride-releasing materials with Qraypen C

3. Quantitative Light-Induced Fluorescence (QLF™)[11-12]

QLF™ stands for Quantitative Light-induced Fluorescence based on the principle that different (organic) substances in the oral cavity absorb light of a certain wavelength (colour) and then re-emit the absorbed energy at a different wavelength. By filtering away the illuminating light the fluorescence-or QLF™ image is obtained.

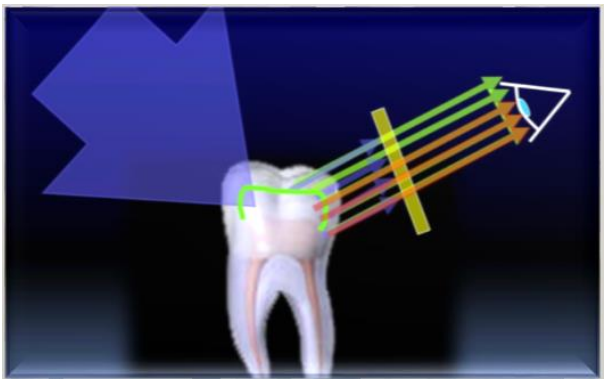


Figure 3: Tooth tissue is illuminated with strong blue light which generates a fluorescence response from the enamel-dentine junction (green auto-fluorescence) and porphyrins by bacteria (red fluorescence). Using a special QLF™ filter, the illuminating blue light is filtered away so only the fluorescent response is transmitted to the eye or camera.

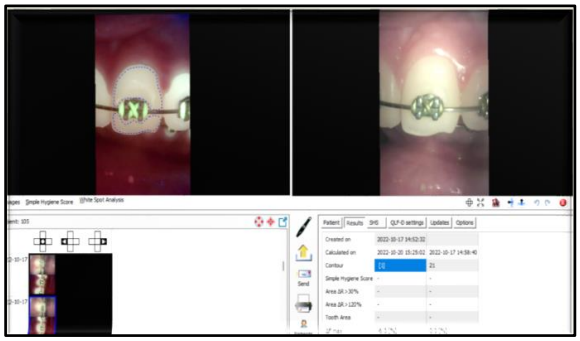


Figure 4: WSL assessment of assessed tooth with Qray pen C

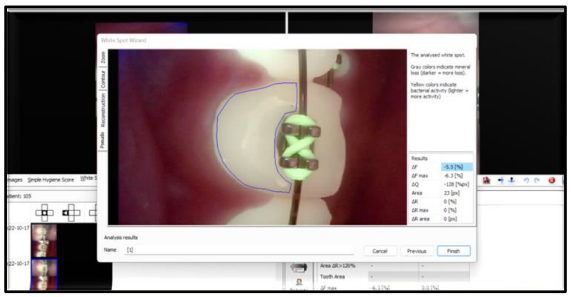


Figure 5: Area of contour over tooth

Apart from the auto-fluorescence response, anaerobic bacteria in plaque, calculus and carious lesions are known to generate porphyrins that fluorescence bright red or orange when illuminated by blue light. This effect is superimposed on the auto-fluorescence signal and is an indication of bacterial activity.

Red fluorescence is generally seen in mature plaque (roughly older than 2 or 3 days), calculus and active carious lesions and other various sites such as secondary caries, cracks or failing sealants.[11-12]

Early enamel decalcification or initial caries are quantified result of Delta F, and Delta R score, these scores indicate the degree of mineralization and biofilm activity respectively.

3.1. Clinical procedure for evaluating white spot lesions

The examiner was blinded as he did not have any information about the groups being tested and had received sufficient training from the Qray PenC AioBio Seoul representative. Examination of 30 samples from each group (4 groups), Scanning was done from the labial surface of maxillary right canine to maxillary left canine with Qray Pen C device. A total of 720 samples (120 patients x 6 teeth) were examined, each sample had two readings gingival and incisal area. Further, each patient was evaluated at 4-time intervals T0,T1,T2&T3at each appointment a total of 14 values i.e.,ΔFG, ΔFI, ΔFmaxG, ΔFmaxI, ΔQG, ΔQI, Area G, Area I,ΔRG,ΔRI, ΔRmaxG, ΔRmaxI, ΔRareaG, ΔRareaI, where I stands for incisal and G for gingival were recorded. As a result, a total of approximately 40,000 readings were recorded. Instructions about dietary habits and efficient oral hygiene including Senquel (F) toothpaste and mouthwash Senquel AD were given to the patients during the orthodontic treatment and during the study. The patients were provided with F toothpaste and mouthwash to be used twice daily throughout the investigation. In MI VarnishTM group fluoride varnish was applied at T0 time intervals. All subjects were recalled after1 week (T1), 2 weeks (T2) and 4 weeks (T3) for re-evaluating the progression or regression of the white spot lesions.

3.2. Statistical analysis

Data obtained was analyzed using SPSS Version 23, descriptive statistics and multiple-way ANNOVA test was done for inter-group and inter-duration comparison. **MANOVA** tests were used to detect if there was a significant difference between the means of multiple groups. A post hoc test was used to identify exactly which groups differ from each other. The **Bonferroni test** was used to detect statistical significance in the dependent variable.

4. Result

Data evaluated by statistics evaluation MANOVA and Post HOC test.

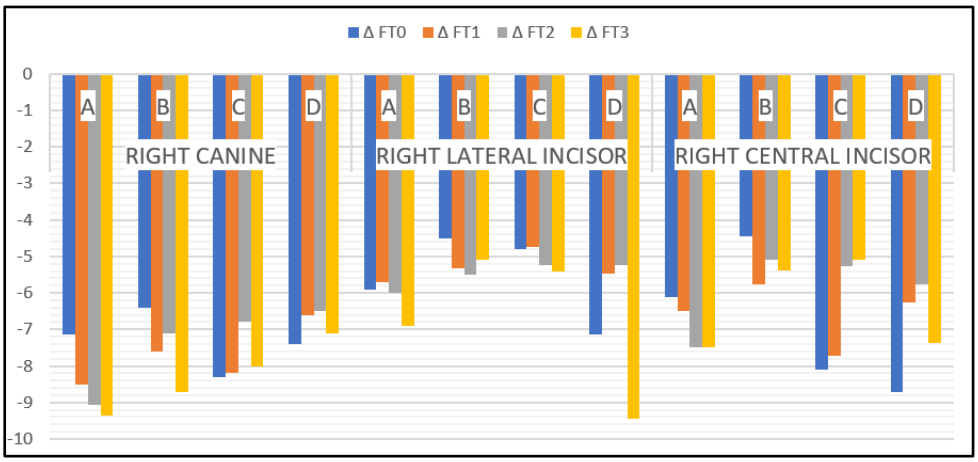
The mean values of ΔF, ΔQ, and ΔR for all 4 groups from T0 -T3 for maxillary left canine to maxillary right canine are depicted in **Table 2** & **Table 3**.

Table 1: Analysis of white spot lesion[12]

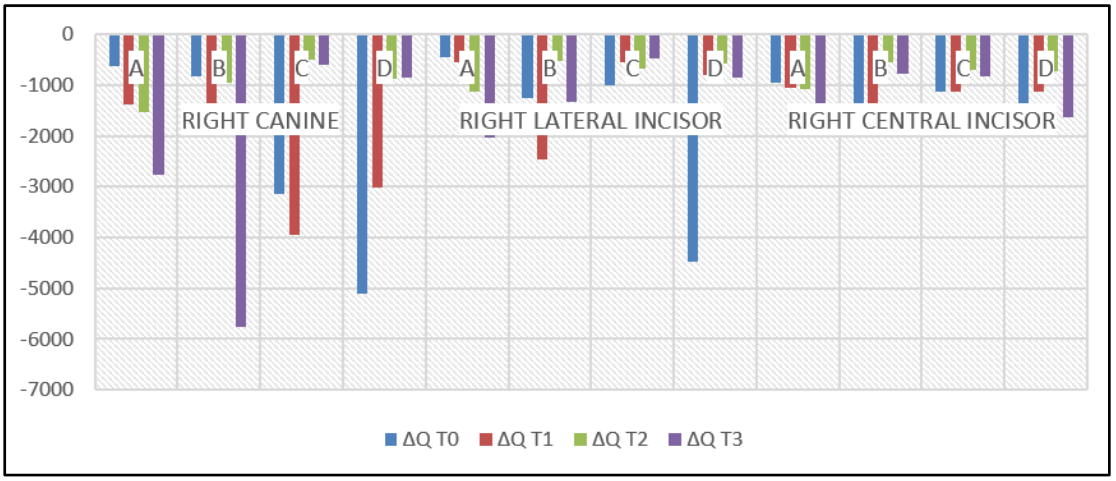
Symbol	Explanations
ΔF	Average fluorescence loss A measure for the average loss of the intensity of the fluorescence measured relative to the intensity of the fluorescence of the reconstructed surface ΔF is indicate to the loss of mineral content in a lesion
ΔFmax	Lesion depth The highest value of AF measured within the contour An indication of the maximum lesion depth
ΔQ	Lesion volume Technically the integral of ΔF over the area of the contour Practically a measure of the volume of the lesion Higher values of ΔQ indicate a bigger lesion
Area	Lesion area The number of pixels within the contour that show a significant value of ΔF (defined as a pixels with a fluorescence intensity that is lower than that of the reconstructed surface by 5% or more).
ΔR	Area with bacterial activity. The percentage of the lesion area (see above) that shows a red fluorescence that is raised with 30% or more compared to the average of the tooth tissue within the contour
ΔR max	Maximum bacterial activity. The highest raise of ΔR measured within the contour as a percentage of the average red fluorescence in the contour This value is 30 or higher but in case of no or small amount of red fluorescence
ΔR area	Area of bacterial activity. The number of pixels of the lesion that show a raised red fluorescence

Table 2: The mean values of ΔF, ΔQ, and ΔR for all 4 groups from T0 -T3 for maxillary right canine to maxillary right central incisor.

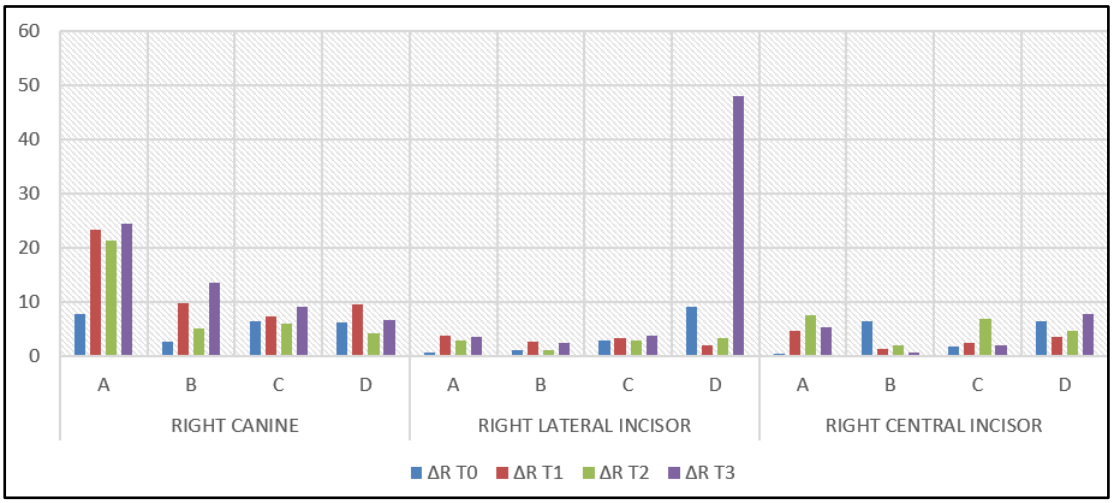
Values	Right canine				Right lateral incisor				Right central incisor			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Δ FT0	-7.15	-6.4	-8.3	-7.4	-5.9	-4.5	-4.81	-7.13	-6.1	-4.45	-8.09	-8.72
Δ FT1	-8.51	-7.6	-8.2	-6.6	-5.7	-5.33	-4.75	-5.46	-6.5	-5.76	-7.71	-6.27
Δ FT2	-9.06	-7.1	-6.8	-6.5	-6.0	-5.49	-5.23	-5.25	-7.5	-5.1	-5.26	-5.77
Δ FT3	-9.35	-8.7	-8.0	-7.1	-6.9	-5.08	-5.41	-9.45	-7.5	-5.37	-5.10	-7.38
ΔQ T0	-631	-838.9	-3143.9	-5115.8	-443.9	-1268	-995.6	-4490.2	-961.7	-1388.3	-1129.5	-1703.4
ΔQ T1	-1395	-1972.2	-3941	-3029.8	-553.2	-2470.7	-558.2	-816.2	-1048.3	-1705.6	-1136	-1139.9
ΔQ T2	-1543.5	-951.8	-503.9	-881.5	-1124.2	-519.86	-682.6	-569.2	-1087.6	-554.9	-703	-739.2
ΔQ T3	-2775.8	-5756.3	-599.6	-847.7	-2032.7	-1333.9	-484	-861.2	-1590.8	-785.1	-820.5	-1635.8
ΔR T0	7.8	2.6	6.4	6.3	0.7	1.25	3	9.2	0.4	6.38	1.8	6.4
ΔR T1	23.4	9.8	7.4	9.5	3.9	2.8	3.4	2.1	4.7	1.4	2.4	3.6
ΔR T2	21.4	5.1	6	4.2	3	1.2	2.9	3.3	7.6	2	7.0	4.6
ΔR T3	24.4	13.5	9.2	6.8	3.5	2.5	3.9	48	5.3	0.8	2	7.9



Graph 1: Graphical representation of Δ F values from T0 to T3 for all 4 groups within Right Quadrant



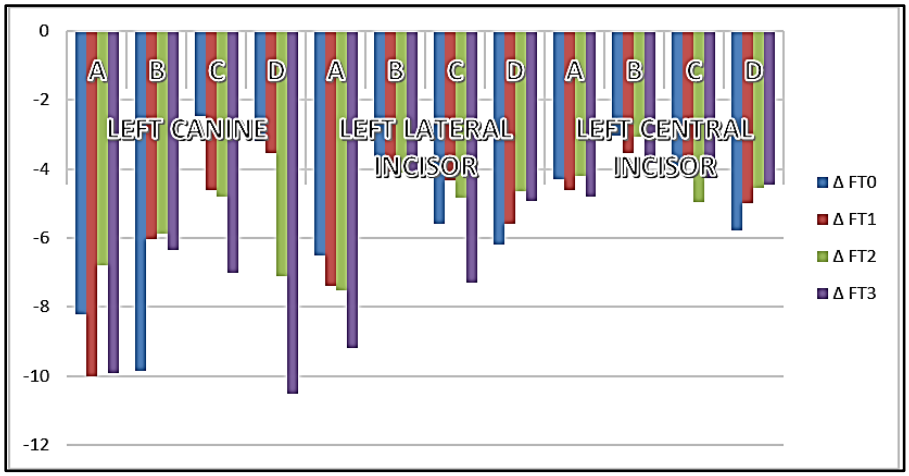
Graph 2: Graphical representation of ΔQ values from T0 to T3 for all 4 groups within Right Quadrant



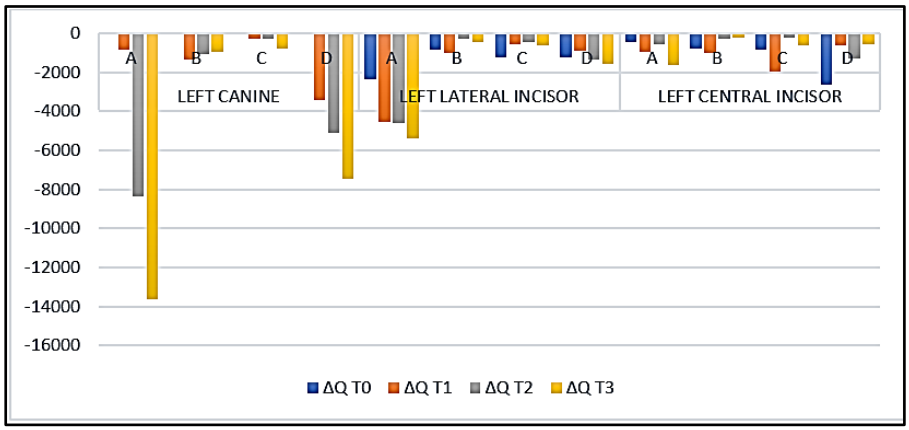
Graph 3: Graphical representation of ΔR values from T0 to T3 for all 4 groups within Right Quadrant

Table 3: The mean values of ΔF, ΔQ, and ΔR for all 4 groups from T0 -T3 for maxillary left canine to maxillary left central incisor.

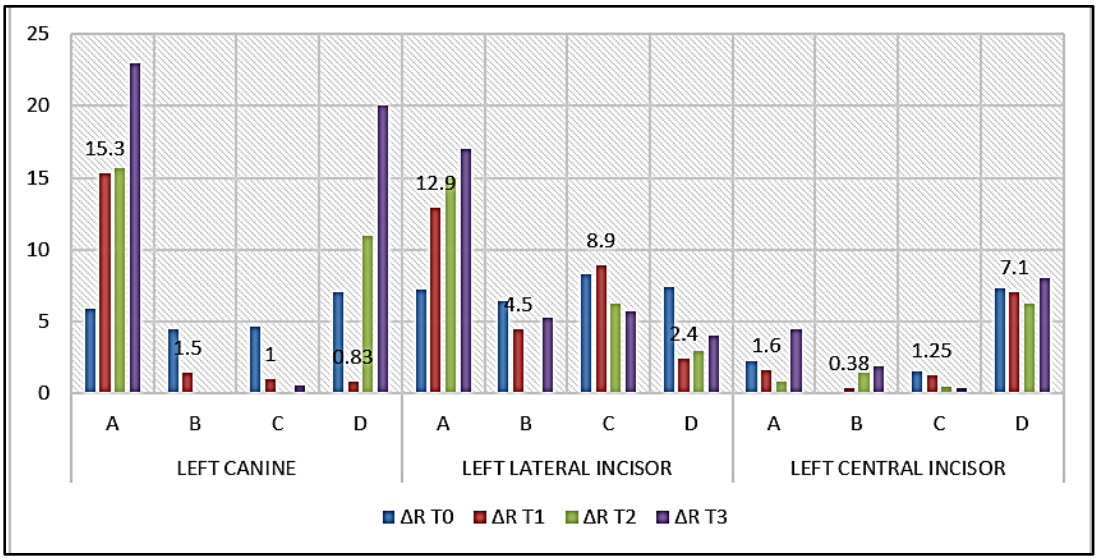
Values	Left canine				Left lateral incisor				Left central incisor			
	A	B	C	D	A	B	C	D	A	B	C	D
Δ FT0	-8.2	-9.86	-2.45	-3.2	-6.5	-3.99	-5.6	-6.19	-4.3	-3.02	-3.9	-5.78
Δ FT1	-10	-6.02	-4.6	-3.54	-7.4	-4.08	-4.34	-5.59	-4.6	-3.54	-3.68	-5.0
Δ FT2	-6.8	-5.87	-4.79	-7.09	-7.5	-4.09	-4.82	-4.63	-4.2	-3.06	-4.97	-4.55
Δ FT3	-9.9	-6.36	-7.01	-10.5	-9.2	-4.13	-7.3	-4.94	-4.8	-3.83	-4.25	-4.46
ΔQ T0	-15.7	-1.09	-8.49	-6.6	-2359	-820	-1258	-1216	-449	-793.9	-859.1	-2633.3
ΔQ T1	-841.5	-1360	-261	-3400	-4563	-1014	-580	-890	-961	-1017	-1973.5	-602
ΔQ T2	-8357	-1040	-289.3	-5080	-4605	-256	-452	-1363	-564.2	-260	-242.2	-1297
ΔQ T3	-13605	-938.5	-776	-7463	-5403	-465	-592.9	-1574	-1643.7	-244.3	-589.4	-540.15
ΔR T0	5.9	4.45	4.7	7.1	7.2	6.4	8.3	7.4	2.26	0	1.58	7.3
ΔR T1	15.3	1.5	1	0.83	12.9	4.5	8.9	2.4	1.6	0.38	1.25	7.1
ΔR T2	15.7	0	0	11	15	0	6.29	3.0	0.8	1.48	0.5	6.3
ΔR T3	23	0	0.6	20	17	5.3	5.76	4	4.5	1.88	0.4	8



Graph 4: Graphical representation of ΔF values from T0 to T3 for all 4 groups within Left Quadrant



Graph 5: Graphical representation of ΔQ values from T0 to T3 for all 4 groups within Left Quadrant



Graph 6: Graphical representation of ΔR values from T0 to T3 for all 4 groups within Left Quadrant

Table 4: Comparison of effect of various fluoride-releasing materials at t0 and t3 on maxillary right canine

ΔF I	Control	Fluoride varnish	-2.2558*	.001
	Control	Toothpaste	-2.0525*	.004
	Control	Mouthwash	-2.1742*	.002

ΔQ I	Fluoride varnish	Toothpaste	-1999.2717*	.016
AREA G	Control	Toothpaste	412.933*	.001
	Control	Mouthwash	372.525*	.004
ΔR I	Control	Fluoride varnish	7.042*	.003
	Control	Toothpaste	6.625*	.006
	Control	Mouthwash	10.508*	.000
ΔRmax I	Control	Fluoride varnish	31.692*	.000
	Control	Toothpaste	31.342*	.000
	Control	Mouthwash	33.058*	.000
ΔF G	Control	Mouthwash	-5.8058*	.000
ΔFmax G	Control	Toothpaste	-6.5325*	.042
	Control	Mouthwash	-12.0317*	.000
ΔQ G	Control	Fluoride varnish	-5892.858*	.023
	Control	Toothpaste	-6472.517*	.009
	Control	Mouthwash	-7105.383*	.003
AREA G	Control	Mouthwash	290.517*	.009
AREA I	Fluoride varnish	Toothpaste	127.842*	.000
	Control	Toothpaste	89.898*	.013
ΔR G	Control	Toothpaste	13.4283*	.025
ΔRmax G	Control	Fluoride varnish	138.7325*	.005
	Control	Toothpaste	141.7258*	.004
	Control	Mouthwash	141.3108*	.004
ΔRmax I	Control	Fluoride varnish	41.67667*	.009

Table 5: Comparison of effect of various fluoride-releasing materials at t0 and t3 on maxillary left canine

ΔFmax G	Control	Mouthwash	-9.0500*	.022
	Control	Toothpaste	-9.6808*	.012
ΔQ G	Fluoride varnish	Toothpaste	-5823.471	0.034
ΔQ I	Control	Mouthwash	-8573.8609*	.033
	Control	Toothpaste	-9295.2172*	.016
ΔR G	Control	Toothpaste	21.2517*	.020
	Control	Mouthwash	20.9050*	.023
ΔR I	Control	Fluoride varnish	4.4600*	.001
	Control	Toothpaste	4.5208*	.001
	Control	Mouthwash	4.7825*	.000
ΔRmax G	Control	Mouthwash	677.7892*	.007
	Control	Toothpaste	677.8358*	.007

Table 6: Comparison of effect of various fluoride-releasing materials at t0 and t3 on maxillary right lateral incisor

ΔF G	Fluoride varnish	Toothpaste	-2.6308*	.009
	Fluoride varnish	Mouthwash	-2.3442*	.028
ΔFmax G	Control	Toothpaste	-4.5108*	.048
	Fluoride varnish	Toothpaste	-5.2792*	.012

Statistically significant different ΔF I value were found when group B (p=0.002, C (p=.004, and D (p=0.001) compared with group A, at T0 and T3 time intervals.

Statistically significant different ΔQI values were found when group C (p=0.016) was compared with group D, at T0 and T3 time intervals showing better remineralization of

WSLs in the group D compared to group C. Statistically significant different AREA G values were found when group B (p=0.004), C (p=0.001, and D (p=0.007) Compared with group A, at T0 and T3 time intervals with group C showed highest decrease in area of WSLs.

Statistically significant different ΔR I value were found when group B (p=0.000), C (p=0.006), and D (p=0.003) compared with group A, at T0 and T3 time intervals with group D showing positive changes

Statistically significant different ΔR max I values were found when group B (p=0.000, C (p=.000), D (p=0.000) compared with group A, at T0 and T3 time intervals group c showing decreasing bacterial activity. positive finding.

Table 7: Comparison of effect of various fluoride-releasing materials at t0 and t3 on maxillary left lateral incisor

Statistically significant different ΔF G values were found when group B (p=0.000) Compared with group A, at T0 and T3 time intervals showing Positive changes in group B.

Statistically significant different ΔQ G values were found when Group B (p=.003), Group D (p=0.023) and Group C (p=0.009) were compared to Group A at T0 and T3 time intervals showing better remineralization of WSLs in Group C

Statistically significant different AREA G values were found when Group B (p=0.009), compared with Group A, at T0 and T3 time intervals showing better remineralisation of WSLS in Group B compared with Group A

The statistically significant difference in Area I value (P=0.013) was found when Group A compared with Group C, also Group C compared with Group D significant values at T0 and T3 time intervals showing positive result in Group D.

Statistically significant different ΔR max G value were found when group B (p=0.004), C (p=.004), and D (p=0.005) compared with group A, at T0 and T3 time intervals. Group C shows Positive findings.

Statistically significant different ΔR max I value were found when comparing group D (p=0.009) with group A, at T0 and T3 time intervals. Group D showing decrease bacterial activity in compared group.

Statistically significant different ΔF max G value were found when group B (p=0.022), and C (p=.0012), and were compared with group A, at T0 and T3 time intervals. Group C showed better remineralization of WSLs in the group compared with A, B and C

Statistically significant different ΔQ I value were found when group B (p=0.016, and C (p=0.033) compared with group A, at T0 and T3 time intervals group C showing better remineralization of WSLs in the group compared with A, B and C.

Statistically significant different R max G value were found when group B (p=0.007), C (p=.007), compared with group A, at T0 and T3 time intervals group C showing reduced bacterial activity.

Statistically significant different ΔF G values were found when group B (p=0.028), C (p=.009) ware compared with group D, at T0 and T3 time intervals, group D showed better remineralization of WSLs.

Statistically significant different ΔF max G values were found when comparing group C (p=.048), with group A, also group C and group D (p=0.012) were compared between at T0 and T3 time intervals.

Statistically significant different AREA G values were found when group B (p=0.005), and C (p=.004) were compared with group A, at T0 and T3 time intervals.

5. Discussion

The present in-Vivo study was done to evaluate the efficacy of various fluoride releasing materials in reducing white spot lesions which occur during orthodontic treatment. A total of 120 subjects undergoing fixed orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopaedics were selected for the study. All the subjects who were undergoing 0.022 MBT fixed appliance treatment with at least one month after bracket placement were selected. Subjects were randomly categorized into 4 Groups with each group containing 30 patients.

1. Group A: Control Baseline Group.
2. Group B: Sodium fluoride 0.2% mouthwash (Dr Reddy's Senquel AD).
3. Group C: Sodium monoflurophosphate 0.7% toothpaste (Dr Reddy's Senquel F).
4. Group D: Sodium fluoride 5% GC MI Varnish ™ (Casein phospho peptide amorphous calcium phosphate GC corporation, Tokyo corporation Japan).

Among the latest techniques in diagnosing WSLs, QLF and DIAGNOdent are the most sensitive and provide highly accurate quantitative measurements based on the fluorescence of the lesion.[13] Gomez et al[14]concluded that electrical conductance (EC) and QLF are excellent tools for detecting early lesions.

According to our study, **Table 2**& **Table 3** showed that significant improvement in WSLs was observed in the fluoride varnish group, the fluoride toothpaste and the fluoride mouthwash group as compared to the control group. When compared within the fluoride-releasing groups, fluoride varnish was found to be more effective in its ability to remineralize white spot lesions from T0 to T2 time intervals. This can be attributed to the multifactorial anti-

cariogenic mechanism of CPP-ACP. The threefold mode of action is because of:

1. Promoting remineralization by maintaining a supersaturated state of calcium and phosphate minerals within plaque
2. Inhibiting bacterial adhesion on the tooth surface and thus delaying the formation of biofilm
3. Acting as a buffering agent and prevents oral environment pH reduction[15]

Similarly in another study, the effectiveness of fluoridated mouthwash in reduction of white spot lesions after orthodontic treatment was assessed and found to be effective in remineralising white spot lesions. Pithon et al[16] reported that the use of fluoridated toothpaste and fluoride varnish during orthodontic treatment are effective as a preventive measure in reducing WSLs around orthodontic attachments as similarly observed in the present study. Fluoride varnish effectively decreases caries' incidence in deciduous and permanent dentitions. Advantages of fluoride varnish over other topical fluoride regimens include enamel protection in the absence of proper patient compliance and sustained fluoride release over a prolonged period. The application of a fluoride varnish resulted in a 44.3% decline in enamel demineralization in patients undergoing orthodontic treatment.

According to the **Table 4** in our study, fluoride-releasing toothpaste gave statistically significant positive results when compared with the control group.

The present study is in accordance with the findings of Gjorgievskaet al[17] who reported that treatment of demineralization with Novamin toothpaste resulted in the formation of a protective bioactive glass layer on the enamel surface and returning it to that of undamaged enamel. Brushing is the most important oral hygiene measure so fluoride-containing toothpaste plays a major role in the intervention of white spot lesions in orthodontic patients. Toothpaste having 1350 ppm or more of fluoride is recommended a minimum of twice a day for better control over WSLs.

WSLs should be managed using a multifarious approach. The principal modality is to prevent demineralization and biofilm accumulation, and use of remineralisation procedures such as, adhesive composite resin restorations, micro abrasion, resin-infiltration, and bonded facets.[18]

Prevention should first commence by educating and motivating the patients about non-cariogenic diet and maintenance of oral hygiene. Mechanical plaque control with proper brushing atleast twice daily with fluoride-containing toothpaste. The fluoride concentration of fluoridated toothpaste should be above 1000ppm which is most effective in the enamel remineralization.[19]

According to **Table 5**, it was found that fluoride-containing mouthwash gave statistically significant positive results when compared with the Control group. This finding is in agreement with the results of the study by Khalaf[6], who suggested regular use of fluoride mouthwash during orthodontic treatment to significantly reduce the risk of developing WSLs.[6] At the 6th-month evaluation, Casein phospho Peptide amorphous calcium phosphate, fluoride mouthwash, and Calcium sodium phosphor silicate showed a highly significant difference to the Baseline DI scores while Fluoridated toothpaste did not show any difference.

Geiger et al[20] found that a fluoride mouth rinse resulted in a 30% reduction in the prevalence rate and a 25% reduction in the incidence rate of WSLs in orthodontic patients [6.]Sagarikaet et al[5] recommended 0.05% acidulated phosphofluoride mouth rinses to patients and were surprised to observe the high rate of WSL prevalence. Sodium fluoride-containing mouthwash resulted in a significant decline in the development of carious lesions around and beneath orthodontic bands. Antibacterial agents have also been incorporated into these mouthwashes, including chlorhexidine, triclosan, or zinc to enhance their cariostatic effects.[20] Benson[21] carried out a systematic review and concluded that the daily use of 0.05% NaF mouthwash during fixed orthodontic treatment prevents enamel demineralization. A mouthwash containing NaF (0.05% or 0.2%) used daily has been shown to decrease the incidence of enamel demineralization during fixed orthodontic treatment.

Although the use of fluoride mouthwash during orthodontic treatment seems to reduce the incidence of WSLs, effect is directly proportional to the patient's compliance.

Anderson et al[22] reported that the combination of CPP-ACP and sodium fluoride showed significant improvement in WSLs. Our results in **Table 5** show that mouthwash and toothpaste are more effective and better results were observed in the maxillary left canine region, but varnish effect deteriorated on left canine after 3-week time interval, it may be attributed to brushing technique as there is a high possibility that brushing wears off the protective coat of varnish layer.[23]

According to **Table 6**, it was observed that fluoride-releasing varnish demonstrated statistically significant decrease in WSLs when compared with the mouthwash group and toothpaste group. Our result was in accordance with the results of the meta-analyses by Sheiham A, et al[24] where 15 studies were included and they concluded that fluoride toothpaste did not significantly differ from mouth rinse, or gel, or both gel and mouth rinse. Results from the single trial comparing toothpaste with fluoride varnish in primary teeth were inconclusive. The pooled results from the comparisons of fluoride varnish with mouth rinse was a non-significant difference favouring fluoride varnish, but this result was not robust to sensitivity analysis performed, and heterogeneity

was considerable. Results from the single trial comparing varnish with gel and the single trial comparing gel with mouth rinse were inconclusive (favoured varnish and mouth rinse respectively).[24]

The results of our study shows that the effect of fluoride varnish deteriorated after 2 week follow up which is in accordance with the results of Krischneck et al**.** Who showed that single application of a fluoride varnish, before the start of orthodontic treatment was not sufficient and did not provide any additional advantage over good dental hygiene with the use of fluoride toothpaste in patients at a low to moderate caries risk. Patients often undergo an application of fluoride varnish just before orthodontic treatment with fixed appliances. However, the efficacy of this technique is yet to be established.

6. Conclusion

White spot lesion during ongoing orthodontic treatment is a major issue and needful prevention and intervention are necessary, hence this study was carried out to assess the effect of various fluoride-releasing materials on white spot lesions during orthodontic treatment with the help of QLF™ technology. Based on the finding of this study and within its limitations, we conclude that.

1. All fluoride-releasing materials show significant differences in comparison to the control group.
2. No significant difference was found when fluoride-containing mouthwash was compared with other fluoride-releasing materials. The effect of mouthwash is dependent upon patient compliance and motivation and frequency of use.
3. Similarly, fluoride-containing toothpaste when compared with the control group showed a significant difference but an insignificant difference was found when compared to the other groups.
4. Fluoride Varnish showed a significant difference between the control group and all other groups however the protective effect of fluoride varnish deteriorated after three weeks. Hence for long-term benefits, it is recommended to use fluoride varnish every month instead of twice/ thrice application in a year.
5. All the materials in the present study helped in the prevention of WSLs depending upon patients' compliance. Order of prevention of WSLs was as follows: fluoride varnish ≥ fluoride toothpaste >fluoride mouthwash.

Patients and legal guardians must be educated about the importance of sufficient domestic preventive measures as well as about the risk of enamel demineralization during orthodontic treatment with fixed appliances in addition to the use of these fluoride releasing materials.

Further, a longer duration of evaluation would add more validation to the study. Additionally, if the patient compliance can be monitored during the study period better results can be obtained.

7. Source of Funding

None.

8. Conflict of Interest

None.

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