

Efficacy of Three Different Remineralising Agents on White Spot Lesions During Fixed Orthodontics Treatment - A Controlled Clinical Trial

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DOI: 10.31080/ASDS.2023.07.1553

Received: December 19, 2022

Published: January 05, 2023

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Abstract

Aim: The aim of the present article was to deepen the discussion of inducing a rapid increase in the volume of dental plaque which has a lower pH which in turns result in white spot lesions.

Methods: Based on evidences found in the literature, the method focussed in providing the basis for clinical decision-making.

Results: The present study showed that significant decalcification occurred within only 6 months after orthodontic bonding by using products like Clinpro creme, MI varnish, tooth min. Considering how quickly these lesions can develop and become irreversible, early diagnosis is of critical importance. Given the high number of lesions that were found at 6 months, it is crucial to evaluate the oral hygiene status of patients during the first months of orthodontic treatment, and if necessary, to implement preventive actions immediately, in order to prevent demineralization.

Conclusion: In the present study, we demonstrated that the tendency of plaque to accumulate around fixed orthodontic appliances can result in rapid demineralization. Despite recent advances, prevention of demineralization during orthodontic treatment is one of the greatest challenges faced by clinicians. For each patient, there is a need to develop an oral hygiene protocol that should be followed both at home and at the dental practice.

Keywords: Fixed Orthodontics Appliance; White Spot Lesions; Remineralization Agents; Clinical Trials Registry-India, Clinical Trials Registry-India Registration, Dental Clinical Trials

Introduction

Fixed orthodontic appliances induce a rapid increase in the volume of dental plaque which has a lower pH which in turn results in white spot lesions that often occur in otherwise well- treated cases [1,2].

The term "white spot lesion" (WSL) refers to the first signs of demineralization that may be seen with the naked eye on smooth enamel surfaces [3]. The lesions are commonly observed on the labial surfaces of the maxillary incisors and have been reported to affect up to 96% of orthodontic patients [5]. Clinically, the demineralization sites are detected as opaque and porous WSLs that may compromise the final result of the orthodontic treatment [7].

Many prophylactic measures have been introduced in the last decades aiming at prevention of WSLs. Among the most effective preventive measures is oral-hygiene instructions including a recommendation for the use of high-fluoride toothpaste, fluoride mouth-rinse and others supplements. Various types of re-miner-

alising agents are applied with different recommended concentrations, frequency of use and dosage like CPP-ACP, MI Paste Plus, and Toothmin cream to enhance remineralisation and prevent demineralisation [10].

Direct visual examination has long been the method of choice for detecting WSL. The International caries detection and assessment system (ICDAS), which introduces a new technique for measuring dental caries to detect WSLs [14]. In the last two decades, methods for detecting caries have been researched, such as monitoring the fluorescence of the lesion, and equipment for chairside caries diagnostics, such as the DIAGNOdent pen and vistaproof, have been created [16].

So, the study was planned to determine the efficacy of three different re-mineralising agents in controlling active white spot lesion during orthodontic treatment as evaluated using visual detection criteria i.e. ICDAS and Digital examination method i.e. DIAGNODent pen.

Materials and Method

Patients undergoing orthodontic treatment in the Department of Orthodontics were selected for this prospective clinical study based upon the inclusion criteria, no previous fixed orthodontic treatment, permanent dentition, fully erupted anterior teeth, first two month of fixed appliance therapy, no smoking habit and exclusion criteria, patients with systemic problems, enamel hypoplasia, dental fluorosis, intrinsic and extrinsic pigmentation, periodontal problems.

Materials were used Re-mineralizing Agents (Colgate, MI Varnish, Clinpro, Toothmin), DIAGNodent Pen (Kavo), Standard Loupes. All the patients recruited for the study were undergoing fixed appliance therapy with MBT 0.022 slot.

Screening of patients

All anterior teeth were prophylaxis and dried using air syringe and screened by using the standard loupes for the evaluation of WSLs over the maxillary and mandibular anterior teeth.

ICDAS II criteria

Score	Description
0	Sound
1	First visual change in enamel (seen only after prolonged air drying or restricted to the confines of a pit or fissure)
2	Distinct visual change in enamel
3	Localized enamel breakdown (without clinical visual signs of dentinal involvement)
4	Underlying dark shadow from dentin
5	Distinct cavity with visible dentin
6	Extensive distinct cavity with visible dentin

Table 1: ICDAS II score Criteria.

Teeth with a score of 2 to 4 on the labial surface as per ICDAS II criteria were selected and further assessed using DIAGNodent pen (KAVo, Germany).

DIAGNodent pen (KAVo, Germany)

All anterior teeth was cleaned and dried using an air syringe before the DD is used under cotton roll isolation. The angle of tip will be rotated and scanned over the area of interest on the labial tooth surface to record the peak value. The measurements were

performed after 5s drying with compressed air. The peak reading displayed on the panel of the DDpen was measured thrice, and finally, a mean of all the three reading was calculated by the examiner is the final fluorescence value for each specific tooth. In this study, type B probe was used by holding the tip in close contact with tooth surface and tilting the tip along the measuring side in order to collect fluorescence in all directions.

DIAGNODent Scale (KaVO DIAGNODent 2095)	
Display value	Clinical situation
0-10	Healthy tooth structure
11-99	Caries

Table 2: DIAGNODent score Criteria.

Teeth with a score of 0-10 when assessed using a DD pen on the labial surface were selected. Teeth with a score of 11 and above were excluded from the study.

Sample distribution

The selected sample i.e., total numbers of the anterior teeth with active white spot lesion were randomly divided into four groups: 1-Control group (Fluoride toothpaste) and 3- Test groups (MI Varnish, Clinpro and Toothmin).

Groups		Toothpaste	Re-mineralising Agent	Sample Size (N)
Control Group	CG	Fluoride Toothpaste	No	22
Test Group - 1	TG-1	Fluoride Toothpaste	MI Varnish	21
Test Group - 2	TG-2	Fluoride Toothpaste	Clinpro	21
Test Group - 3	TG-3	Fluoride Toothpaste	Toothmin	22

Table 3: Distribution of study Groups.

Measurements

Measurements were taken using both the methods i.e., ICDAS II Criteria using Loupes and Digital method using DDpen at baseline (T0), at the 6-month period (T1). All the data collected was tabulated and was sent for statistical evaluation.

Statistical analysis

Data was analysed using Statistical Package for Social Sciences (SPSS) version 22,IBM Inc. Descriptive statistics were presented in

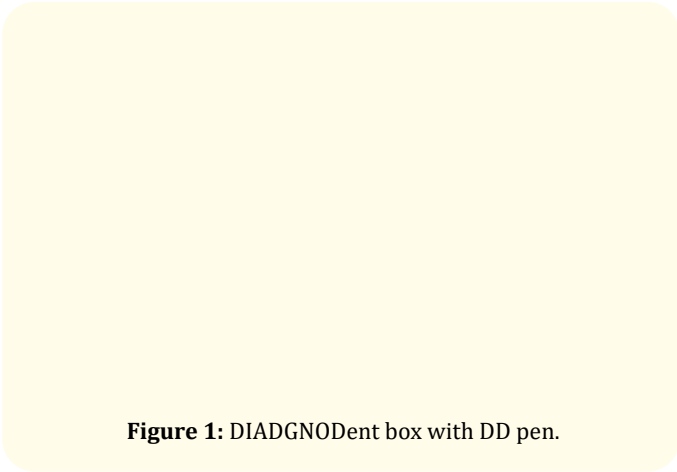


Figure 1: DIADGNODent box with DD pen.

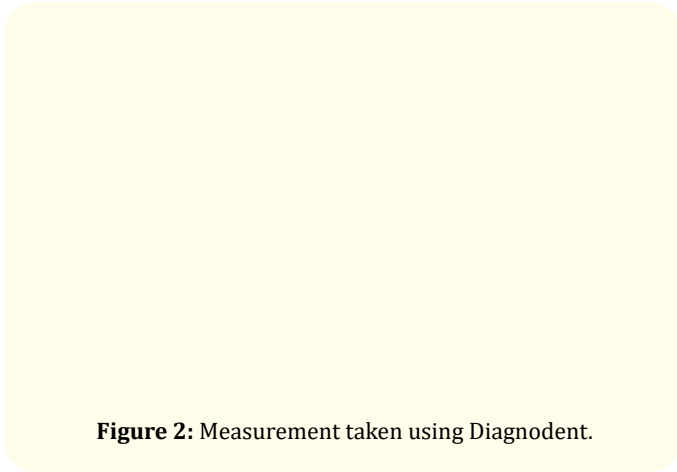


Figure 2: Measurement taken using Diagnodent.

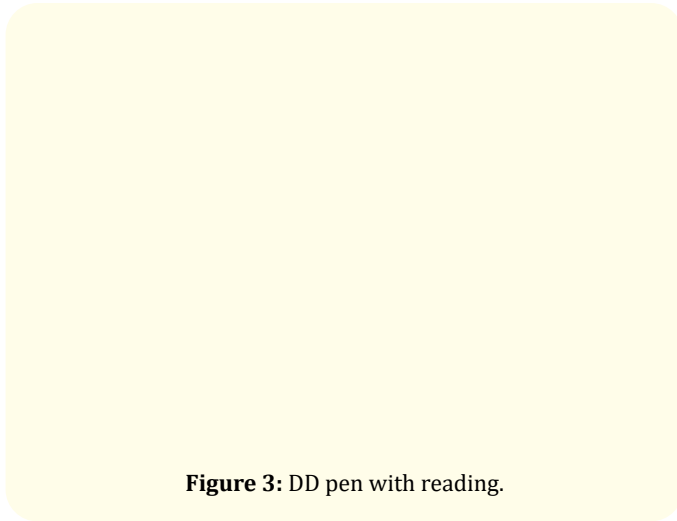


Figure 3: DD pen with reading.

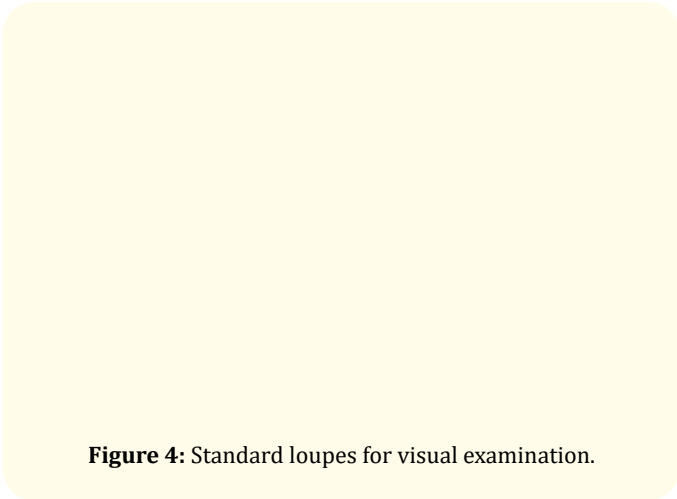


Figure 4: Standard loupes for visual examination.

form of mean and standard deviation (SD) for continuous variables and frequency statistics were presented for qualitative variables. Shapiro Wilk test was used to check the normality of data. The data was found to be normal and hence quantitative analysis was used. Paired t-tests, Repeated Measures ANOVA followed by post hoc Tukey HSD and Pearson correlation were used.

Result

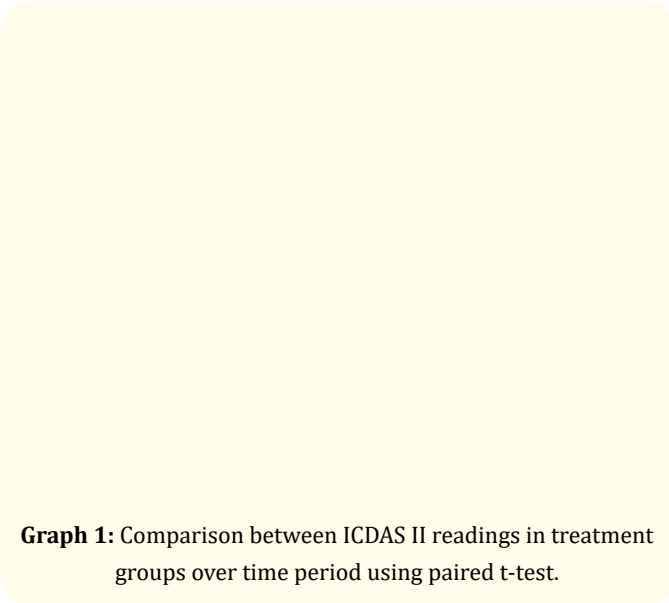
The sample group consisted of 86 patients (38 females and 14 males) with a mean age of 20.6± 0.6 years who were undergoing orthodontic treatment. Scores obtained using the ICDAS II criteria and DDpen were compared between two time periods using paired t- test. In all groups, the mean ICDAS II and DDpen scores decreased from baseline (T0) to after 6 months reevaluation (T1) which confirms the effect of re-mineralization agents on the WSL. ICDAS II and DDpen scores were significant in the test groups presented in table 4 and 5 and graph 1 and 2.

Group	N	T0		T1		T-value	P value
		Mean	Std. Deviation	Mean	Std. Deviation		
Colgate	22	2.32	0.48	2.00	0.00	3.13	.005
Varnish	21	2.24	0.44	1.76	0.54	4.26	.000
Clinpro	21	2.43	0.51	1.67	0.48	8.00	.000
Toothmin	22	3.00	0.00	2.00	0.00	0	NA

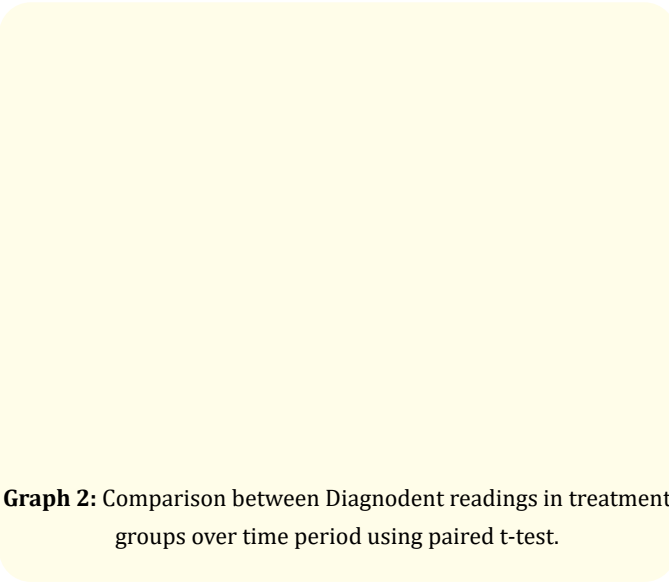
Table 4: Comparison between ICDAS II readings in treatment groups over time period using paired t-test.

Group	N	T0		T1		T-value	P value
		Mean	Std. Deviation	Mean	Std. Deviation		
Colgate	22	4.16	2.02	3.22	1.13	3.99	.001
Varnish	21	4.18	2.55	2.83	2.13	3.67	.002
Clinpro	21	3.84	2.45	2.31	1.44	3.95	.001
Toothmin	22	6.60	0.00	4.60	0.00	0	NA

Table 5: Comparison between Diagnodent readings in treatment groups over time period using paired t-test.



Graph 1: Comparison between ICDAS II readings in treatment groups over time period using paired t-test.



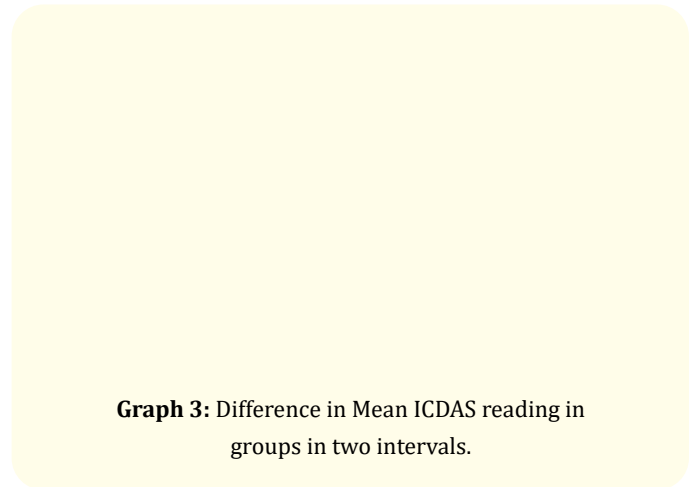
Graph 2: Comparison between Diagnodent readings in treatment groups over time period using paired t-test.

In table 6 and graph 3 showed that difference in mean ICDAS II was significant between all the treatment groups by using repeated ANOVA. The Post hoc Tukey showed that difference in mean ICDAS scores was maximum between Toothmin and Varnish groups and least difference was between Varnish and Clinpro groups. Significant inter group difference was obtained only when comparing toothmin group with other groups i.e., Clinpro, Colgate and Varnish presented in table 7 and graph 4.

Time interval	Group	Mean	Std. Deviation	N
T0	Colgate	2.32	0.48	22
	Varnish	2.24	0.44	21
	Clinpro	2.43	0.51	21
	Toothmin	3.00	0.00	22
T1	Colgate	2.00	0.00	22
	Varnish	1.76	0.54	21
	Clinpro	1.67	0.48	21
	Toothmin	2.00	0.00	22

Tests of Within-Subjects Contrasts						
Source	Interval	Type III Sum of Squares	df	Mean Square	F	Sig.
Interval	Linear	17.552	1	17.552	208.283	.000
Interval * Group	Linear	3.003	3	1.001	11.877	.000
Error (Interval)	Linear	6.910	82	.084		

Table 6: Comparison between ICDAS II readings between 04 treatment groups over time period using Repeated Measures ANOVA.



Graph 3: Difference in Mean ICDAS reading in groups in two intervals.

Post hoc Tukey HSD				
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Colgate	Varnish	0.16	0.10	0.38
	Clinpro	0.11	0.10	0.68
	Toothmin	-0.34	0.10	0.00
Varnish	Colgate	-0.16	0.10	0.38
	Clinpro	-0.05	0.10	0.96
	Toothmin	-0.50	0.10	0.00
Clinpro	Colgate	-0.11	0.10	0.68
	Varnish	0.05	0.10	0.96
	Toothmin	-0.45	0.10	0.00
Toothmin	Colgate	0.34	0.10	0.00
	Varnish	0.50	0.10	0.00
	Clinpro	0.45	0.10	0.00

Table 7: Comparison between ICDAS II readings between 04 treatment groups over time period using Post hoc Tukey.

Time interval	Group	Mean	Std. Deviation	N
T0	Colgate	4.16	2.02	22
	Varnish	4.18	2.55	21
	Clinpro	3.84	2.45	21
	Toothmin	6.60	0.00	22
T1	Colgate	3.22	1.13	22
	Varnish	2.83	2.13	21
	Clinpro	2.31	1.44	21
	Toothmin	4.60	0.00	22

Tests of Within-Subjects Contrasts						
Source	Interval	Type III Sum of Squares	df	Mean Square	F	Sig.
Interval	Linear	91.034	1	91.03	102.52	.000
Interval * Group	Linear	6.320	3	2.11	2.37	.076
Error (Interval)	Linear	72.816	82	.89		

Table 8: Comparison between Diagnodent readings between 04 treatment groups over time period using Repeated Measures ANOVA.

Graph 4: Comparison between ICDAS II readings between 04 treatment groups over time period using Post hoc Tukey.

In table 8 and graph 5 showed that difference in mean of DDpen was significant between all the treatment groups. The post hoc tukey HSD test showed that differences in mean DDpen scores were maximum between toothmin and Clinpro treatment groups and least difference was between varnish and Colgate groups. Significant inter group difference was obtained only when comparing toothmin group with other groups i.e. Clinpro, Colgate and Varnish presented in table 9 and graph 6.

Graph 5: Difference in Mean Diagnodent reading in 04 treatment groups in two intervals.

Post hoc Tukey HSD				
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Colgate	Varnish	0.19	0.49	0.98
	Clinpro	0.61	0.49	0.59
	Toothmin	-1.91	0.48	0.00
Varnish	Colgate	-0.19	0.49	0.98
	Clinpro	0.43	0.50	0.82
	Toothmin	-2.10	0.49	0.00
Clinpro	Colgate	-0.61	0.49	0.59
	Varnish	-0.43	0.50	0.82
	Toothmin	-2.52	0.49	0.00
Tooth min	Colgate	1.91	0.48	0.00
	Varnish	2.10	0.49	0.00
	Clinpro	2.52	0.49	0.00

Table 9: Comparison between Diagnodent readings between 04 treatment groups over time period using Post hoc Tukey.

Graph 6: Comparison between Diagnodent readings between 04 treatment groups over time period using Post hoc Tukey.

In table 10 and table 11 showed a strong positive correlation (0.8) which was statistically significant was observed between ICDAS II and DDpen readings at baseline, and at the 6 months' time interval, showed a moderate positive correlation (0.5) which was statistically significant was observed between ICDAS II and DDpen readings.

Correlations			
		ICDAS at T0	Diagnodent at T0
ICDAS at T0	Pearson Correlation	1	.804**
	Sig. (2-tailed)		.000
	N	86	86
Diagnodent at T0	Pearson Correlation	.804**	1
	Sig. (2-tailed)	.000	
	N	86	86

** . Correlation is significant at the 0.01 level (2-tailed).

Table 10: Correlation between Diagnodent and ICDAS II readings at baseline.

Correlations			
		ICDAS at T1	Diagnodent at T1
ICDAS at T1	Pearson Correlation	1	.533**
	Sig. (2-tailed)		.000
	N	86	86
Diagnodent at T1	Pearson Correlation	.533**	1
	Sig. (2-tailed)	.000	
	N	86	86

** . Correlation is significant at the 0.01 level (2-tailed).

Table 11: Correlation between Diagnodent and ICDAS II readings at after 6 months interval.

Discussion

White spots lesions are subsurface enamel porosities, which develop due to enamel demineralization. They are highly prevalent in patients under fixed orthodontic treatment, which enhance plaque retention, decrease pH and results in rapid shift of oral microbial flora to a pathogenic flora [30]. Hadler-Olsen., *et al.* reported in his study that 50% of the patients with fixed appliances developed at least one WSLs lesion during treatment [8].

Various agents are used to treat WSLs like Resin infiltration and topical application of re-mineralising agents [21]. Although Davila., *et al.* (1975) concluded in his study resin infiltration as a restorative treatment for WSLs nearly 40 years ago [36]. Recent advances

in re-mineralising of the WSLs include the use of various agents like Casein phosphopeptide amorphous calcium phosphate (CPP-ACP), Clinpro 5000 1.1% Sodium Fluoride Anti-cavity Toothpaste with Tri- Calcium Phosphate that contains 5000ppm fluoride and an innovative tricalcium phosphate (3M ESPE), tri-calcium phosphate nano complexes with fluoride ions (Clinpro tooth crème), GC Tooth Mousse (Recaldent), Toothmin cream (Biodental Remin), MI Varnish (GC American, Alsip, III, USA), MI Paste Plus (GC American, Alsip, III, USA), Cerevitec Plus varnish and Enamel Pro- Varnish.

The selected samples were further divided randomly into 4 groups- Group 1- Colgate group, Group 2- MI Varnish, Group 3- Clinpro crème and Group 4-Toothmin toothpaste. All patients was educated and motivated to use the re-mineralising agents two times a day. Every patient was monitored every month and patients were asked to submit empty tubes of re-mineralising agents. Screening of patients was done using standard loupes and DDpen for visual and digital examination at T0 (at baseline) and T1 (after 6 months).

Scores obtained using the ICDAS II criteria and DDpen were compared between two time periods using paired t- test. In all groups, the mean ICDAS II and DDpen scores decreased from baseline (T0) to after 6 months reevaluation (T1) which confirms the effect of re-mineralization agents on the WSL. ICDAS II and DDpen scores were significant in the test groups presented in table 4 and 5 and graph 1 and 2. Our study was in concordance with the study done by Karabekiroglu., *et al.* (2018) in which he concluded that the scores obtained using ICDAS II Criteria were decreased in all the groups after 6 months using CPP-ACP (MI Varnish) and NaF (Clinpro crème) re-mineralising agents [25] whereas in DIAGNODent result was in concordance to various studies by Karabekiroglu., *et al.* (2018) and Singh., *et al.* (2016), as they have concluded that DD reading were significantly decreased using CPP-ACP (MI-Varnish) and fluoride toothpaste (Colgate) at 6 months of interval period [22,25].

When comparing the all 4 group at T0 (baseline), the difference was statistically significant when evaluated using ICDAS criteria (Table 6 and Graph 3). The post hoc tukey HSD test showed that difference between these groups was significant only when comparing toothmin with other groups whereas no statistically difference was seen when comparing Clinpro, MI Varnish and Colgate among themselves (Table 7 and Graph 4). Same results were obtained by

Kaur., *et al.* (2015) in which they concluded that Toothmin is better agents for re-mineralising agents than CPP-ACP (Clinpro crème) [13].

When comparing all 4 group at T0 (baseline), the difference was statistically significant when evaluated using DIAGNODent criteria (Table 8 and Graph 5). The post hoc tukey HSD test showed that difference between these groups was significant only when comparing toothmin with other groups whereas no statistically difference was seen when comparing Clinpro, MI Varnish and Colgate among themselves (Table 9 and Graph 6). Same results were obtained by Kaur., *et al.* (2015) in which they concluded that Toothmin is better agents for re-mineralising agents than CPP-ACP (Clinpro crème) [13].

A strong positive correlation (0.8) which was statistically significant was observed between ICDAS II and Diagnodent readings at T0 (baseline) (Table 10). These results are in concordance to the results concluded by Kavvadia., *et al.* (2018) where they say that the correlation is low in cases of early lesions with score <2 using ICDAS II criteria which we have excluded from our study [16].

However, our study showed a moderate positive correlation (0.5) which was statistically significant between ICDAS II and Diagnodent readings at T1 (after 6 months) (Table 11). Same correlation was seen in a study by Almosa [35], *et al.* (2014) in which they concluded the correlation of the diagnodent pen with the ICDAS criteria as good (.71). Possible reasons for the decrease in correlation at baseline(T0) to after 6 months of interval(T1) of ICDAS II criteria and DIAGNODent pen is that at the baseline (T0), samples were included with the specific score using ICDAS II (score 2-4) and DIAGNODent PEN (0-10). Another reason for the decrease correlation might be the calculus, and plaque which are usually seen during orthodontic treatment and DDpen readings are often affected by stains [13].

Kavvadia [16], *et al.*, mentioned regarding the clinical relevance of results in his study, fluorescence devices were proven to be less valid for mild WSL than the visual examination. Mild WSL are difficult for the orthodontist to clinically detect (Lopatiene [34], *et al.* 2016). Their findings support that DIAGNODent Pen and Vista Proof™ may not be the ideal tool for such lesion detection in an orthodontic practice. Regarding the extended WSL, the perfor-

mance of the fluorescence devices was similar to the visual method; however such lesions may be easily discernible with clinical observation thus adjunct diagnostic tools do not seem necessary in the everyday clinical practice [17].

Khalaf [10] reported in his study that developing WSLs is more in males compared to females. However in our study we have not divided the sample based on the gender. Also some studies have revealed that self-ligating brackets have fewer bacteria in plaque compared with elastomeric ligated brackets (Karad, 2019) [3] and thus effect the WSL but as in our study we have used only Conventional MBT brackets this result cannot be justified by our study.

In our study, only WSLs on the anterior teeth were considered and posterior teeth were not evaluated. Another limitation of our study is that in one group of MI vanish we used one time application only at the baseline (T0) did not provide any advantages [5]. Another limitation, the patient compliance could not be ideally controlled [12]. Furthermore, the use of DDpen is also of high cost, time consume and possibility of false-positive results [7].

Importantly, in our study, Toothmin seems to be good agents for treatment of WSLs during fixed orthodontic treatment. However, other re-mineralising agent also found to be effective in our study but Toothmin gave the best results outcome.

In the future, it would be useful to conduct a similar study to evaluate and compare the efficacy of re-mineralising agents in the posterior and anterior teeth in males and females. There is still some controversy about the frequency of WSLs on different types of teeth. Like, which tooth is most commonly affected, other criteria such as the type of bracket, orthodontic technique and the association between fluoride and antimicrobial agents should also be considered in the future.^{1,7}

Conclusion

The following conclusions can be drawn from this controlled clinical trial

- Toothmin and Clinpro showed maximum reduction of WSLs over a period of 6 months.
- Toothmin proved to be the most effective means of treating WSLs over other treatment regimens.
- Both the visual method (ICDAS II) and the digital method (DI-AGNOdent) can be used for the evaluation of WSLs.

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