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RESEARCH ARTICLE

COMPARISON OF DIFFERENT TREATMENT MODALITIES FOR WHITE SPOT LESION USING UV VISIBLE SPECTROSCOPY AND MICROHARDNESS OF ENAMEL SURFACE

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ABSTRACT

Objective: The aim of the present study is to evaluate the efficiency of microabrasion, enamel remineralising agent and resin infiltration technique in treatment of white spot lesion.

Materials and Methods: Ninety extracted teeth with no visible enamel defects were taken. The teeth were then subjected to demineralisation cycle for 2 weeks. The samples after demineralisation were divided into three groups of thirty teeth each**:** GROUP A treated with microabrasion technique, Group B s treated with remineralising agent, Group C treated with resin infiltration technique. The microhardness, transmittance and absorbance values were recorded pre-treatment (T0), after demineralisation (T1) and after different treatment modalities (T3) using microhardness tester, and UV-Visible spectrophotometer respectively. The data were analysed using ANOVA followed by Bonferroni post hoc analysis to compare the microhardness and absorbance and transmittance between the groups.

Results: The results suggested that there was statistically significant difference between group A, B,C in improvement of microhardness, transmittance and absorbance values after demineralisation, the improvement was more in group C followed by group A and group B.

Conclusion: The results of the present concludes that white spot lesion can be best treated by resin infiltration technique which improves the microhardness as well as mask the white spot lesion lesions by getting camouflaged with the adjacent sound enamel.

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INTRODUCTION

The term WSL was defined by Fejerskov as "the first sign of caries like lesion on enamel that can be detected with the naked eye." (Sangmesh and Kallury, 2011; Summitt *et al*., 2006) The WSL has also been defined as "subsurface enamel porosity from carious demineralization" that presents itself as "a milky white opacity when located on smooth surfaces." (Sangmesh and Kallury, 2011; Summitt *et al*., 2006) As most of the patients who come for orthodontic treatment, are more concerned about esthetics. WSLs can cause caries thereby leading to poor esthetics, patient dissatisfaction and associated problems (Sangmesh and Kallury, 2011; Zachrisson and Brobakken, 1978; Ogaard *et al*., 1988). The formation of WSL after completion of orthodontic treatment is not satisfactory to the orthodontist whose goal is to improve esthetics in the dento-facial region as well as the patient who come seeking for esthetics. WSL develop in association with brackets, bands, arch wires, ligatures and other orthodontic attachments that complicate conventional oral hygiene measures, leading to prolonged plaque accumulation. This concern raises the need for assessing the saliva, oral hygiene status and caries rate before beginning of treatment and initiating preventive measures. Clinically, formation of white spots around orthodontic attachments can occur as early as 4 weeks into treatment (Zachrisson and Brobakken, 1978) and their prevalence among orthodontic patients ranges from 2% to 96%. (Mizrahi, 1982; Gorelick *et al*., 1982; Mitchell, 1992) The frequency of WSLs occurring in orthodontically treated patients were on lateral incisors, canines, first premolars, second premolars, central incisors, reason being more exposure to dietary carbohydrates and less flow of saliva in these regions. (Kamna *et al*., 2013) Tufekci *et al*. concluded in his clinical study that a sharp increase in the number of WSLs occurred during the first 6 months of treatment that continued to rise at a slower rate to 12 months, thus in initial months of the treatment critical evaluation of oral hygiene is recommended. (Tufekci *et al*., 2011) The appearance of WSL

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on the enamel surface during fixed orthodontic treatment is due to multiple factors. Co-existence of the four factors namely, bacterial plaque, fermentable carbohydrates, a susceptible tooth surface and a sufficient period of time are necessary for WSL to develop.

The risk of enamel demineralization during fixed orthodontic treatment can be prevented:

1. By improving patient oral hygiene using mechanical plaque control methods.
2. By enhancing the enamel resistance to the microbial acid by using remineralising agents.

However, despite of all preventive measures white spot lesion are still a problem for some patients after fixed orthodontic treatment has been completed. In such cases, various methods have been proposed, to effectively manage white spot lesion, e.g. microabrasion, remineralisation and resin infiltration. Though many studies have compared these methods and evaluated their efficiency, most studies have focused only on the color matching properties to the surrounding unaffected enamel. However in clinical scenario the microhardness of enamel is also important as the treated enamel has to be strong to resist breakdown in oral environment. Prevention and treatment of white spot lesion is a demanding and challenging concern post orthodontic therapy. Hence this study has been undertaken to evaluate the various methods of white spot lesion treatment using UV Visible spectrophotometer and microhardness test, to provide an insight of the best treatment modality which can be used for the treatment of WSLs in terms of esthetics as well as efficacy of the treatment.

MATERIALS AND METHODS

This study was carried out in Dayananda Sagar College of Dental Sciences, Central Manufacturing and Technology Institute and Indian Institute of Science, Bangalore. The material for this study comprised of Ninetyextracted premolars collected from Oral and Maxillofacial Surgery Department, Dayananda Sagar College of Dental Sciences, Bangalore.

Inclusion Criteria: Premolar teeth extracted for orthodontic purpose.

Exclusion criteria: Decayed teeth, Fluorosed teeth, Attrited teeth, Restored teeth, Hypoplastic teeth, Fractured teeth.

The sample size consists of 90 premolars which were divided into 3 groups: GROUP A(n-30) samples treated with microabrasion technique. Group B (n-30) samples treated with remineralising agent. (Sensodyne Repair and protect, Calcium sodium silicophosphate (novamin), Topical cream, GSK Pharmaceutical Ltd,). Group C (n-30) samples treated with resin infiltration technique. Ninety extracted Premolars with no visible enamel defects were collected. Any tissue, calculus and/or bone remaining on the teeth was removed with an ultrasonic dental scaler and was stored in 0.1% thymol solution at room temperature until required. The buccal surface of the crowns was polished with non- fluoridated pumice to remove any external stains present. The root was separated from the crown with separating disks. The acid-etched areas (WSLs) were restricted to 4 mm x 4 mm of the enamel surfaces by coating the surrounding enamel surfaces with two layers of acid-resistant nail varnish. Acidic assaults was simulated by demineralization cycles 3 times per day, each lasting 60 minutes, by using a demineralization solution. After each acid challenge the surface layers in the exposed enamel windows was removed by brushing with a soft tooth brush for 10 seconds and kept in deionised water. This process of demineralisation was repeated for 2 weeks. After 2 weeks, specimens was washed thoroughly with distilled deionized water (DDW), and the nail varnish was removed using acetone before washing the teeth in DDW again. After this procedure each tooth was displaying an artificial WSL of 4 mm x 4 mm.
Ninety samples with artificial white spot lesion created were grouped into 3 groups of 30 samples each: Group A (n-30) samples treated with microabrasion technique. Group B (n-30) samples treated with remineralising agent. Group C (n-30) samples treated with resin infiltration technique.

Group A – In samples treated with microabrasion, 18% hydrochloric acid was mixed with a fine pumice powder to form a slurry. This mixture was applied to the buccal surface of each experimental tooth with a small wooden toothpick. The slurry was agitated onto the tooth surface for 10 seconds using rubber cup and then washed off with an air – water spray. The cycle of acid pumice application, agitation, and washing was repeated 10times for each experimental tooth. Finally, the tooth was washed for 30 seconds. This technique was repeated 4 times at an interval of 1 week for 4 weeks.

Group B- In samples treated with remineralising agent, remineralising agent was applied onto the buccal surface of each experimental tooth for 1 min using a soft toothbrush and then washed using air –water spray and stored in deionized water. This procedure was repeated for 31 days, twice daily.

Group C- In samples treated with resin infiltration, the infiltration procedure was performed onto the buccal surface according to the manufacturer's instructions:

- Icon-Etch was applied for 2 min.
- Specimens were water rinsed and air dried for 30 s.
- Icon-Dry was applied for 30 s and air-dried.
- Icon-Infiltrant was applied two times, the first time for 3min and the second time for 1min. Both applications were light cured for 40 s.

For each specimen, surface micro hardness was recorded using Microhardness tester (Key sight Nanoindenter G-200) and absorbance & transmittance was recorded using UV Visible Spectrophotometer Specord S600 - 212C205, before any treatment (T0), after demineralisation (T1) and after different treatment modalities (T2), to find out which technique gives microhardness and absorbance and transmittance values closer to pre-treatment, in order to find out which treatment modality gives better results.

RESULTS

The purpose of this study was to quantify the efficiency of microabrasion, enamel remineralising agent and resin infiltration technique in treatment of white spot lesion, and to compare between the three techniques, in terms of surface microhardness and esthetics of the treated enamel surface. A sample of Ninety extracted teeth without decay, fluorosis, attrition, restoration, hypoplasia and fracture were taken. The teeth were grouped into three groups, Group A –

Microabrasion, Group B- Remineralisation, Group C Resin Infiltration. All the samples were tested for micro-hardness, transmittance and absorbance pre-treatment. Microhardness was tested between the 3 study groups using ANOVA followed Bonferroni's post hoc analysis. Before treatment there was no statistically sigificant difference between the microhardness of the tooth samples in all the three groups suggested by p value 0.97 as shown in Table 1 and Fig 1. The samples were then subjected to demineralisation to create artificial white spot lesion, and the microhardness was tested again, there was no statistically sigificant difference between the microhardness of the tooth samples in all the three groups suggested by p value 0.56 in Table 1 and Fig 1. After the demineralisation the samples of group A were subjected to microabrasion, samples in group B to remineralisation and samples in group C to resin infiltraton. It was noted that there was statistically signficant difference between the three groups suggested by p-value <0.001 in table 1 and Fig 1. The diffence between the group A VS C was 0.01, and B Vs C was <0.01 showing the microhardness after treatment was improved in group C followed by Group A and Group B.

Comparison was also done within each group for the change in micro-hardness before treatment, after demineralisation and after treatment as shown in Table 2 and Fig 2. There was statistically significant difference present at different stages for each group. Transmittance was tested between the three study groups at different stages and statistically significant difference was found out in the transmittance values in all the three group as shown in Table 3 and Fig 3. Absorbance was tested between the three study groups at different stages and statistically significant difference was found out in the absorbance values in all the three groups as shown in Fig 4 and Table 4. Absorbance was also compared within each group after different stages, and statistically significant change in transmittance values were found out in group A and group B as shown in Fig 5 and Table 5. However in group C when comparison was made before treatment and after treatment there was no statistically significant difference showing that the resin infiltration technique was able to treat the enamel as near to pre-treated enamel level.

Table I. Comparison Of mean Microhardness (In VHN) between the 03 Study Groups using ANOVA followed Bonferroni's Post Hoc Analysis

Time Period	Study Groups	N	Mean	SD	Std. Error	95% CI for Mean		P-Value	Sig. Diff	P-Value
						Lower	Upper			
Before Rx	Group A	30	64.09	12.03	2.20	59.60	68.58	<0.001*	A Vs C	<0.001*
	Group B	30	64.25	4.93	0.90	62.41	66.09		B Vs C	<0.001*
	Group C	30	53.88	8.41	1.54	50.74	57.02			
After DM	Group A	30	78.04	7.97	1.45	75.06	81.01	0.001*	A Vs C	0.002*
	Group B	30	76.99	6.10	1.11	74.71	79.27		B Vs C	0.01*
	Group C	30	70.59	10.31	1.88	66.73	74.44			
After Rx	Group A	30	68.79	10.53	1.92	64.86	72.72	<0.001*	A Vs C	<0.001*
	Group B	30	67.34	5.13	0.94	65.42	69.25		B Vs C	<0.001*
	Group C	30	52.74	7.99	1.46	49.75	55.72			

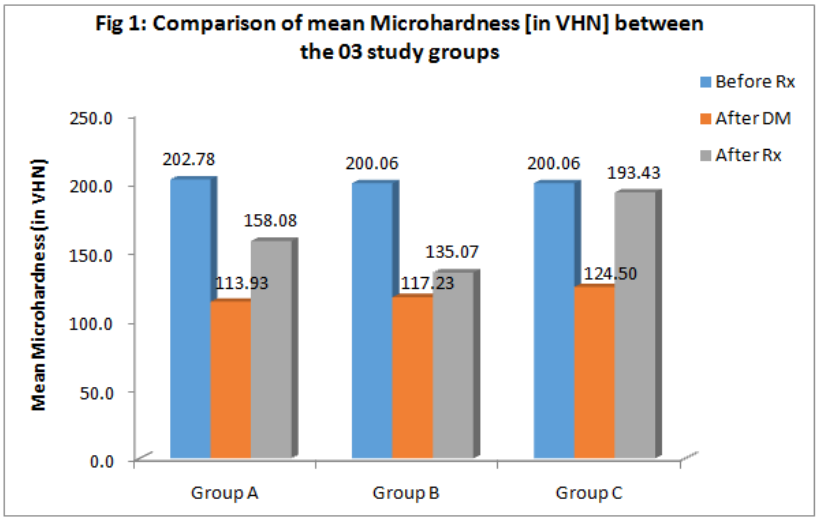


Table II: Comparison of mean microhardness (in VHN) within each group at different time periods using repeated measures of ANOVA followed by Bonferroni's post hoc analysis

Time Period	Study Groups	N	Mean	SD	Std. Error	95% CI for Mean		P-Value	Sig. Diff	P-Value
						Lower	Upper			
Before Rx	Group A	30	202.78	47.79	8.73	184.93	220.63	0.97	..	..
	Group B	30	200.06	47.26	8.63	182.41	217.71			
	Group C	30	200.06	48.70	8.89	181.88	218.25			
After DM	Group A	30	113.93	33.90	6.19	101.27	126.59	0.56	..	..
	Group B	30	117.23	37.53	6.85	103.22	131.24			
	Group C	30	124.50	44.80	8.18	107.77	141.23			
After Rx	Group A	30	158.08	47.61	8.69	140.31	175.86	<0.001*	A Vs C	0.01*
	Group B	30	135.07	38.97	7.11	120.52	149.62		B Vs C	<0.001*
	Group C	30	193.43	48.87	8.92	175.18	211.68			

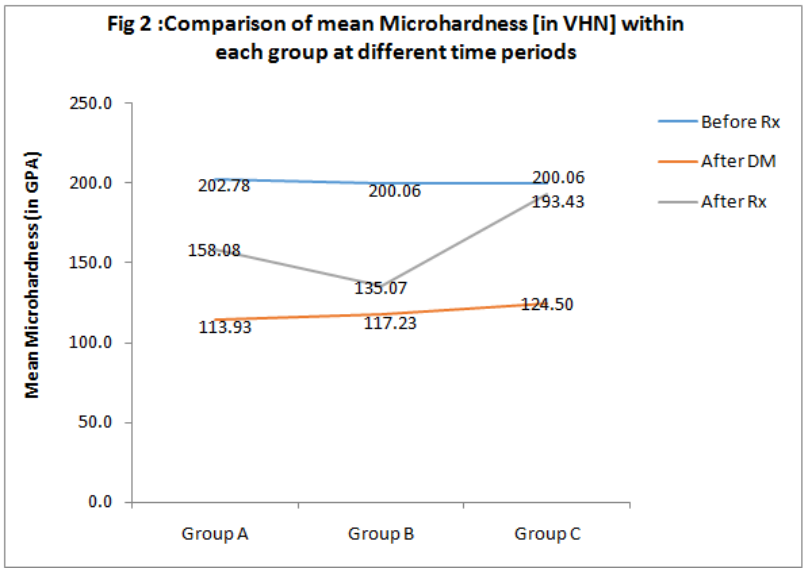


Table III. Comparison of mean Transmittance between the 03 Study Groups Using ANOVA followed by Bonferroni's Post Hoc Analysis

Group	Time	N	Mean	SD	Std. Error	95% CI for Mean		P-Value	Sig. Diff	P-Value
						Lower	Upper			
Group A	Before Rx	30	202.78	47.79	8.73	184.93	220.63	<0.001*	1 Vs 2	<0.001*
	After DM	30	113.93	33.90	6.19	101.27	126.59		1 Vs 3	<0.001*
	After Rx	30	158.08	47.61	8.69	140.31	175.86		2 Vs 3	<0.001*
Group B	Before Rx	30	200.06	47.26	8.63	182.41	217.71	<0.001*	1 Vs 2	<0.001*
	After DM	30	117.23	37.53	6.85	103.22	131.24		1 Vs 3	<0.001*
	After Rx	30	135.07	38.97	7.11	120.52	149.62		2 Vs 3	0.01*
Group C	Before Rx	30	200.06	48.70	8.89	181.88	218.25	<0.001*	1 Vs 2	<0.001*
	After DM	30	124.50	44.80	8.18	107.78	141.23		1 Vs 3	<0.001*
	After Rx	30	193.43	48.87	8.92	175.18	211.68		2 Vs 3	<0.001*

Note: 1 - Pre treatment, 2 – After Demineralisation, 3 – Post treatment
*- statistically significant

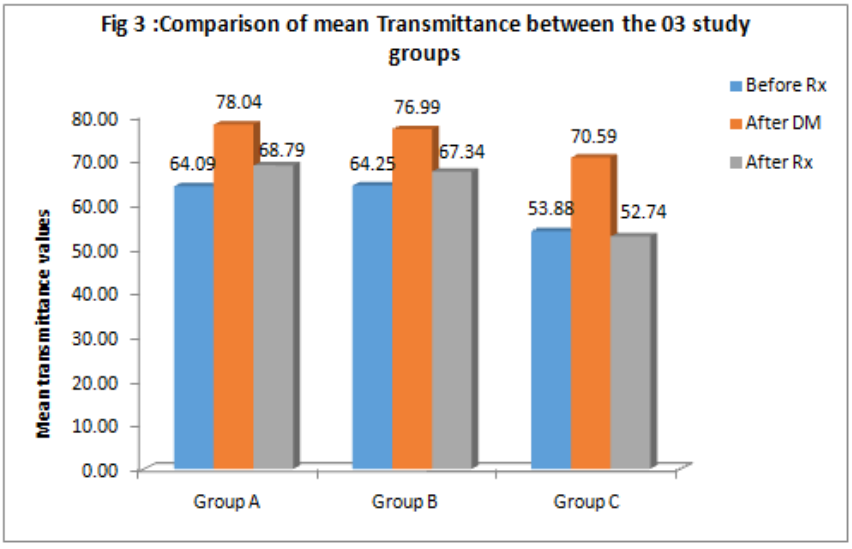


Table IV: Comparison of mean absorbance between the 03 study groups using ANOVA followed by Bonferroni's post hoc analysis

Time Period	Study Groups	N	Mean	SD	Std. Error	95% CI for Mean		P-Value	Sig. Diff	P-Value
						Lower	Upper			
Before Rx	Group A	30	0.20	0.08	0.02	0.17	0.23	<0.001*	A Vs C	<0.001*
	Group B	30	0.19	0.03	0.01	0.18	0.21		B Vs C	<0.001*
	Group C	30	0.27	0.07	0.01	0.25	0.30			
After DM	Group A	30	0.11	0.04	0.01	0.09	0.13	0.001*	A Vs C	<0.001*
	Group B	30	0.11	0.03	0.01	0.10	0.13		B Vs C	0.005*
	Group C	30	0.16	0.06	0.01	0.13	0.18			
After Rx	Group A	30	0.17	0.07	0.01	0.14	0.19	<0.001*	A Vs C	<0.001*
	Group B	30	0.17	0.03	0.01	0.16	0.19		B Vs C	<0.001*
	Group C	30	0.28	0.07	0.01	0.26	0.31			

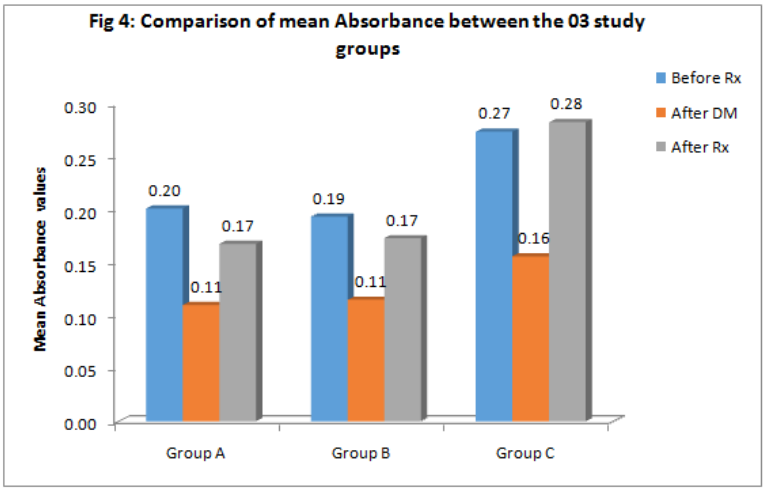


Table V. Comparison of mean absorbance within each group at different time periods using repeated measures of ANOVA followed by Bonferroni's post hoc analysis

Group	Time	N	Mean	SD	Std. Error	95% CI for Mean		P-Value	Sig. Diff	P-Value
						Lower	Upper			
Group A	Before Rx	30	0.20	0.08	0.02	0.17	0.23	<0.001*	1 Vs 2	<0.001*
	After DM	30	0.11	0.04	0.01	0.09	0.13		1 Vs 3	<0.001*
	After Rx	30	0.17	0.07	0.01	0.14	0.19		2 Vs 3	<0.001*
Group B	Before Rx	30	0.19	0.03	0.01	0.18	0.21	<0.001*	1 Vs 2	<0.001*
	After DM	30	0.11	0.03	0.01	0.10	0.13		1 Vs 3	<0.001*
	After Rx	30	0.17	0.03	0.01	0.16	0.19		2 Vs 3	<0.001*
Group C	Before Rx	30	0.27	0.07	0.01	0.25	0.30	<0.001*	1 Vs 2	<0.001*
	After DM	30	0.16	0.06	0.01	0.13	0.18		1 Vs 3	0.05
	After Rx	30	0.28	0.07	0.01	0.26	0.31		2 Vs 3	<0.001*

Note: 1 - Pre treatment, 2 – After Demineralisation, 3 – Post treatment
*- statistically significant

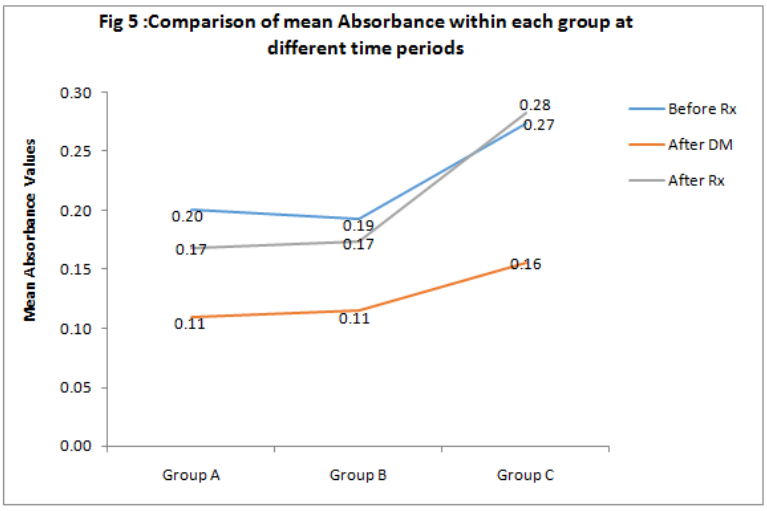
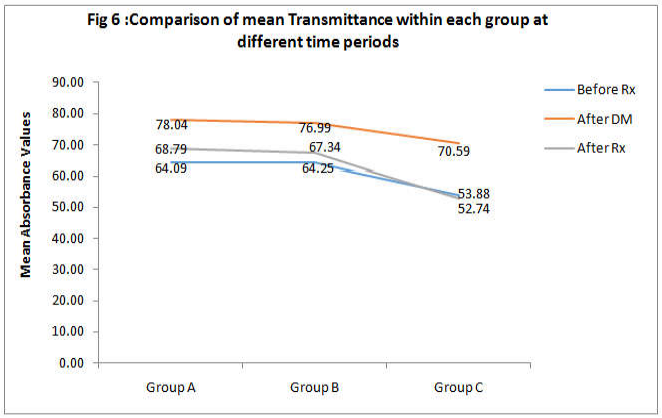


Table VI. Comparison of mean Transmittance within each Group at different time periods using repeated measures of ANOVA followed by Bonferroni's post hoc analysis

Group	Time	N	Mean	SD	Std. Error	95% CI for Mean		P-Value	Sig. Diff	P-Value
						Lower	Upper			
Group A	Before Rx	30	64.09	12.03	2.20	59.60	68.58	<0.001*	1 Vs 2	<0.001*
	After DM	30	78.04	7.97	1.46	75.06	81.01		1 Vs 3	<0.001*
	After Rx	30	68.79	10.53	1.92	64.86	72.72		2 Vs 3	<0.001*
Group B	Before Rx	30	64.25	4.93	0.90	62.41	66.09	<0.001*	1 Vs 2	<0.001*
	After DM	30	76.99	6.10	1.11	74.71	79.27		1 Vs 3	<0.001*
	After Rx	30	67.34	5.13	0.94	65.42	69.25		2 Vs 3	<0.001*
Group C	Before Rx	30	53.88	8.41	1.54	50.74	57.02	<0.001*	1 Vs 2	<0.001*
	After DM	30	70.59	10.31	1.88	66.73	74.44		1 Vs 3	0.04*
	After Rx	30	52.74	7.99	1.46	49.75	55.72		2 Vs 3	<0.001*

Note: 1 - Pre treatment, 2 – After Demineralisation, 3 – Post treatment
*- statistically significant.



Transmittance was also compared within each group after different stages, and statistically significant change in transmittance values were found out as shown in Fig 6 and Table 6. However in group C when comparison was made before treatment and after treatment there was no statistically significant difference showing that the resin infiltration technique was able to treat the enamel as near to pre-treated enamel level.

DISCUSSION

In the present study three different treatment modalities microabrasion, resin infiltration and remineralisation are used to treat white spot lesion, and their efficacy in treatment of white spot lesion is evaluated using microhardness test and transmittance and absorbance test of the enamel surface at different stages, pre-treatment, after demineralisation and after treatment with different treatment modalities. Microhardness is the hardness of the material gauged with instruments using small indenters. Adit Bharat Mehta *et al*. (Mehta *et al*., 2014) demonstrated that the microhardness of the substance reduces with reduction in mineral content as shown by the reduction in vicker's microhardness number after demineralization of enamel surface when compared to the untreated surface, which was similar to the finding in the present study. The absorbance of the substance is the amount of light absorbed by the substance and transmittance is the amount of light that is transmitted through a substance. Absorbance increases as the concentration of the substance increases and transmittance decreases as the concentration of substance increases. (Robert and Christopher, 1994)

$$\text{absorbance} = \log\left(\frac{1}{\%\ \text{transmittance}}\right)$$

In this study in pretreatment samples, absorbance of the sample was more and transmittance was less. When the same samples were demineralized and transmittance and absorbance was tested again the absorbance decreased due to loss of mineral from the enamel and transmittance increased as concentration of the enamel reduced. According to study done by Shivanna *et al*. (2011) resin infiltration can be an alternative to micoabrasion and restorative treatment. The study states the resin penetrates into the lesion micro porosities driven by capillary force and is hardened by light curing. Infiltrated lesions lose their whitish appearance and look similar to sound enamel, additionally the treatment prevents lesion progression. The findings of the present study showed a statistically significant change in the improvement of white spot lesions in the resin infiltration group followed by microabrasion and remineralisation. The result of this study was not in agreement with the study done by Hussam Milly *et al*. (2014) and Elizabeta. Gjorgeiska (2010) to evaluate the potential of bioactive glass to remineralise white spot lesion using scanning electron microscope, which showed that bioactive glass remineralisation increased the mechanical properties of enamel. In the present study there was an improvement in microhardness of enamel surface but the improvement in mechanical properties was less when compared to other treatment modalities. However, it was in agreement with the study done by Sombir Singh *et al*. (2016) in which they concluded that remineralising agents had no additional benefit in the remineralisation of post orthodontic WSLs. The study is also in agreement with the systematic review done by Hong Chen *et al*. (2013) which concluded that there is a lack of reliable evidence to support the effectiveness of remineralising agents for the treatment of post orthodontic white spot lesion.

In the present study the microhardness of the enamel surface showed improvement after treating with microabrasion technique which was in comparison with the study done by Murphy *et al*. (2007) where Microabrasion significantly reduced visible enamel demineralization. The mean reduction in lesion size after treatment was 83% as quantified by using image processing software before and after treatment with micro abrasion technique. The present study showed that the resin infiltration technique was better when compared to remineralising technique both in relation to improvement in microhardness as well as absorbance, as similar with the study done by Torres *et al*. (2011) to evaluate the performance of different treatments on masking white spot lesions by assessing the colour change using spectrophotometer and concluded that resin infiltration was proven to be an effective treatment for masking white spot lesions. Also, after a new acid challenge, the group infiltrated with low viscosity resin presented the lowest means of colour change. He Yuan *et al*. (Akin and Basciftci, 2012) conducted a study comparing the effects of remineralising agents and resin infiltration in the treatment of WSLs using Crystal eye spectrophotometer and quantitative light induced Fluorescence at different time intervals after treatment schedule as mentioned: (1) baseline, (2)2 weeks, (3)4 weeks, (4)6 weeks, and concluded that resin infiltration is more effective than remineralising agents. The results were similar to the present study in which resin infiltration proved to be the most effective treatment modality in improvement of WSLs after treatment when compared to remineralisation and microabrasion. The results of the present study states that white spot lesion can be best treated by resin infiltration technique which improves the microhardness as well as mask the white spot lesion lesions by getting camouflaged with the adjacent sound enamel. Microabrasion and remineralisation also improves the white spot lesions but remineralisation offers the least good results. In the present study all the teeth in the three groups did not exhibit similar transmittance and absorbance values pre-treatment which can be attributed to difference in the time of extraction and time kept in storage media before the teeth were taken for the testing.

Conclusion

The conclusion of the present study is as follows:

1. Decrease in microhardness occurred after demineralization of all the samples in Group A, B, C.

2. Decrease in absorbance and increase in transmittance was observed in all the samples in Group A, B, C after demineralization.
3. After treatment with different treatment modalities, the greatest improvement in microhardness and increase in absorbance was observed in resin infiltration group (Group C), followed by micro abrasion (Group A) and remineralisation (Group B)
4. Resin infiltration technique is concluded to be the most effective treatment modality in treatment of white spot lesion.

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