



A STANDARDIZED *IN VIVO* PHOTOGRAPHIC TECHNIQUE TO ASSESS THE REMINERALIZATION OF WHITE SPOT LESIONS AFTER ORTHODONTIC TREATMENT

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ABSTRACT

Abstract: The aim of this study was to innovate a standardized *in vivo* Photographic technique to assess the change in appearance and dimensions of white spot lesions present after orthodontic treatment before and after remineralization.

Subjects and Methods: Forty five children from 12 to 17 years old who had just finished their orthodontic treatment were selected from the Orthodontic Clinic Faculty of Dentistry Ain Shams University. The purpose of the study was clearly explained to the patients and they agreed by signing an "Informed Consent". The children were randomly assigned to either the MI plus or the control groups. MI plus paste was applied weekly per the manufacturer instructions in the Pediatric Clinic at Faculty of Dentistry Ain Shams University. Examination of white spot lesions was performed using the ICDAS II criteria and compared with the photographic assessment at the beginning of the study period as a baseline and every month for six months throughout the study. The white spot lesions as a percentage area of the visible labial surface of the tooth were calculated by image analysis using ADOBE PHOTOSHOP™ and Auto CAD 2007.

Results: Standardized photographic technique has been proved to be reliable, accurate and reproducible when carried out on digital images in comparison with direct clinical examination using the ICDAS II.

KEYWORDS: Remineralization, Photoshop, MI plus paste, Photographic technique, White spot lesions

INTRODUCTION

Esthetics is the major demand for the orthodontic patient whom often seeks comprehensive treatment to improve not only function, but mainly appearance. Unfortunately, the ultimate success of an ideal occlusion is often tarnished by the appearance of

white spot lesions (WSLs) due to demineralization on the facial surface of teeth after removing the fixed appliances.¹ It should be emphasized here that as long as the surface of the WSL remains intact, there is possibility of arrest or even reversal of the lesion.²

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The ICDAS II (International Caries Detection and Assessment System 2005) is considered a useful method for measuring surface changes and potential histological depth of the carious lesions by relying on surface characteristics.³ Due to the large degree of subjectivity with visual inspection of WSLs, other methods have been tested such as photographic examination, fluorescent dye uptake, ultraviolet light, lasers, and quantitative light induced fluorescence.^{4,5}

Clinical dental photography is a helpful tool in dentistry and specifically orthodontic treatment. The first time photographs were utilized to assess the carious changes occurring in enamel was reported by **Hill and Geddes**.⁶

Digital photography has been boosted recently with advancement in computing, telecommunication and the internet. Digital images can be taken and stored using recently developed digital cameras⁷. An attempt was made to investigate the use of computer scanning of photographic images to trace the area of WSLs around orthodontic brackets. The area was calculated by a computer, which was about 1.8 times the actual site.⁸

Traditionally, topical fluoride application has been the most common method to prevent development of white spot lesions around orthodontic appliances.^{9,10} However more recently, MI Paste™ and MI Paste Plus™ which are complexes of Recaldent™ casein phosphopeptides and amorphous calcium phosphate (CPP-ACP) have been introduced, for preventing and even reversing white spot lesions. Several studies results pointed out that in-office and at home treatment with MI Paste Plus™ showed a statistically significant reduction in WSLs area when compared to controls. Therefore it provided some remineralization of white spot lesions.^{11,12}

Therefore this study was designed to evaluate a standardized in vivo Photographic technique to assess the change in appearance and dimensions of white spot lesions present after orthodontic treatment before and after remineralization.

SUBJECTS AND METHODS

Forty five children from 12 to 17 years of age who had just undergone bracket debonding were selected from the Orthodontic Clinic Faculty of Dentistry Ain Shams University. All the patients who were suffering from WSLs with a score of 1 & 2 according to the ICDAS II¹³ detected clinically on the buccal surface of permanent anterior teeth were included in the study.

The purpose of the study was clearly explained to the patients and patients who agreed to participate were asked to sign an Informed Consent. The faculty Research Ethics Committee reviewed the proposal.

Clinical examination together with photographic assessment was performed at the beginning of the study period as a base line for comparison and every month for six months throughout the study period for all the patients.

Since WSLs are usually associated with plaque deposits, the dental plaque deposit had to be removed before the assessment. Dental prophylaxis was performed with a bristle brush and non-fluoridated prophylactic paste during the initial clinical examination and monthly before examination, with the aim of providing clean tooth surfaces for the clinical evaluation of the WSLs.

Each white spot lesion was also assessed and scored according to severity and activity using the ICDAS II criteria. Surfaces were examined each time whilst wet and after air drying. All measurements were carried out by the two examiners and again after a 5-minute interval in between series of four images and repeated after 1 week and kappa value was 0.45.

The following were determined, from photographs for all the patients in relation to WSLs:

- 1- The area of the labial surface of the tooth
- 2- WSL area
- 3- The area of WSL to area of the labial surface of the tooth ratio percent (Percent of WSL)

- 4- The percentage of WSL ratio related to initial condition at the measured time (Relative Percent)
- 5- The percentage of decrease in WSL ratio due to time (**Percent Decrease**)
- 6- The decrease in the WSL area related to the initial condition (**Relative Decrease**)

The patient was asked to sit upright in habitual occlusion and with relaxed lips and mentalis muscles. The subject's head was positioned so that the Frankfurt horizontal plane was parallel to the floor, and the midsagittal plane of the head was aligned with the center of the camera lens. The patient's eyes should be looking straight ahead and unstrained.¹⁴ A Cephalostat was used to keep the head of a patient in a well-defined position throughout the photographic session. It consists of a chin rest and ear rods to determine the position of the head in relation to the camera every time the photos were taken. A retractor was used to fully expose the teeth. Patients were asked to bite on tongue blade to expose all the labial surfaces of anterior teeth. Patient position remained the same in the three views (Figure 1).¹⁵



Fig. (1) The patient was made to sit upright in habitual occlusion and with relaxed lips and mentalis muscles

All the photographs were taken with Nikon DX camera* with an 18-55 mm AF-S Nikon lens. The camera was set to manual with an aperture of f16 and a shutter speed of 1/125 of a second. Macro lens configuration was selected the image quality was set as fine and ISO sensitivity 200. All images were saved as Joint Photographic Experts Group (JPEG) files suitable for manipulation with the image analysis software. Light is supplied by ring flash (Macro Ring Flash Vivitar DF S86N) mounted around the lens.

Patient's confidentiality was respected through the photographic technique. Special settings were performed to standardize the photographic procedure in relation to the distance and angle of camera-tooth. Tripod and label marks on the floor to be able to seat the tripod in the same position on subsequent visits to get the accurate distance between cephalostat-camera and patient to achieve patient and camera distance standardization (Figure 2).

The subject's head was positioned so that the Frankfurt horizontal plane was parallel to the floor, and the midsagittal plane of the head was aligned with the center of the camera lens. Side mirror was used to aid in head orientation.



Fig. (2) Marks on the floor for tripod placement for frontal view

* Nikon Corporation, Tokyo, Japan

Camera grid was utilized to add for further standardization for the head orientation in addition to the Cephalostat which was used to keep the head of a patient in a well-defined position throughout the photographic session. A cheek retractor was used to fully expose the teeth. Patients were asked to bite on tongue blade to expose all the labial surfaces of anterior teeth.¹⁴ (Figure 1) Patients positions remained the same throughout all views.

After examination, the children were randomly assigned by the aid of random tables to either the MI plus or the control groups. MI plus paste was applied weekly per the manufacturer instructions in the Pediatric dentistry Department clinic, Faculty of Dentistry Ain Shams University.¹² The Control group was only instructed to perform regular brushing with fluoridated toothpaste

After digital images were captured, they were downloaded and stored as JPEG. Then the images were analyzed, and compared with baseline images by Abode Photoshop and Auto CAD 2007. Each patient has at least seven photos from the beginning of the study till the end of follow up the first photo take letter a then b ,c ,d.... ect.

Magnification and image enhancement with Abode Photoshop helped properly identify and mark the actual lesion edges by means of the freehand preselection tool and the computer mouse. In order to accurately measure surface area of WSLs and of the labial surface of the tooth the images were saved and reopened by Auto CAD as Abode Photoshop can not perform this operation accurately.

The JPEG* images were imported into image analysis software. The images were opened by Adobe Photoshop™ **. During the analysis, images were magnified up to 100%; the outline of the tooth and the outline of WSLs were traced by means of

the freehand preselection tool and the computer mouse. The traced tooth which has the WSL in first view was cut as a layer and duplicated in order to be compared with itself in the future views. This step is repeated with every new photo taken every month throughout the follow up periods. Discrepancy of about 0.3-0.5 cm³ between same tooth in 2 views although it was statistically insignificant, but this was corrected by Adobe Photoshop™ Discrepancy of more than 0.3-0.5 cm³ between same tooth in the two views, although it was statistically insignificant, but in this case the view was retaken. The images were saved and reopened by Auto Cad 2007***. In the Auto CAD 2007 the outline of the tooth and the outline of WSLs were retraced to calculate the surface areas of the WSL and total surface area of the labial surface of the tooth. WSL%: The white spot lesion as a percentage area of the visible labial surface of the tooth was calculated by:

WSL%: Area of WSL/Area of labial surface of tooth (t) x 100.152

All the data was collected and tabulated. Statistical analysis was performed by Microsoft Office 2013 (Excel) and Statistical Package for Social Science (SPSS) version 20.

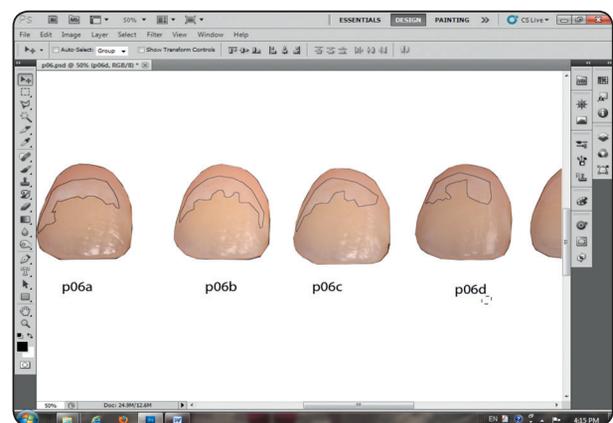


Fig. (3) Comparing of surface area of the same tooth in every view with the first one.

* Image J version 1.33u for Windows XP, US National Institutes of Health, Bethesda, Md).

** 7.0 J; Adobe Systems incorporated, San Jose, Cal., U.S.A.

*** DWG 2007 AC1021, Autodesk sued.

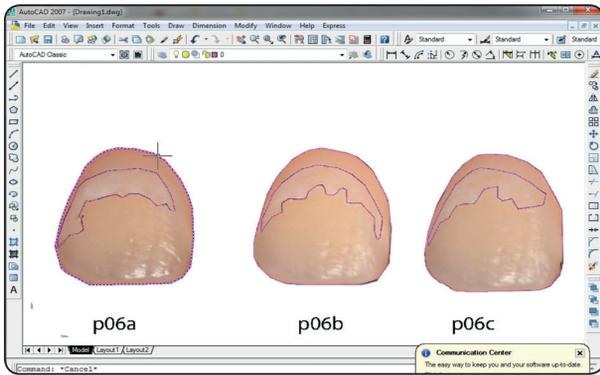


Fig. (4) The images were reopened by Auto CAD 2007

RESULTS

In the present study, the significant decrease in the total surface area of WSLs in MI paste in comparison to control group through out the follow up periods and the differences between the MI paste plus group and control group were efficiently demarcated by the photographic technique.

From the previous tables and figure 6 it was shown that there was a decrease in rate of progression of WSLs in the first two months in MI group and then decreases again after the fourth month till the end of follow up period at sixth month. While the curve of the control group was between up and down through out the study period and this was not significant. MI group was statistically significant than control group.

The special settings and procedures that were performed in our study to standardize the photographic technique showed that the photos obtained throughout the follow up period were accurately superimposed on each other without any discrepancies.

The measurements of the tooth outline and the WSLs outline which were retraced in the Auto CAD program to calculate the surface areas of the WSLs

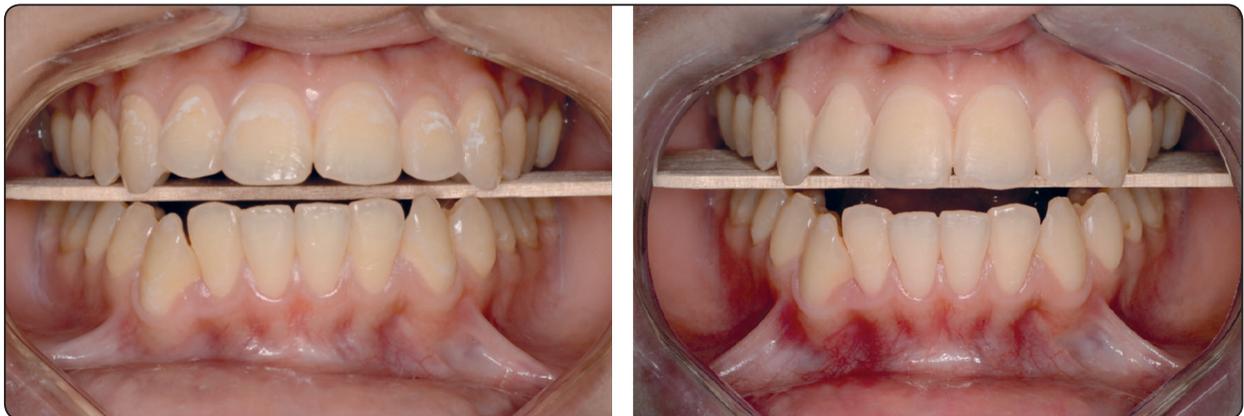


Fig. (5): Pre-operative and postoperative photo of patients in Mi plus group.

TABLE (1) The change in Percent of WSL through the follow up period:

Group	Stat.	Time in Months					
		1	2	3	4	5	6
Control	Mean	26	27.25	25.07	24.4	23.83	27.09
	STD*	11.35	12.55	12.44	11.81	14.22	15.83
MI plus	Mean	19.87	14.83	11.61	7.801	3.236	1.287
	STD	15.65	12.59	13.5	10.83	3.626	0.577

*Standard deviation

TABLE (2) The change in Relative Percent in WSL through the follow up period:

Group	Stat.	Time in Months					
		1	2	3	4	5	6
Control	Mean	100	104.8	96.44	93.86	91.66	104.2
	STD*	43.66	48.26	47.86	45.42	54.68	60.87
MI plus	Mean	100	74.65	58.42	39.27	16.29	6.476
	STD	78.78	63.39	67.94	54.51	18.25	1.443

*Standard deviation

TABLE (3) The percentage decrease in WSL through the follow up period:

Group	Stat.	Progress Period				
		A	B	C	D	E
Control	Mean	-1.2	2.172	0.671	0.572	-3.26
	STD	6.397	4.979	7.35	10.76	13.29
MI PLUS	Mean	5.035	3.225	3.805	4.565	1.95
	STD	6.766	3.935	6.576	8.163	2.438

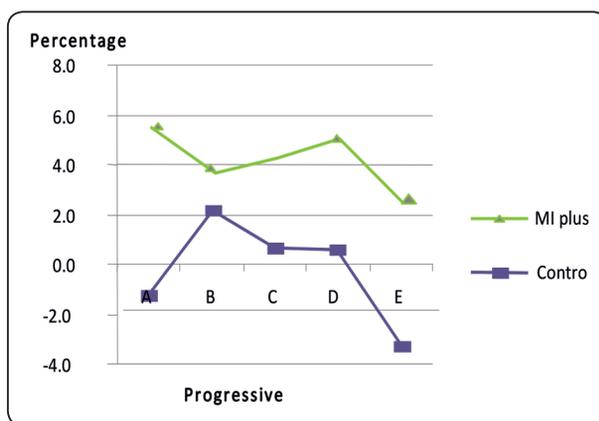


Fig. (6) Percentage of decrease in WSL through the follow up period

and total surface area of the labial surface of the tooth were carried out by the two examiners and again after a 5-minute interval in between series of four images and repeated after 1 week, kappa yielded the intra-examiner agreement as 0.61 and the inter-examiner agreement as 0.59 and this proved that this method has a higher agreement level than the ICDASII which was only 0.45.

DISCUSSION

The ICDAS II was used in our study to include or exclude children from the study in accordance to the clinical trial of tooth mousse on WSLs which was conducted by the Cooperative Research Centre for Oral Health Science at The University of Melbourne. As the ICDAS II measure surface changes and potential histological depth of carious lesions by relying on surface characteristics.¹³

We chose teeth with score 1 and 2 according to the ICDAS II in the inclusion criteria and we excluded teeth with the score 3,4,6 according to the ICDAS II because it was emphasized in the study done by **Ardu S. et al.**¹⁶ and the study done by **Ogaard B.**¹⁷ that as the surface remains intact, there is possibility of arrest or even reversal of the demineralized lesion.

Together with the ICDAS II, photographic assessment was chosen to be used for quantification of demineralized areas in accordance to the study done by **Willmot D. R. et al.**¹⁸ and the study done

by **Benson P.E. et al.**¹⁹ As the reproducibility of this method has been confirmed. Also, its accuracy has been proved when carried out on digital images.²⁰

Special settings and procedures were performed in our study to standardize the photographic technique to obtain reproducible photographs in order that the photos obtained through out the follow up period can be accurately superimposed on each other without any discrepancies.

Cephalostat is one of these settings, which was used in our study in accordance with the study done by **Florine Vegeter** and **Joris Hage**.¹⁴ It consists of a chin rest and ear rods to determine the position of the patient head in relation to the camera. It also contains a pointer defining the position of any facial landmark. That's why its use facilitates patient orientation in the same position every time the photos were taken throughout the follow up period.

The camera was perpendicularly positioned in a manner to set the lens at the same level as the area being photographed. This setting goes with the studies done by **Cochran et al.**¹⁵ and **H.F Mckeown et al.**²⁰ That's why the camera remains on the tripod and its place was marked on the floor to be able to seat it in the same position on subsequent visits.

The distance from the patient to the camera lens was fixed. This agreed with the study done by **Senthil Kumar** and **Tamizharasi**²¹ to assure consistent perspective for all patients and similar reproduction ratios and tooth-to-camera distances

According to data from the current study there was a decrease in rate of progression of WSLs in the first two months in MI Paste plus group which after that increased gradually till fourth month and then decreases again after the fourth month till the end of follow up period at sixth month.

In agreement with these findings a prospective randomized clinical trial was carried by **Robertson et al.**,²² in 2011, to determine the effectiveness of MI Paste Plus in reduction of white spot lesions

in orthodontic patients. A double-blind method of randomization was used to determine whether each patient received the MI Paste Plus or a placebo paste. MI Paste Plus decreased the number of white spot lesions already present. On the other hand, the placebo paste had no preventive action on white spot development during orthodontic treatment; the number of lesions actually increased, that's why MI paste plus was chosen as a guaranteed agent to decrease WSLs.

Storing the images as JPEG files was chosen and this agreed with **Benson PE. et al.**¹⁹ and **Chapman JA et al.**²³ as they are suitable and easy for manipulation with the image analysis software.

Magnification and image enhancement with Adobe Photoshop helped properly identify and mark the actual borders of WSLs by means of the freehand preselection tool and the computer mouse. And the study done by **Y. Iijima**²⁴ goes with this finding.

To accurately measure surface area of WSLs and of the labial surface of the tooth the images were saved and reopened by Auto CAD and this agreed with the study done by **Neves et al.**²⁵

CONCLUSION

The reproducibility and accuracy of the in vivo photographic assessment has been proven to be an efficient method to assess and evaluate the efficacy of the remineralizing agent via the decrease in the dimensions of the white spot lesions when carried out on digital images.

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