

SHORT COMMUNICATION

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Application of Image J in Quantitative Analysis of the Therapeutic Effect of Resin Infiltration for White Spot Lesions

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Abstract

Resin infiltration has been increasing used recently, but evaluation methods of it is not objective or practical in clinical. This article aim to introduce the application with details of Image J in quantitative analysis of the therapeutic effect of resin infiltration for white spot lesions (WSL). Images from 10 maxillary central incisors with WSL were collected by digital camera before and after treatment of resin infiltration. Images were imported into Image J. Two methods (gray scale and ratio of WSL) were performed to acquire data of gray scale and ratio of WSL of each crown before and after treatment of resin infiltration. Date of two methods was statistical analyzed respectively. The Student's t-test showed significant difference between data from before and after treatment of resin infiltration. Application of Image J in analysis of the therapeutic effect of resin infiltration for WSL is objective and practical in clinical.

Keywords: Maxillary central incisor; White spot lesions; Resin infiltration; Image J

Introduction

The refractive index of normal enamel is 1.62. As the enamel of crown is demineralized, it becomes porous structure. When the pores of enamel are filled with water, the refractive index of it turns to 1.33, so the lesion area appears to be opaque and cretaceous. And when the surface of the tooth is dried, the moisture in the pores is replaced by air, the refractive index of which is 1.0, so the white spot becomes more obvious [1]. Notably, it is demineralization that leads to difference of the refractive index between enamel with lesions and normal enamel, consequently WSL arise [2]. There are many reasons for demineralization of enamel, demineralization caused by the plaque, demineralization caused by etching agent in orthodontics and enamel hypoplasia caused by dental fluorosis and so on [3].

There are three methods are commonly used to treat WSL in clinical: (1) remineralizative therapy of fluoride or casein phosphopeptideamorphic calcium phosphate (CPP-ACP): They reduce the solubility and promote the remineralization of enamel, inhibit the metabolism of cariogenic bacteria and change the morphology and structure after tooth eruption, however, it needs more times and the effect depending on the compliance of patients. In addition, remineralization is limited at the lesion surface which is not enough [4]; (2) Microabration: It often used to treat the cosmetic problems caused by WSL, but it can cause the loss of tooth tissue, so it only applies to the shallow lesions [5]; (3) Resin filling or veneer repair: The effect of them is clear, however, they are invasive. Patients received orthodontic treatment are mostly children and adolescents, resin filling or veneer repair will sacrifice some dental tissue, leading to the early loss of it [6]. (4) Resin infiltration: It is a new product invented in recent years using high fluidity and low viscosity resin materials to infiltrate the porous structure of demineralized enamel through the capillary siphon. It can block the channels for the invasion of acid and the flee of mineral ions in order to stop the development of early caries. At the same time, since the refractive index of resin infiltration is 1.48, with that the refractive index of enamel with lesions raises to be close to that of normal enamel, consequently the appearance of WSL is apparently improved [7,8]. Because of its advantages of minimally invasive, painless, aesthetic effect and good permeability, resin infiltration is widely used in clinical work. There are enough evidences that it is effective in the treatment of early dental caries, WSL after orthodontics and mild or moderate dental fluorosis [9].

At present, the evaluation methods of resin infiltration are mainly subjective and objective evaluation. Subjective evaluation means dentists and patients evaluate the color reduction of crowns surface by their naked eye [10]. Objective evaluation is mainly made by using optical system and software. About objective evaluation, nowadays, most reports focus on the studies on the teeth *in vitro*. The data of L*, a* and b* passageways were collected under microscope on the surface of WSL model or slicing, and then ΔE values were calculated, accordingly evaluation of color reduction was obtained [11,12]. Objective evaluation is a method widely used and accurate, however, it is not feasible in clinical as it needs isolated teeth or expensive



equipment. In addition, there are a few researches available that quantitatively analyzed crowns in patients' mouth through digital cameras and image software [13]. We believe this method has high feasibility and it is possible to be introduced widely in clinical. However, such studies are precious little. For that, this study will introduce the application of Image J in quantitative analysis of the therapeutic effect of resin infiltration for WSL.

Materials and Methods

Basic data of subjects

This study was retrospective study. A total of 5 subjects (10 maxillary central incisors) (mean age: 28.60 years) agreed to participate in the study. All patients have consented to the submission of the data without any personal information, and signed informed consents were obtained from every participant. Inclusion criteria: (1) Maxillary two central incisor; (2) Obvious area of WSL found on enamel surface; (3) Non-cavitated enamel surface; (4) Free of any restorations (composites, veneers, crowns). Exclusion criteria: (2) No area of WSL found on enamel surface; (2) Cavitated enamel surface; (3) Presence of any restorations.

Preparations before resin infiltration

After appliances were taken off, adhesive was removed with a carbide finishing bur. All teeth were then polished with fluoride-free polishing paste using a rubber cup. For every subject, the two maxillary central incisors were isolated with cotton rolls and dried with oil- and-water-free air for 5 seconds. All examinations and photos were done by one examiner. Standardized digital photographs were taken first time for the two maxillary incisor teeth of all subjects after debonding and polishing as control groups. The application of the resin infiltration (Icon caries Infiltrant-Smooth Surface, DMG, Germany) was the next step.

Application of resin infiltration

All application procedures were done according to the manufacturer's instructions. Briefly, first, rubber dam kit (HYGENIC, Coltene Whaledent, USA) were placed to protect the gingival and to provide a dry working field. Mylar strips were placed with the wedges distal to the two maxillary central incisors to protect the neighboring teeth. Next, enamel surface was eroded with 15% HCl gel (Icon-Etch, DMG, and Germany). After 2 min, the etchant was rinsed off with water spray for 30 sec, and dried with oil- and-water-free air resulting in a obvious white spot appearance of the etched area. Then, to free the enamel microporosities of any remaining water, 99 % ethanol (Icon-Dry, DMG, and Germany) was applied onto enamel surface for 30 sec. Afterwards, the resin infiltration was applied. A clean Smooth Surface Tip was attached onto the Icon-Infiltrant syringe, and an ample amount of the Icon-Infiltrant was applied onto the lesion surface for 3 minutes and then light-cured (output of 450 nm and a light intensity of 800 mW/cm² for 40 seconds). A second layer of Icon-Infiltrant was applied as first time. Finally, after removing the rubber dam kit, polishing cups were used to finish the surface to a smooth luster.

Photos taking after treatment

Standardized digital photos were taken for the second time after resin infiltration application. All the photos were taken using a digital camera (600D) with a 100 mm/2.8 AF Micro lens and ring flash (Cannon, Japan). The camera was set to manual mode with an aperture of f 22 and a shutter speed of 1/200 sec. The image quality was set as fine and ISO sensitivity 200. All images were saved as JPEG format.

Operation of Image J

The JPEG images were imported into Image J (version 1.51j8 for Windows, National Institutes of Health, USA) (Figures 1A and 1B). Here, we will introduce two methods of analyzing the effect of resin infiltration, gray scale and ratio of WSL. Methods will be introduced as procedure in the tables 1 and 2.

Statistical analyses

All statistics were carried out in Excel (Microsoft, USA) and GraphPad Prism (GraphPad Software Inc., USA) for Windows. Results were presented as mean \pm S.D. The Student's t-test was used for comparing two groups of data. Data at P<0.05, P<0.01 or P<0.001 had statistical significance.

Results

Comparison of data from method of gray scale of crown before and after treatment of resin infiltration

Mean gray scale of crown before treatment of resin infiltration is 156.49 \pm 11.03, while after is 168.62 \pm 12.82 (Figure 1I). The difference between them has statistical significance (P < 0.05) (Figure 1I).

Comparison of data from method of ratio of WSL of crown before and after treatment of resin infiltration

Mean ratio of WSL of crown before treatment of resin infiltration is $68.79 \pm 23.44\%$, while after is $21.91 \pm 13.58\%$. The difference between them has statistical significance (P<0.01) (Figure 2I).

Discussion

With the increase of orthodontic treatment, there are more and more cases of WSL occurring on crown surface after treatment. Resin infiltration has been proven to be the best way to treat WSL at present, so the demand for it is increasing.

The evaluation methods of resin infiltration are divided into subjective and objective evaluation. Subjective evaluation means dentists and patients evaluating the color reduction of crowns surface by naked eye. In this method, researchers or patients evaluated changes in WSLs at photos by using a visual analog scale (VAS) (0=no change, 100=complete disappearance) and area measurements [10]. It is low cost and noninvasive, but maybe lack of objectivity. On the other hand, objective evaluation is mainly made by using optical system and software. Most reports focus on the studies on the teeth in vitro. The data of L*, a* and b* passageways were collected under SpectroShade Micro spectrophotometer or stereomicroscope on the surface of WSL model or slicing, and then ΔE values were calculated, thereby evaluation of color reduction was obtained [11,12]. The advantages of this method is full of accuracy and reliability, however, it needs expensive equipment. Not only that, teeth were extracted to be experiment objects [14]. We consider it is not feasible in practical clinical for its cost and irreversible trauma. To solve this problem, some researchers have quantitatively analyzed crowns in patients' mouth through digital cameras and image software. Hammad S, et al. [13] use camera and Image J to detect the histograms of gray scale from digital photos taken from teeth surface in patients' mouth, which require only a digital camera and software that is freely available. And they succeeded to evaluate the effect of application of resin infiltration on masking the WSL after bracket removal. However, it provided no details as to how WSL were measured. During this study, we have introduced two methods of analyzing the effect of resin infiltration, gray scale and ratio of WSL, using Image J by tables and figures with concrete steps. In the parts of results, we certified that these two

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Figure 1: Illustration of method of gray scale and its results. A: Image of crown before treatment of resin infiltration; B: Image of crown after treatment of resin infiltration; C&D: 8 bits type of A & B; E & F: The outline of whole crown; G&H: Gray scale of A & B; I: Comparison of data from G&H. *: P<0.05.



Figure 2: Illustration of method of ratio of WSL and its results. A&B: The red channel of crown before and after treatment of resin infiltration; C&D: The outline of whole crown; E&F: The scope of WSL; G&H: Ratio of A&B; I: Comparison of data from G&H. **: P<0.01.

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Table 1: Procedure of method of gray scale.

	Procedure	Details
1	Convert to 8-bit	Image-Type-8 bit (Figures 1C and 1D)
2	Select the outline of whole crown	Polygon selections (Figures 1E and 1F)
3	Results output	Analyze-Histogram-copy the value of Mean (Figures 1G and 1H)

Table 2: Procedure of method of ratio of WSL.

	Procedure	Details
1	Split and select the red channel	Image→Color→Split channels→Select the dialog of red channel (Figures 2A and 2B)
2	Select the outline of whole crown	Polygon selections (Figures 2C and D)
3	Select the scope of WSL	Image→Adjust→Threshold→Set the first number to turn WSL into red→Set the second number to 255→Close the dialog (Figures 2A and 2D)
4	Calculate the area of whole crown	Analyze→Measure→Copy the value of Area (Figures 2G and 2H)
5	Calculate the area of WSL	Analyze→Set Measurements→Check Limit to threshold→Close the dialog→Analyze→Measure→Copy the value of Area (Figures 2G and 2H)
6	Calculate ratio of WSL	Divide the area of WSL by the area of whole crown (Figure 21)

methods were available to evaluate the therapeutic effect of resin infiltration for WSL with statistical significance.

Nowadays, since it is in the absence of an official standard for the measurement of WSL improvement from resin infiltration, many researchers devote themselves to invent a better way for it. This study has determined the optimal computer aided method for measuring the change of WSL on crown surface. There is increasing interest in the evolution of WSL from time to time in order to broaden our understanding of resin infiltration, so we need urgently a method for it. Image J is image analysis software that is easy to use, highly practical and objective. It has been used in many researches for quantification of skin lesion, wounds, embryonic development, tissue regeneration and so on [15-18]. Among them, we indicated that Image J was found to be an objective, reproducible, low cost, time-saving and noninvasive method of quantifying the area of WSL.

Conclusion

Image J, computer-aided analysis, is reliable and able to add the evidences of clinical trial. It could be considered a part of routine clinical strategy as well as in the research studies. Application of Image J in analysis of the therapeutic effect of resin infiltration for WSL is objective and practical.

Conflict of Interest

None of the authors has any conflict of interest regarding this article.

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