Short Report

The problem of the conventional transillumination method explained and a proposed solution

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Abstract

In this report, reflected light which is a problem in the conventional transillumination method is explained, and a solution is proposed. The purpose of this report was to investigate the characteristics of transmitted and reflected light on the image of the recorded bite impression material, and to propose a method for distinguishing between the reflected light area and the occlusal contact area.

Gray scale values in the transmitted and the reflected light areas were evaluated through the conventional transillumination method. The reflected light could not be distinguished from the contact area. From this result, it was revealed that the reflected light interfered with the observation of the occlusal contact via the conventional method. From the results of having evaluated RGB values in the transmitted and the reflected light areas, it was considered that the color difference between transmitted light and reflected light was useful to separate the transmitted and reflected light.

Due to the adjustment of the offset and the gamma correction values, the reflected light could be distinguished from the occlusal contact area. It was considered that this method was helpful for accurately detecting the occlusal contact area on a digital photograph.

Key words

Inter-occlusal record, Transillumination method, Occlusal contact

1. Introduction

In daily dental practice, occlusal contacts are examined via occlusal registration paper and a bite impression material. The transillumination method involves examining occlusal contacts from the perforated state of the bite impression material. In previous studies¹⁾⁻⁹⁾, a black silicone has been used for inter-occlusal records. Consequently, this method is called the “silicone-black method.” From this method, it is possible to preserve occlusal records and compare their findings through observation. In our previous studies, we created a threshold curve to accurately detect the occlusal contact area on a digital photograph¹⁰⁾, and investigated

the influence of filler on bite impression material via the transillumination method¹¹⁾.

There are 2 kinds of high-lighted areas on the recorded bite impression materials during observation of occlusal contacts via the transillumination method. One is the perforated spots with transmitted light area which indicate the occlusal contact area. The other one is the reflected light area. It frequently appears near the occlusal contact area, and disturbs the observation of the occlusal contact. In the conventional transillumination method, the occlusal contact areas are detected with the intensity value on a 2-dimensional gray scale image. Therefore, the reflected light area cannot be distinguished from the occlusal contact area. However, to accurately evaluate the occlusal contact, the reflected light area has to be removed. In previous studies¹²⁾¹³⁾, several methods for detection of the reflected light area have been reported. They detected high-lighted areas, and restored

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Received 2013 / 6 / 25 Accepted 2014 / 6 / 25

Fig.1 Fabrication method of model
(a): Contact with the metal plate and the artificial tooth
(b): After taking record

color information on the surface of the subject. However, in these studies, the inquiry point was only the reflected light area. Thus, there is a need in the field for a more thorough means to evaluate the occlusal contacts. In relation to the occlusal contacts, doing so would allow us to more accurately diagnose anomalies of occlusal contacts and to evaluate the occlusal stabilization both quantitatively and visually.

In this report, the reflected light which is the problem of the conventional transillumination method is explained, and a solution is proposed. The purpose of this report was to investigate the characteristics of transmitted and reflected light on the image of the recorded bite impression material, and to propose a method for distinguishing between the reflected light area and the occlusal contact area.

2. Materials and Methods

2.1 Fabrication of experiment model

A model for investigating the characteristics of transmitted and reflected light was fabricated as follows;

- 1) A metal plate and an artificial tooth of the right first molar were set on a material testing machine (MMT-101NV-10, SHIMADZU Co. Ltd., Kyoto, Japan). The placement of the artificial tooth was decided by where the plate and the artificial tooth came into contact. With the mesial and distal buccal cusp and mesial palatal cusp in contact with the metal plate, the baseline was set (**Fig.1(a)**).
- 2) Then the plate and the artificial tooth were separated. A bite impression material (purple silicon material, Correct Quick®, Pentron Clinical Technologies, LLC, USA: hereafter CQ) was placed on the plate. Finally, the artificial tooth was positioned to the baseline via the material testing machine. The condition of the contact was recorded to the bite impression material (**Fig.1(b)**).

2.2 Observation of the model

The model was put on a film viewer. Photos were taken

Fig.2 Overview of photographing (a) and region of interest on photo taken
(b): inside of dotted line

with a digital camera in a darkroom to avoid diffused light. The setting and parameters were as follows: Camera: Nikon D90 (Nikon Co., Tokyo, Japan), Lens: Medical Nikkor 120 mm (Nikon Co., Tokyo, Japan), Shutter speed: 1/20 s, Diaphragm: F4, Film viewer: LightViewer 7000PRO (Mean brightness: 1400 ± 300 cd/mm², Hakuba, Tokyo, Japan), Distance between light and object was: 530 mm. **Fig.2** shows the overview of photography and a taken image (**Fig.2(a),(b)**). In this study, the region of interest (ROI) was inside of dotted line frame. In this area, the reflected light area appeared near the perforated area (**Fig.2(b)**).

2.3 Evaluation of gray scale value and RGB value in the transmitted and the reflected light area

A part of the ROI, which involved the transmitted and reflected light area, was selected (**Fig.3**), and gray scale value and RGB value were measured. The photo was analyzed via Photoshop (Adobe Systems Inc., CA, USA).

2.4 Investigation of method for elimination of reflected light

We investigated the possibility of eliminating reflected light by analyzing the characteristics of transmitted and reflected light on the image of the model.

2.5 Different bite impression materials effect on the characteristics of lighted areas

In addition to CQ, 5 kinds of specimens were fabricated using the following materials; Imprint Bite® (Blue silicon material, 3M ESPE, MN, USA: hereafter IB), EXABITE

Fig.3 A part of the ROI for measuring RGB values on the gray scale (a) and original color image (b)

III[®] (Green silicon material, GC, Tokyo, Japan: EB), Blue Silicone[®] (Blue silicon material, GC, Tokyo, Japan: BS), Memoreg[®] (Pink silicon material, Heraeus Kulzer Inc., NY, USA: MR), REALBITE[®] (Green silicon material, Tokuyama Dental Co., Tokyo, Japan: RB).

Subsequently, the reflected light was observed through the same method as above.

2.6 Feasibility of our method in a clinical case

The feasibility of our method to eliminate reflected light was inspected with a clinical occlusal record. An occlusal record was taken through a common method from a female patient using CQ.

3. Results

3.1 Evaluation of gray scale value and RGB value in the transmitted and the reflected light area

1) Evaluation of gray scale value in the transmitted and the reflected light area through the conventional transillumination method

Fig.4 shows the schema of the position relations between the mesial buccal cusp and the plate, and the distribution of the gray scale values. The thickness of material was calculated with a calibration curve, which was reported in our previous study¹²⁾. The calibration curve indicated the relation between the material thickness and the intensity value. Using the calibration curve, the material thickness is calculated from the intensity value on the gray scale image as follows; intensity value = material thickness: 123=100 μ m, 87=200 μ m, 70=250 μ m.

In the transmitted light area, the range of thickness at each area was calculated as follows; area (a):0-100 μ m, area (b):100-200 μ m, area (c):200-250 μ m.

In the reflected light area, the range of thickness was

Fig.4 Schema of contacted condition (upper) and graph of the distribution of gray scale value (lower)

calculated from approximately 100 to 250 μ m, in spite of having more thickness as shown in the schema (Fig.4).

In the conventional method, the reflected light could not be distinguished from the contact area. From this result, it was revealed that the reflected light interfered with the observation of the occlusal contact.

2) Evaluation of RGB value in the transmitted and the reflected light area

Fig.5 shows gray scale and RGB values. In the transmitted light area, B value was highest, except in the perforated area. On the other hand, G value was highest in the reflected light area.

It was considered that this color difference was useful to separate the transmitted and reflected light.

3.2 Investigation of method for elimination of reflected light

It was considered that the color difference between transmitted light and reflected light was useful to separate the

Fig.5 Distribution of RGB values

Fig.6 A part of the ROI after adjusting the offset and gamma correction values
(Upper: Original color image, Middle: Gray scale image, Lower: After adjusting the offset and gamma correction values)

transmitted and reflected light.

Therefore, the offset and gamma correction values were manually changed to emphasize this color difference. **Fig.6** shows a part of the ROI after adjusting the offset and gamma correction values. The transmitted light area was between the blue areas when the offset and gamma correction values were adjusted as follows; offset value:-0.0812, gamma correction value:2.12. On the other hand, the reflected light area was between green areas.

Furthermore, **Fig.7** shows the image and RGB value at the border of the transmitted light and the reflected light areas.

0,113,76	61,116,84	61,116,84	0,116,0	61,118,0	84,120,0	91,125,61	76,127,91	61,128,96	61,127,84	61,125,84	61,118,61	0,113,0	0,113,0	0,110,0	0,104,0	0,76,0	0,76,0	0,91,0
0,100,0	0,107,0	0,100,0	0,110,0	0,113,0	0,118,0	0,118,61	0,116,84	0,116,84	0,118,76	0,110,61	0,100,61	0,110,0	0,96,0	0,91,0	0,84,0	0,0,0	0,61,0	0,0,0
0,76,0	0,96,0	0,91,0	0,96,0	0,100,0	0,110,0	0,104,61	0,91,76	0,91,61	0,100,61	0,96,84	0,76,76	0,84,0	0,61,0	0,0,0	0,0,76	0,0,76	0,0,0	0,0,0
0,0,0	0,61,0	0,76,0	0,61,0	0,61,0	0,76,0	0,84,61	0,0,0	0,0,0	0,0,0	0,0,0	0,0,76	0,0,76	0,0,0	0,0,0	0,0,61	0,0,76	0,0,76	0,0,0
0,0,76	0,0,76	0,0,0	0,0,0	0,0,0	0,0,0	0,61,0	0,0,0	0,0,0	0,0,0	0,0,0	0,0,84	0,0,76	0,0,0	0,0,0	0,0,0	0,0,84	0,0,91	0,0,61
0,0,100	0,0,96	0,0,76	0,0,61	0,0,61	0,0,84	0,0,91	0,0,100	0,0,104	0,0,100	0,0,100	0,0,91	0,0,76	0,0,76	0,0,91	0,0,91	0,0,96	0,0,96	0,0,76
0,0,91	0,0,104	0,0,107	0,0,104	0,0,107	0,0,113	0,0,110	0,0,116	0,0,118	0,0,110	0,0,110	0,0,100	0,0,91	0,0,91	0,0,113	0,0,107	0,0,104	0,0,104	0,0,104

Fig.7 Image and RGB value at the border of the transmitted light and the reflected light areas. (Upper; Image at the border, Lower: RGB values (R,G,B))

At the border, points indicating loss of RGB color values or points where the Green/Blue values ratio fluctuated appeared between both areas.

Using these values, the ROI was adjusted. **Fig.8** shows the results of our method. The color difference was emphasized (**Fig.8(c)**), and the inside of the green area could be removed (**Fig.8(d)**). To remove the reflected light area, the following process was carried out via Photoshop; Selection>Similar Edit>Fill(Black).

3.3 Different bite impression materials effect on the characteristics of lighted areas

In addition to CQ (purple), 5 kinds of models were fabricated using the following materials; IB (Blue), EB (Green), BS (Blue), MR (Pink), and RB (Green).

The reflected light area appeared at the same position with the same shape on all materials. In addition, the reflected light had more green elements.

Due to the adjustment of the offset and the gamma correction values, in IB, CQ, BS, and MR, the reflected light could be distinguished from the occlusal contact area. On the other hand, in EB and RB, the reflected light could not be distinguished from the occlusal contact area no matter how much the offset and gamma correction values were changed.

Through our method, the reflected light could be

Fig.8 ROI on each condition

(a): gray scale image, (b): original color image, (c): after adjusted the offset and gamma correction values, (d): after removing the reflected light area

distinguished from occlusal contact area except in the bite impression materials colored with green.

3.4 Feasibility of our method in a clinical case

The areas of reflected light appeared on the recorded surface of occlusal contact which was taken from a clinical case (**Fig.9(c)**). These areas interfered with the detection of the genuine occlusal contacts.

Through our method, the area of reflected light could be eliminated (**Fig.9(d)**).

4. Discussion

4.1 Experiment system

In general fluorescent lamps, the green value is higher than the red and the blue values. The distribution of RGB values in our light source was measured at 50 randomized pixels. On the film viewer, average of red value was 240.0, standard deviation was 1.4, green was 254.9 ± 0.4 , blue was 254.9 ± 1.3 . In all pixels, the green value was higher than red and blue values. This viewer's lamp was stable as an environmental light in the transillumination method. In this study, it was considered that our film viewer used a general fluorescent lamp.

The occlusal contacts with upper and lower occlusal surface are recorded on both sides of the bite impression material in a clinic. The configuration of occlusal record becomes very complicated. In this study, we had to detect the area of reflected light. Therefore, the model for investigating the characteristic of transmitted and reflected light was fabricated

Fig.9 Application of our method in a clinical case

(a): Color image, (b): Gray scale image, (c): After adjusting the offset and gamma correction values, (d): After removing the reflected light area

using the metal plate and the artificial tooth. The model has a simple configuration, and facilitated detection of the reflected light.

4.2 Characteristic of reflected light

The reflected lights appeared near the perforated area. Even if all environmental light surrounding the bite impression material was intercepted, these reflected light areas appeared. Moreover, the reflected light had more green like the film viewer's light. Therefore, it was considered that the area of reflected light in the record surface appeared due to diffraction of the light through the perforated area.

The model was also analyzed with a commercial device. The area of reflected light appeared at the same location as our system. Therefore, it was considered that the reflected light is an inevitable phenomenon in the transillumination method.

4.3 Method for elimination of reflected light

In the conventional transillumination method, the contact area was evaluated with the brightness value on the gray scale image. However, the reflected light could not be eliminated with the conventional method. In a previous study, an NIH image was used to automatically detect the occlusal contact area on the 2D-photograph of interocclusal record¹⁴⁾. The image of our specimen was converted to the NIH image. However, the reflected light could not be distinguished from the occlusal contact area. Through the marketed device, our specimen was evaluated. The reflected

light areas were counted as “occlusal contact points.”

Through our method, due to the adjustment of the offset and the gamma correction values, the reflected light could be distinguished from the occlusal contact area. Furthermore, the reflected light area could be removed.

4.4 Different bite impression materials effect on the characteristics of lighted areas

A transillumination method involves examining occlusal contacts from the perforated state of the bite impression material. In previous studies¹⁾²⁾, a black silicone has been used for inter-occlusal recording. Therefore, this method is called the “silicone-black method.” In recent years, most bite impression material is colored silicone material containing filler.

In this report, the material color information was used to eliminate the reflected light. Consequently, due to the adjustment of the offset and the gamma correction values, it was suggested that the reflected light could be distinguished from the occlusal contact area.

However, our method did not support all color materials. Due to the adjustment of the offset and the gamma correction values, the reflected light could be distinguished from occlusal contact area except in the bite impression materials colored with green.

From our results, it was suggested that the application criteria in our method depends on the light source and the color of the bite impression material.

4.5 Feasibility of our method in a clinical case

As shown in Fig.9(c), many areas of reflected light appeared near the genuine occlusal contact areas. In the record with the complicated configuration, the reflected light varied depending on the teeth configuration and the condition of occlusal contact. Dentists should strive to eliminate the reflected light, such as in our method.

4.6 Application of our method

In our previous study¹²⁾, we developed software for analysis of occlusal contact. **Fig.10** shows the overview of our software. To accurately detect the occlusal contact area on the digital photograph using our method, an elimination function for reflected light will be developed and added to the software.

Fig.10 Overview of our software
Visualization of occlusal contacts via transillumination method

5. Conclusion

Due to the adjustment of the offset and the gamma correction values, the reflected light could be distinguished from the occlusal contact area. It was considered that this method was helpful for accurately detecting the occlusal contact area on a digital photograph.

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