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COMPARISON OF DENTAL PLAQUE DETECTION USING VARIOUS WAVELENGTH OF LIGHT EMITTING DIODE (LED) (Analysis based on digital imaging techniques)

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ABSTRACK

Background: Dental plaque indicates the grade of dental hygiene. Bacterial dental plaque will emit reddish fluorescence, when irradiated by compatible rays. Fluorescence is produced by an object that absorbs appropriate light spectrum photons. Advances technology has developed Light Emitting Diode (LED) that can emit visible light with low energy.
Objective: The purpose of this research is to observe the wavelength of LED light that can be used as dental plaque detector.
Methods: A quasi experimental study was done on 44 maxillary and mandibular central incisor teeth, Muallimin Yogyakarta boarders. Teeth were exposed using LED colour ring lamp with 400nm wavelength (UV), 420nm (violet), and 450nm (blue). Teeth were photographed using DSLR camera. As control, teeth were applied with disclosing agent. Image result observed by determining the reddish dental plaque fluorescence and counting surface with software design by SST-Laboratory, Faculty of Engineering, UGM, based on digital imaging technique. The comparison of fluorescence surface plaque area between UV light detection, violet, and blue by using disclosing agent which had been undertaken. Data were analyzed by using nonparametric Wilcoxon test.
Result: Detection using UV LED 400nm showed reddish fluorescent dental plaque surface (25,7632$\pm$20,8247), violet 420nm and blue 450nm showed no fluorescence area, and as control group (29,9177 $\pm$ 22,1266). Nonparametric Wilcoxon test results showed that there were no significant difference between detection of 400nm UV LED and disclosing agent ($p > 0.05$).
Conclusion: The conclusion of this study is the wavelength of the LED light be able to used as a dental plaque detector is UV LED wavelength 400nm.

Keywords: dental plaque detection , UV LED light

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INTRODUCTION

Dental plaque is one causal factor occurring in major diseases of oral cavity, dental caries and periodontal disease.[1] Third quarters of the plaque consists of bacteria. Dental plaque bacteria play an important role in the initiation of caries and periodontal disease.[2] Detection of dental plaque is important for the dentist to determine the level of personal oral hygiene. Computer-based research has become a method to quantify dental plaque. This technique can reduce the bias and mismanagement among operators by using a computerized image analysis system (CIAS), plaque area and tooth area are digitally calculated so the number of pixels is calculated. Plaque Percent Index (PP Index) reveals plaque area as a percentage of the tooth area. The results of previous research indicate that the repetition of Plaque Percent Index value with error of less than 3.0% is obtained from the photographs taken.[3]

Light Emitting Diode (LED) is an electronic component that can emit monochromatic light when given the electrical voltage. Light Emitting Diode is a complex semiconductor that converts electrical currents into incoherent light spectra, wich has around since the 1960s. Light

Emitting Diode is based on semiconductor technology, such as computer processors, that improve brightness, energy efficiency, and semiconductor lamp resistance. Emitted light is available at wavelengths range from ultraviolet (UV) 247 nm to near infrared (NIR) 1300 nm.[4] Therapy using NIR-LED light has been claimed cause no significant risk by the Food and Drug Administration and approved to be used in humans.[5] The advantage of LEDs is their possibility to combine wavelengths of various sizes. Currently, LEDs have a variety of colors, including red, yellow, blue, white, green, orange and infrared. The color diversity of the LED depends on the wavelength and the semiconductor compound.[6] By technology advances in the field of semiconductors, LEDs can replace laser and ultraviolet (UV) rays. Laser rays are known to require large size, high power consumption and a very expensive price. LED technology could be designed as a fluorescence sensor. LEDs are small, lightweight, power consumption is very small, stable and cheap. UV-LED is the best choice as a fluorescence sensor.[7]

Compared to conventional UV light sources, UV LEDs have a compact, powerful, and energy-efficient benefits at an affordable price. UV LEDs make a device more practical, effective and portable. The UV spectrum is divided into Vacuum UV (40-190 nm), Far UV (190-220 nm), UVC (220-290 nm), UVB (290-320), and UVA (320-400 nm) .[8] Bacteria will produce red fluorescence when exposed to UVA due to the presence of porphyrin component especially protoporphyrin-IX (PP9) .[9]

The diagnostic method using fluorescence is the latest technology to detect the presence of dental caries, dental plaque, calculus and tumors in the oral cavity. Calculating the surface area of dental plaque using quantitative light-induced fluorescence (QLF) can be used as one of the basic techniques of automatic dental plaque counting. The resulting fluorescence was calculated based on the percentage of labial surface tooth area. [10]

The method of calculating the surface area of dental plaque using quantitative light-induced fluorescence (QLF) and Percent Index Plaque (PP Index) reveals plaque area as a percentage of tooth surface area, can be used as one of the basic techniques of automatic dental plaque quantification.[11] Image segmentation is a fundamental process in interpreting images and videos using computer applications. In this process, the image captured is divided into several areas. From this part, it will be analyzed using algorithmic system, so that the dental plaque can be quantified from the tooth picture. [12] This study aims to know the wavelength of LED rays that can be used as a detector of child's dental plaque.

METHODS

This research is a quasi experimental research. This research had been approved by Unit of Ethics and Advocacy, Faculty of Dentistry, UGM No.00880 / KKEP / FKG-UGM / EC / 2016. The study subjects were 44 permanent maxillary central incisuvus teeth from 11 of the Muallimin boarders who met the inclusion criteria. Each child was photographed using an anterior teeth DSLR camera illuminated with UV (400nm), violet (420 nm), and blue (450nm) LED light. As a control, a disclosing agent dye applied to the maxillary and mandibular anterior teeth, then photographed using a DSLR camera, using a white LED light. The surface area of dental plaque was calculated in percentage with tooth surface area calculated using dental plaque detection software based on digital imaging technique designed by Laboratory Sensor and Telekontrol System, Department of Physics Engineering, Faculty of Engineering UGM.

The data were analyzed using Wilcoxon non parametric comparative test.

RESULT

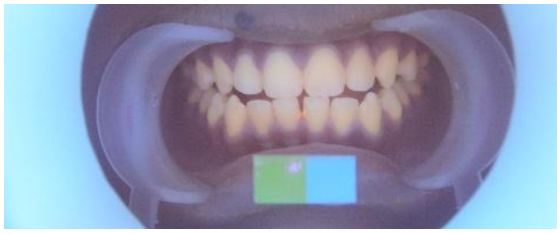
The results of this study showed that the anterior teeth that were exposed using violet (420nm) and blue (450nm) LED colors did not show fluorescence. Tooth that exposed to UV LED light wavelength 400 nm emitted visible reddish orange fluorescence color.

(a)

(b)

(c)

(d)



(e)

Figure 1. Results of anterior teeth photographs (a) using disclosing (b) without disclosing (c) blue LED (450nm) (d) violet LED (420nm), and (e) UV LED (400nm)

The fluorescence was calculated by dental plaque counting software designed by Laboratory Sensor and Telekontrol System, Department of Physics Engineering, Faculty of Engineering UGM. A comparison of the mean dental plaque surface area between detection using UV LED light wavelength 400 nm with disclosing agent has no significant difference (Table 1).

Table 1. The mean and standard deviation of the surface area of dental plaque detected using UV light LED and disclosing agent

Variable	N*	Mean ± standard deviation (in percentage)	t**	p***
Surface area of dental plaque detection with 400 nm UV LED light	44	25,7632 ± 20,8247	-1,435	0,151
Surface area of dental plaque detection with disclosing agent	44	29,9177 ± 22,1266		

*N: number of samples
**t: Wilcoxon coefficient value
***p: value of significance

Wilcoxon non parametric comparability test results shows that the surface area of dental plaque detection using UV LED wavelength 400 nm has no significant difference with the surface area of dental plaque detection results using disclosing agent (p> 0.05) (Table 1).

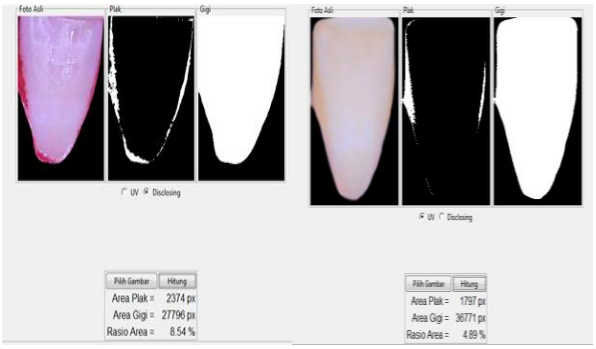


Figure 2. Calculation results using software based on digital imaging technique of dental plaque surface, designed by laboratory sensor and telecontrol system, physics engineering department, Faculty of Engineering, UGM

DISCUSSION

This study shows that UV LED wavelength 400 nm can be used as a detector of dental plaque without disclosing staining. The reddish orange color that appears on the image

using UV light 400 nm LED is fluorescent protoporfirin bacteria present in dental plaque. The excitation of an LED ray with an appropriate wavelength on an object that has fluorescent properties will emit an emission beam that the camera can capture. The red fluorescent color will appear on plaque detection using UV LED when the wavelength of the LED rays match with the absorptive spectrum or bacterial photosensitizer.[13]

In the detection of child's dental plaque using 400 nm UV LED light, orange color that appears is the fluorescence of amino acids and proteins in bacteria. Dental plaque bacteria contain porphyrin component especially protoporphyrin-IX which has fluorescent properties. When the bacteria containing the component are exposed with a 400nm excitation, this component will emit the redish-orange colored.[14] This condition suitable to Shakibakie's statement in 2011, that bacteria in plaque will emit fluorescence if exposed using UVA light wavelength 320 - 400nm. The benefit of detection dental plaque using UV LED light compared using a disclosing agent is that it does not use dye that often causes discomfort for patient. Calculating dental plaque surface in this study still requires cameras and computer software, so needed for further research to find a prosedure of calculating area of dental plaque is more efficient.

The surface area of dental plaque that was detected using a 400 nm UV LED light was not as large as the result of detection using a disclosing agent, indicating that a large portion of dental plaque was bacterial. It can be concluded that the wavelength of the LED light be able to used as a dental plaque detector in this study is UV LED wavelength 400nm.

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