The Efficiency of Fluorescence Technique Used For Gingival Inflammation and Plaque Detection

Jananya Plianrungsi[1*], Paroj piyakitsomboon[2], Nattaporn verayangkura[2], Sittirat ananthanandon[2], Salisa Sriyarun[2], and Thaninthorn presertrungrueng[2]

[1]Lecturer in Doctor of Dental Surgery (DDS) College of Dental Medicine, Rangsit University, Thailand
[2]Undergraduate students in Doctor of Dental Surgery (DDS) College of Dental Medicine, Rangsit University, Thailand
[*]Corresponding author, E-mail: Jananya.p54@rsu.ac.th

Abstract

Periodontal disease is one of the most important oral health issues in Thai population due to high prevalence. Therefore, the instrument required for early detection clinically is an interesting topic for further discussion in order to prevent disease progressions. The study recruited 40 human subjects. All subjects will undergo both standard examination and SOPROCARE® examination to detect gingival inflammation and plaque accumulation. Plaque accumulation and gingival inflammation were scored in numeric data by Sillness and Loe index in P0-P3 and G0-G3, respectively. The result of the dental plaque score and gingival inflammation revealed that the average score of fluorescence examination had an average score lower than clinical. While old and new plaque detection by SOPROCARE® and conventional method had the same result as 71.5% and gave the different result of 28.5%. This study found that the sensitivity of fluorescence examination for dental plaque detection was 88.68%; whereas, specificity was 33.33%. Gingival inflammation detection had a sensitivity of 83.79%; whereas, specificity was 50.00%. In other words, this method was sensitive for gingival inflammation detection. In conclusion, the conventional method was able to detect gingival inflammation and dental plaque more than fluorescence examination. ROC curve was also analyzed. SOPROCARE® in PERIO mode had high disease detection ability but did not suit for diagnostic assessment. However, it should be used as a tool for patient motivation for oral hygiene instruction.

Keywords: *Fluorescence, conventional examination, gingival inflammation, dental plaque*

1. Introduction

Oral health is an important part of the general health of one's body. According to National Oral Health Survey of Thailand Vol.8 2017, periodontal disease is one of the most crucial oral health issues in Thai population due to their high prevalence. It is also multifactorial disease, in which the risk is increasing, especially in smoking patients, patients with Diabetes Mellitus (DM) and patients with poor hygiene. With periodontal disease, the inflammatory reaction is associated with progressive loss of periodontal ligament and alveolar bone and eventually will have mobility and loss of teeth (Coventry et al, 2000). The inflammation of the periodontal tissue is the most common oral disease caused by the dental plaque presented on the teeth (Marsh, 1994).

Dental plaque becomes more pathogenic when presents on the tooth surface for a long period (matured plaque) (Kolenbrander, Palmer, Periasamy, & Jakubovics, 2010). Prevention of oral disease relies on frequent plaque removal (Axelsson & Lindhe, 1978). Therefore, plaques accumulation and gingival inflammation are necessarily recorded in order to be able to determine disease progression and treatment (Carvajal et al., 2016).

Both gingival inflammation and plaque accumulation mentioned above require early detection in order to be able to prevent disease progressions. However, the method to detect those lesions usually rely solely on visual under operating unit light which could be quite subjective, so the adjunctive screening tool could provide some benefit for early detection of those lesions. (Seshan & Shwetha, 2012)

One of the new technologies was invented to aid an early diagnosis of various substances (Morgan, 2011) in which each one emits different fluorescent color to detect lesions is called fluorescence examination. This concept has been used widely in dentistry such as in restorative dentistry, caries detection and in oral cancer investigation (Mualla, 2016). Fluorescence detects red autofluorescence, produced when illuminated with blue light at 405 nm.

This phenomenon has been observed in the fluorescence images of teeth coated with plaque or calculus originate from specific bacterial metabolites formed in the oral biofilm, such as protoporphyrin IX (Konig, Flemming, & Hibst, 1998). In the present days, there is only one study (Angelino, 2017) using SOPROCARE® to detect the color of plaque-affected areas.

In terms of detection dental plaque and gingival inflammation, there are many studies done via different fluorescent systems, however, to date there is only one system called "SOPROCARE®".

SOPROCARE®, consists of an LED camera fitted with a specific CCD sensor, enables dental plaque and gingival inflammation to be detected in PERIO mode by illuminating the tooth surfaces in a wavelength bandwidth located in the visible (blue) spectrum and by supplying an auto-fluorescence image superimposed over a natural anatomical image.

Therefore, this study will compare standard visual examination with fluorescence examination for the detection plaque accumulation and gingival inflammation to establish the most effective way of diagnosis these diseases. The study conducted by using Silness-Löe Index for dental plaque detection. It is often used in longitudinal studies and clinical trial because it is very sensitive to small changes of the amount of dental plaque (Bathla, 2011). For gingival inflammation detection, Gingival Index (GI) was used since it is the most widely used in therapeutic trials and generally provide more objective assessment of gingivitis than others, which rely solely on visual criteria (Lobene et al., 1989).

2. Objectives

To determine and compare the efficiency of gingival inflammation and plaque accumulation between standard visual examination and fluorescence examination.

3. Materials and Methods

This clinical study was performed at College of Dental Medicine, Rangsit University with the human ethic number RSUERB2019-067 approved by Ethical Committee of Research Institute of Rangsit University. There are 40 human subjects aged between 18 to 45 years old from Oral Diagnosis Clinic, Collage of Dental Medicine, Rangsit University. The subjects recruited were healthy patient and willing to sign the "Authorization" form. There were no gender restrictions. The study excluded those with full coverage prosthesis (ex. crown and bridge), orthodontic braces, prolong retention of primary teeth, pregnant patients and patient with history of head and neck radiation.

The examined teeth for gingival inflammation and dental plaque detection were 16, 12, 24, 36, 32 and 44 on buccal/labial, proximal and palatal/lingual aspects. The three examiners calibrated by pearson's correlation.

4. Results and Discussion

Dental plaque

The first variable was dental plaque score. The data was collected from 960 observations. Descriptive statistics was shown in table 1.

Table 1 Frequency table of dental plaque scores from clinical examination and fluorescence examination

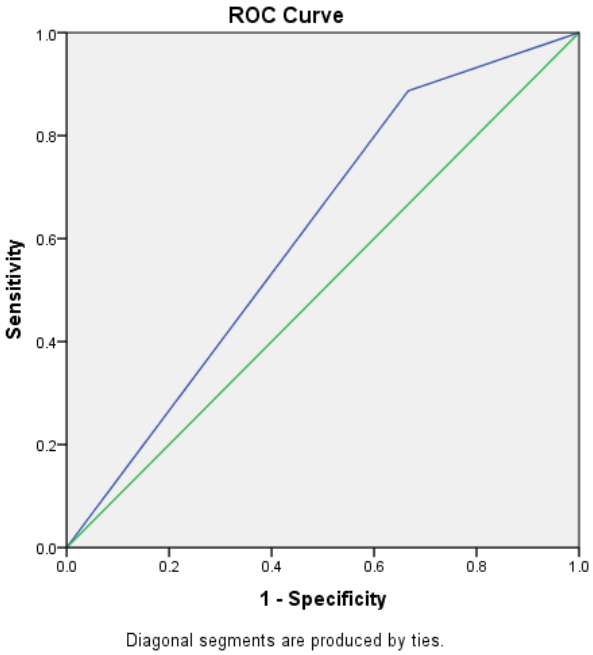
Dental plaque	Clinical Examination		Fluorescence Examination	
	Frequency	Percent	Frequency	Percent
Normal	151	15.7 %	141	14.7%
Mild	533	55.5%	610	63.5%
Moderate	266	27.7%	201	20.9%
Severe	10	1.0%	8	0.8%
Total	960	100.0%	960	100.0%

From table 1, clinical examination revealed lower proportion of observations that had a mild dental plaque than fluorescence examination, 55.5 and 63.5%, respectively. On the other hand, fluorescence examination showed a lower proportion of observations that had a less moderate dental plaque than clinical examination, accounting for 20.9% and 27.7% respectively.

Table 2 Confusion matrix of dental plaque examination

Variables			Gold Standard		Total
			Plaque	No Plaque	
Fluorescence Examination	Plaque	Count	721	98	819
		%	88.68%	66.67%	85.31%
	No Plaque	Count	92	49	141
		%	11.32%	33.33%	14.69%
Total		Count	813	147	960
		%	100.00%	100.00%	100.00%

Table 2 presents a sensitivity of fluorescence examination as dental plaque detection was 88.68%; whereas, specificity was at 33.33%. In other words, the method claimed that 66.67% of observations had plaque but they did not.



Test result variable(s): fluorescence examination derived

Area
.610

Figure 1 ROC curve of sensitivity and specificity of dental plaque

From figure 1, the area under the curve was 0.610, which indicated that the fluorescence examination had poor efficiency.

Gingival inflammation

The data was collected from 960 observations. Table 3 presents descriptive statistics of score from both types of examination.

Table 3 Frequency table of gingival inflammation scores from clinical examination and fluorescence examination

Gingival Scores	Clinical Examination		Fluorescence Examination	
	Frequency	Percent	Frequency	Percent
Normal Gingival	13	1.4%	159	16.6%
Mild Inflammation	754	78.5%	616	64.2%
Moderate Inflammation	192	20.0%	185	19.3%
Severe Inflammation	1	0.1%	0	0.0%
Total	960	100.0%	960	100.0%

From table 3, clinical examination demonstrated that only 1.4% of observations had normal gingival; whereas, fluorescence examination claimed that 16.6% of observations had normal gingival. Moreover, 78.5% of observations had mild inflammation, but there were only 64.2% of observations from fluorescence examination that had mild inflammation. It seemed that fluorescence examination detection showed lower severe levels of gingival inflammation, comparing with clinical examination. However, the moderate inflammation between clinical and fluorescence examination were about the same.

Table 4 Comparing rank between fluorescence examination and clinical examination

		N	Mean Rank	Sum of Ranks
Fluorescence Examination – Visual Examination	**Negative Ranks**	228[a]	172.55	39341.50
	Positive Ranks	103[b]	151.50	15604.50
	Ties	629[c]		
	Total	960		

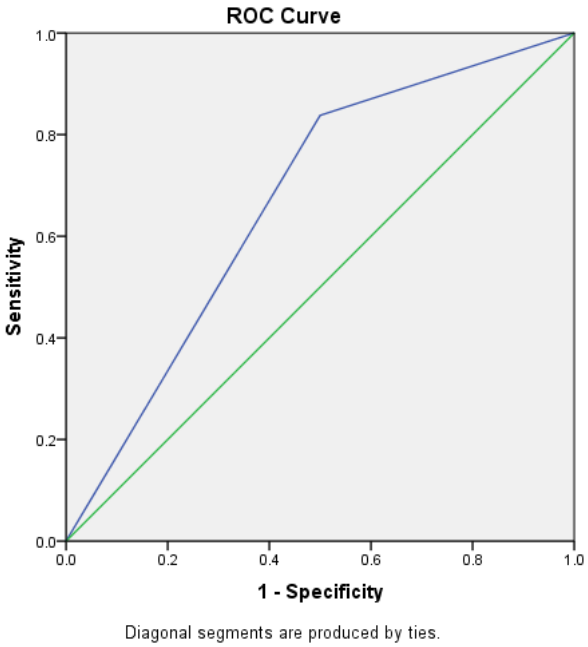
a. Fluorescence Examination < Clinical Examination
b. Fluorescence Examination > Clinical Examination
c. Fluorescence Examination = Clinical Examination

From table 4, it showed that there were 228 observations that fluorescence examination gave lower gingival inflammation scores than clinical examination. There were 103 observations that scores from fluorescence were higher than clinical examination. Lastly, there were 629 observations that scores between two methods were the same.

Table 5 Confusion matrix of gingival inflammation examination

Variables			Gold Standard		Total
			Inflammation	No Inflammation	
Fluorescence Examination	**Inflammation**	Count	796	5	801
		%	83.79%	50.00%	83.44%
	No Inflammation	Count	154	5	159
		%	16.21%	50.00%	16.56%
Total		Count	950	10	960
		%	100.00%	100.00%	100.00%

Table 5 presents a sensitivity of fluorescence examination for gingival inflammation detection was 83.79%; whereas, specificity was 50.00%. It meant that this method was sensitive to detect inflammation.



Test result variable(s): fluorescence examination derived

Area
.669

Figure 2 ROC curve of sensitivity and specificity of dental inflammation

Regarding figure 2, the area under the curve was 0.669, indicated that the fluorescence examination had poor efficiency.

Old/new plaque

The data was collected from 984 observations. Table 6 was a frequency table to explain a number of the same results and different results from the two methods.

Table 6 Frequency table of old/new plaque detection result with the same or different results

Values	Frequency	Percentage
Same	704	71.5%
Different	280	28.5%
Total	**984**	**100.0%**

Table 6 presented 704 observations that illustrate the same results between clinical and fluorescence examination. The percentage of same results detection was 71.5%; hence, the percentage of different results detection was 28.5%.

Table 7 Binomial test for same result detection proportion

Values	N	Observed Prop.	Test Prop.	Exact Sig. (1-tailed)
Same	704	0.715	0.9	0.000
Different	280	0.285		
Total	984	1.000		

Old/new plaque detection has significance level at P <0.05

Regarding table 7, there were 704 observations, receiving the same results detection between clinical examination and fluorescence examination. The observed proportion was 0.715 or 71.5%. It could be concluded that the proportion of same results detection did not higher than or equal to 90%. In other words, it could be said that the proportion of same results detection of 71.5% was lower than expected results (90%).

Discussion

Nowadays, the oral hygiene problem is a rising concern. One of the most common of oral disease is periodontal disease that has been overlooked. Therefore, the lesion that was detected early should be included in the treatment plan and should raise the patient's awareness.

Bacterial metabolites in dental plaques are believed to be able to produce prophyrins, which was the source of red autofluorescence (Liu, Gomez, Khan, Peru, & Ellwood, 2017). Fluorescence is illuminated with blue light at 405 nm. which has developed further to be the system used nowadays (Konig et al., 1998).

SOPROCARE® is based on the stimulation of endogenous fluorophores present in the tissues of the teeth and don't require exogenous fluorophores, which can cause toxic and error result from diagnostic. This product was introduced to market to initially detect gingival inflammation through PERIO mode option. SOPROCARE® used wavelength of light between 440 and 680 nm. (Hollay, 2014)

The gingival inflammation and dental plaque detection were performed through PERIO mode. According to Peter Rechmann et al. in 2016, it was stated that SOPROCARE® in PERIO mode allowed scoring of microbial plaque that is comparable to the Turesky modification of the Quigley Hein plaque index (T-QH) and scoring of gingival inflammation comparable to the Silness and Löe gingival inflammation index (GI).

In Rechmann study, SOPROCARE® was used to capture in PERIO mode and in DAYLIGHT mode. The average T-QH was 1.1±1.2 (mean±SD). Scoring with SOPROCARE® PERIO mode generated a slightly higher average than the T-QH scores of SOPROCARE® DAYLIGHT mode, and digital photography showed the highest plaque scores. The average GI index was 0.7±0.9. SOPROCARE® in PERIO mode scored slightly lower. The study demonstrated that the SOPROCARE® fluorescence assessment tool in PERIO mode allows reliable judgment of microbial plaque and the gingival inflammation levels are similar to the established Turesky-modified Quigley Hein index and the Silness and Löe gingival inflammation index. The SOPROCARE® fluorescence tool in PERIO mode provides reliable evaluation of microbial plaque and gingival inflammation for dental clinicians.

Rechmann study also found that the data obtained from fluorescence examination demonstrates a higher score than conventional examination. (Rechmann, Liou, Rechmann, & Featherstone, 2016) In contrast, this study revealed that the dental plaque and gingival inflammation score obtained from SOPROCARE® tend to be lower than conventional method. Sensitivity of fluorescence examination for dental plaque detection was 88.68%; whereas, specificity was 33.33%. In gingival inflammation, sensitivity was 83.79% while specificity was 50.00%. Thus, the device has high sensitivity but low specificity. The ROC curve of dental plaque accumulation and gingival inflammation were 0.610 and 0.669, respectively, which can be inferred that SOPROCARE® had poor efficiency. Therefore, the fluorescence technique would be useful for screening, but not as diagnostic tools.

SOPROCARE® in PERIO mode can also be used to detect old and new plaque accumulation. It has not only helped reduce procedural complexity but also able to display the real time video and image of the patient's intraoral condition. For the reason that using Erytrosin dye can be considered an inconvenience due to its unsatisfying taste and dye removal can be time consuming, SOPROCARE® is an alternative method in detecting dental plaque. Moreover, it allows operator to communicate and motivate patient.

In this study, operator factor did not affect the results since inter-examiners analysis were tested by using Pearson's correlation. The results of dental plaque accumulation and gingival inflammation shown highly agreement between operators.

The limitation encountered in examining dental plaque and gingival inflammation was computer monitor. The images captured under PERIO mode were interpreted and scored. The brightness and the quality of the monitor affects the photo color. This was not the factor that one can easily control. Another factor is patient including their gender, age and physical conditions. These factors affect the data collected by the device. It demonstrated that most female patients had limited mouth-opening ranges, which affect the angle of the device handpiece to the tooth surface. Consequently, it led to misdiagnosis of the lesion.

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5. Conclusion

Gingival inflammation and dental detection by PERIO mode of SOPROCARE® have high sensitivity but low specificity. To elaborate, both of them can be interpreted from ROC curve that they have poor efficiency. Therefore, the SOPROCARE® fluorescence is not suitable for diagnostic assessment, however, the fluorescence technique can be examined in patient in a short period of time when compared to the standard visual examination. So, this technique would be useful for screening especially first time patient.

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