LED Induced Autofluorescence (LIAF) Imager with eight multi-filters for Oral Cancer Diagnosis

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ABSTRACT

Oral cancer is one of the serious and growing problem in many developing and developed countries. The simple oral visual screening by clinician can reduce 37,000 oral cancer deaths annually worldwide. However, the conventional oral examination with the visual inspection and the palpation of oral lesions is not an objective and reliable approach for oral cancer diagnosis, and it may cause the delayed hospital treatment for the patients of oral cancer or leads to the oral cancer out of control in the late stage. Therefore, a device for oral cancer detection are developed for early diagnosis and treatment. A portable LED Induced autofluorescence (LIAF) imager is developed by our group. It contained the multiple wavelength of LED excitation light and the rotary filter ring of eight channels to capture ex-vivo oral tissue autofluorescence images. The advantages of LIAF imager compared to other devices for oral cancer diagnosis are that LIAF imager has a probe of L shape for fixing the object distance, protecting the effect of ambient light, and observing the blind spot in the deep port between the gumsgingiva and the lining of the mouth. Besides, the multiple excitation of LED light source can induce multiple autofluorescence, and LIAF imager with the rotary filter ring of eight channels can detect the spectral images of multiple narrow bands. The prototype of a portable LIAF imager is applied in the clinical trials for some cases in Taiwan, and the images of the clinical trial with the specific excitation show the significant differences between normal tissue and oral tissue under these cases.

Keywords: Autofluorescence, filter, oral cancer, LED, induced

1. INTRODUCTION

Oral cancer is one of the serious and growing problem in many developing and developed countries of the world, especially in Taiwan. According to the report from Ministry of Health and Welfare of Taiwan, the mortality of oral cancer in 2013 is 21.4 per 100,000 persons, and oral cancer is ranked as the fifth leading cause of death in the common cancer of males in Taiwan [1], and the habit of smoking and betel-nut chewing are the possible reasons.

Traditionally, the sample oral examination for oral cancer is through visual inspection and palpation of oral lesions. The simple oral visual screening by clinician can reduce 37,000 oral cancer deaths annually worldwide [2]. After the sample oral examination, an oral biopsy for histopathological analysis is necessary when the clinician suspects the risk of abnormal tissue progressing to cancer tissue. However, many patients of oral cancer are diagnosed and receive the treatment in the last stage of oral cancer. The early detection of oral cancer may be the best and cost-effective methods to raise the survival for oral cancer patients [3], but the traditional oral examination with the visual inspection and palpation is still not sufficient for oral cancer [4-7], and it causes the delayed treatment for the patients of oral cancer [4, 5, 8]. Therefore, technologies for the oral cancer detection are developed for patients to receive early diagnosis and treatment [9-12]. Several studies have shown that autofluorescence will cause difference intensity between oral tissue and normal tissue [13]. In order to provide an objective and reliable manner of oral cancer detection for clinicians, a portable detection device is developed for the accuracy of the diagnosis.

In this study, a portable LED Induced autofluorescence (LIAF) imager is developed by our group. It contained the multiple wavelength of LED excitation light and the rotary filter ring of eight channels to capture ex-vivo oral tissue autofluorescence images. The advantages of LIAF imager compared to other devices for oral cancer diagnosis are that LIAF imager has a probe for fixing the object distance, protecting the effect of ambient light. Moreover, observers can

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detect the blind spot in the deep port between the gumsgingiva and the lining of the mouth with a probe of L shape. Besides, the multiple excitation of LED light source can induce multiple autofluorescence, and LIAF imager with the rotary filter ring of eight channels can detect the spectral images of multiple narrow bands for accurate analysis. The prototype of a portable LIAF imager is applied in the clinical trials for some cases in Taiwan. Finally, in the experiments, images of the clinical trial with the specific excitation show the significant differences between normal tissue and oral tissue under these cases.

2. METHODS

A portable LED Induced autofluorescence (LIAF) imager with a probe of L shape is proposed in our previous study. The imager contain a LED excitation, a probe, a filter ring, a long pass filter, and an image module shown as Fig.1. The LED excitation contains two kind of wavelength to induce autofluorescence from oral lesions. The Probe ahead the LED light module is for the fixing object distance and shading the ambient light, moreover, and the LED light is directed by the probe with different shape. A probe of cone shape is a sample and direct type to detect LED light on the target, but doctors cannot easily observe the deep part of the oral cavity with a right angle. Therefore, a probe of L shape contained a mirror for clinicians to capture the images of oral cavity with the right angle is proposed shown as Fig. 2(a), and subjects do not need to open their mouse constrainedly for oral examinations [14]. A cross section of the new probe of L shape is shown as Fig. 2(b). A glass plate for preventing the liquid or moisture entering in the body of a portable LIAF imager is inserted in the L shape of the probe, and it is placed in the back-end of the probe to prevent the LED light spots in the image. The rotary filter ring integrate with the detector head for user to select the band of filter they interested is placed behind the LED module. The rotary filter ring contains eight holes for holding the filters, and seven filters are assembled in seven holes. The side view and the front view of the rotary filter ring contains eight holes are shown in Fig. 3, and the transmittance of seven band-pass filters are shown in Fig. 4. The excitation light emitted from LED light module projects on the target of oral mucosal surface with the probe, then the autofluorescence will be induced from oral mucosal surface and go through the probe. A hole is located in the middle of the LED light source as shown in Fig. 3(b). A long pass filter is placed in front of the image module. Finally, the image module contained a lens module and a color CMOS captures the fluorescence images.

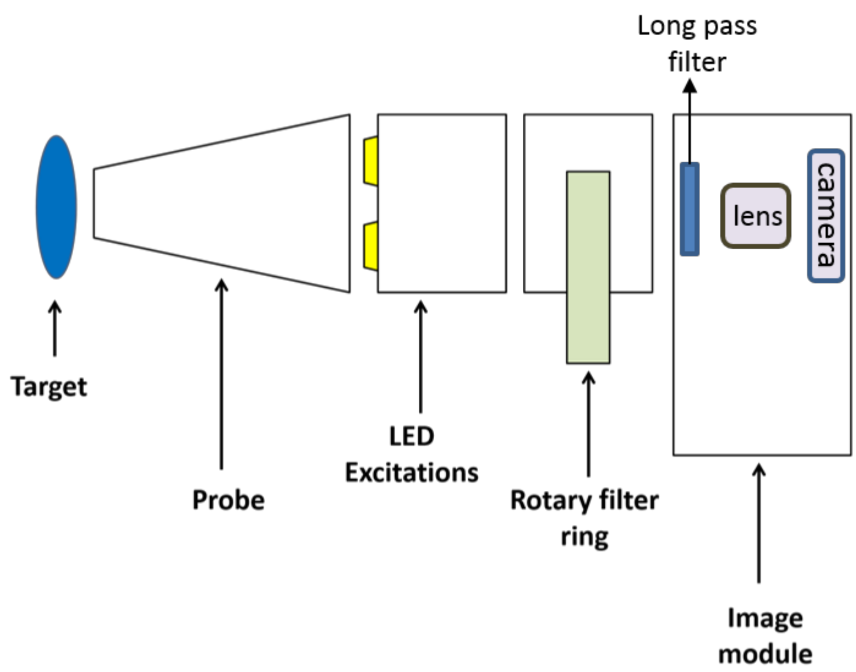
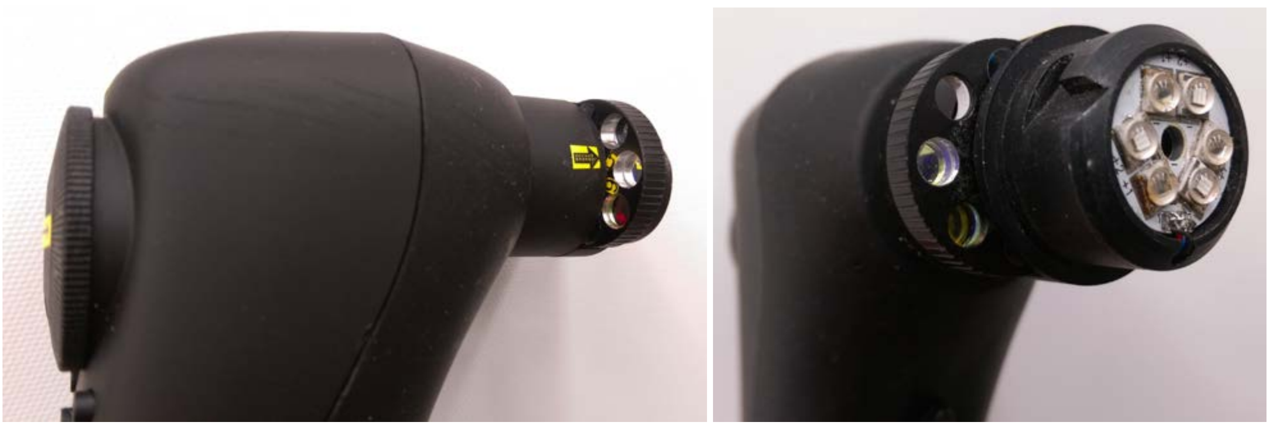


Fig. 1. System block diagram of the portable LIAF imager

(a) (b)

Fig. 2. (a) The embodiment of a portable (LIAF) imager with the new probe of L shape; (b) a cross section of the probe of L shape.



(a) (b)

Fig. 3. (a) The side view and (b) the front view of the rotary filter ring contains eight holes for holding the filters

The excitations of LED light module have two kind of LED light sources whose wavelength regions are 355nm~385nm (L_1) and 395nm~435nm (L_2). The rotary filter ring contains three band-pass filters that their wavelength regions are about 445nm ~ 465nm (F_1), 4650nm ~ 480nm (F_2), 495nm ~ 510nm (F_3), 520nm ~ 535nm (F_4), 540nm ~ 565nm (F_5), 580nm ~ 600nm (F_6), and 630nm ~ 645nm (F_7). The wavelength of the long pass filter for filtering the excitation and image enhancement is about 440nm. The CMOS resolution of the image module is 1600x1200. The wavelength of L_1 and L_2 excitation and the transmittance of seven band-pass filters are shown in Fig. 4 respectively.

3. EXPERIMENTS AND ANALYSIS

In the experiments, patients who were waiting for head & neck surgery in the hospital ward were recruited to participate in the study. The clinical study was reviewed and approved by the hospital and the image analysis study was reviewed and approved by our group. Written informed consent was obtained from each subject enrolled in the study. Patients in the region between 20 to 100 years of age scheduled for surgery to remove a previously diagnosed oral squamous carcinoma were eligible to participate in the study. The autofluorescence images with the L_1 and L_2 excitations are shown in Fig. 5 and Fig. 6 respectively. The autofluorescence images with L2 excitation is brighter than the autofluorescence images with L1 excitation. Besides, the autofluorescence images of the tumor tissue are darker than the autofluorescence images of the normal tissue.

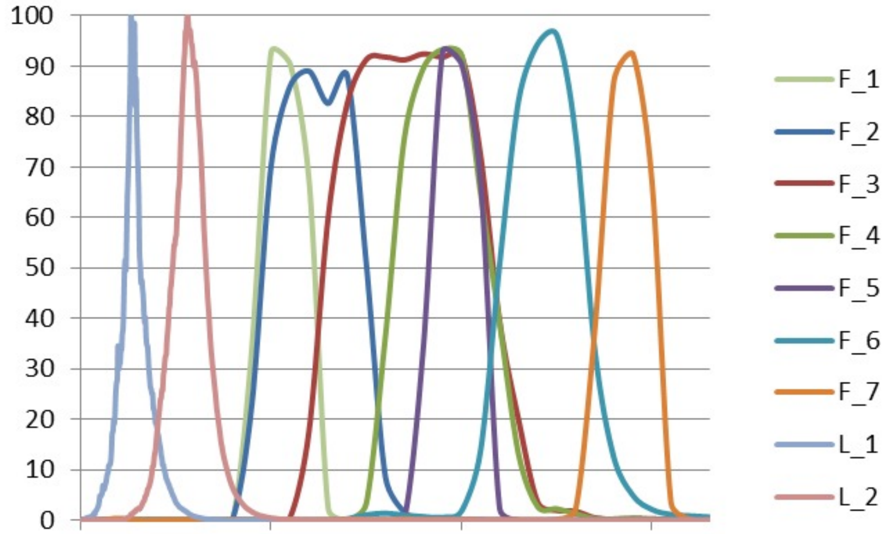


Fig. 4. The wavelength of L_1 and L_2 excitation and the transmittance of seven band-pass filters

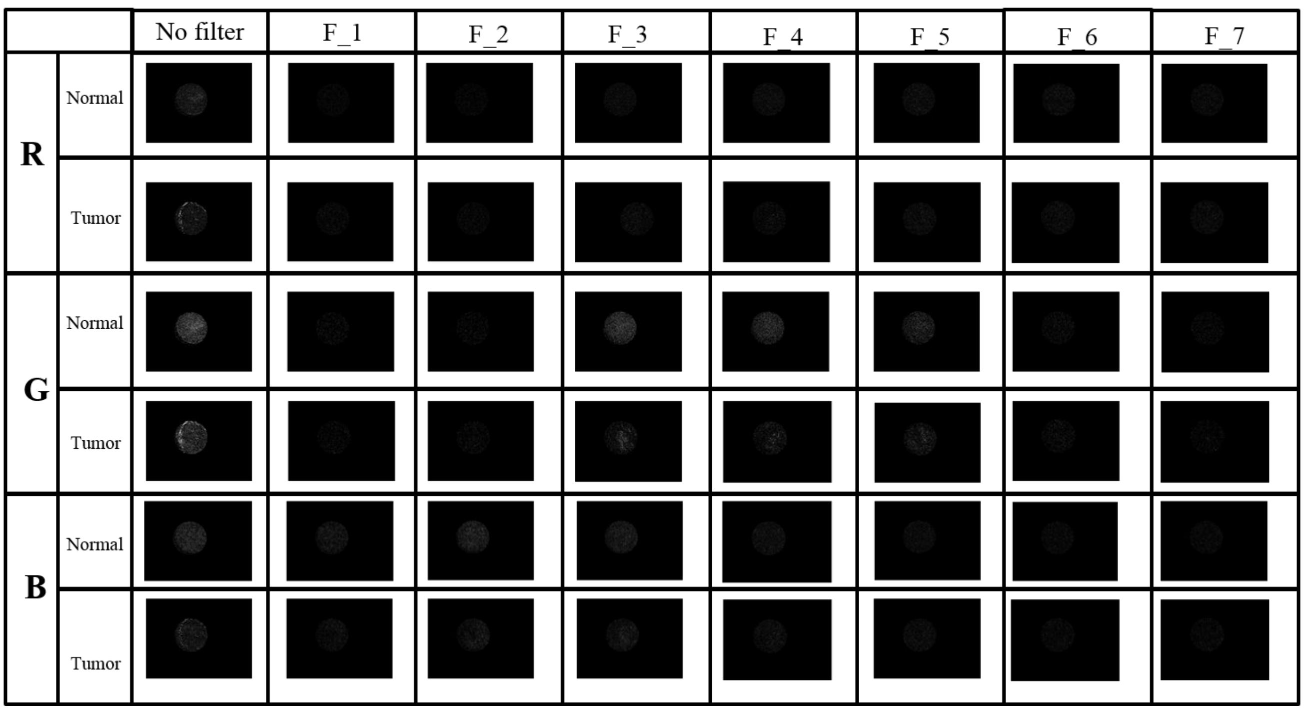


Fig. 5. The autofluorescence images with the L_1 excitation

4. CONCLUSIONS

In this study, we proposed a portable LED Induced autofluorescence (LIAF) imager. It contained the multiple wavelength of LED excitation light and the rotary filter ring of eight channels, where seven filters are assembled in seven holes, to capture ex-vivo oral tissue autofluorescence images. Therefore, the multiple excitation of LED light source can induced multiple autofluorescence, and LIAF imager with the rotary filter ring of eight channels can detect the spectral images of multiple narrow bands. The prototype of a portable LIAF imager is applied in the clinical trials for some case in Taiwan. From the experiments, the autofluorescence images with L2 excitation is brighter than the autofluorescence images with L1 excitation. Besides, the autofluorescence images of the tumor tissue are darker than the autofluorescence images of the normal tissue. The images of the clinical trial show the significant differences between normal tissue and oral tissue with L1 excitation. We will collect more the autofluorescence images of clinical trials for analysis in the future.

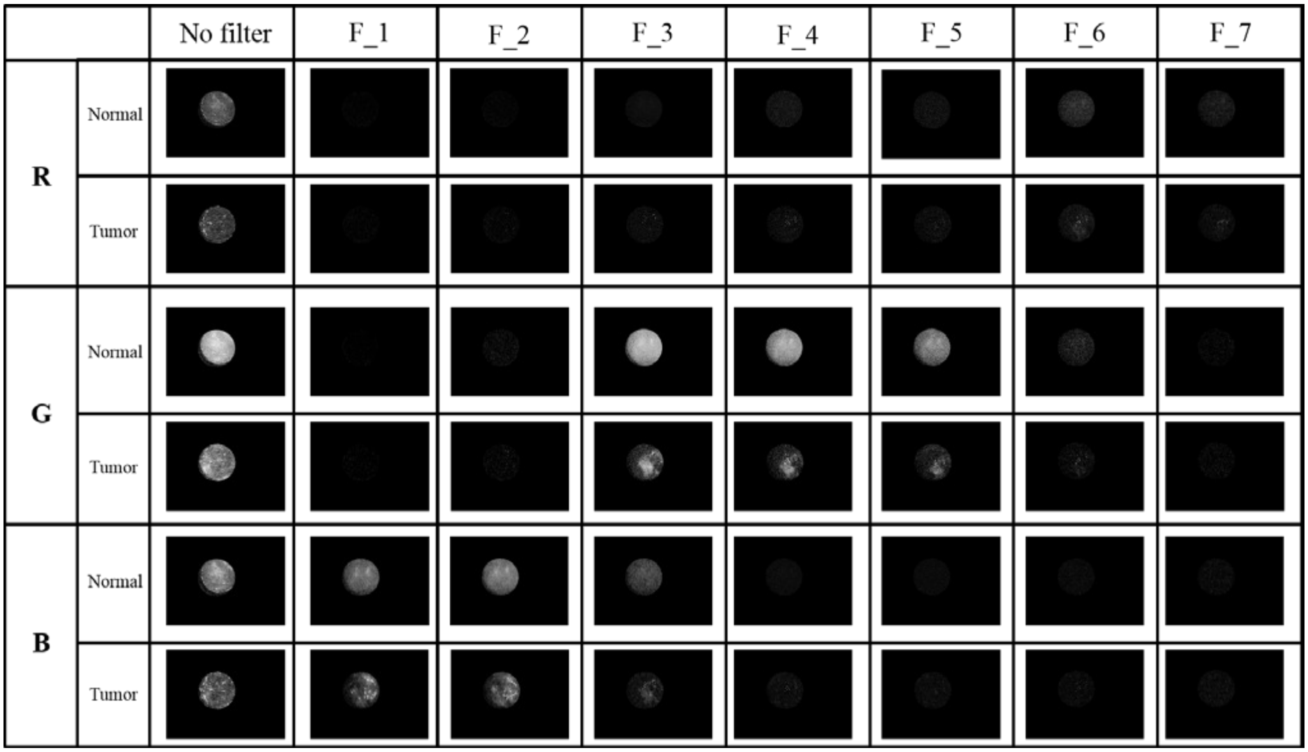


Fig. 6. The autofluorescence images with the L_2 excitation

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