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Abstract

Optical Coherence Tomography (OCT) is nowadays being widely employed as a diagnostic tool for skin cancer. It can produce feedback on tissue morphology alterations produced by different pathologies. OCT images are mainly produced by differences in refractive index and attenuation coefficient, providing in-depth information. Intensity OCT images display the effect of tissue alterations on backscattered light, but it does not represent real physical magnitude. In a number of occasions, morphology alteration events within the same tissue type, produce intensity variations in OCT images that can be misclassified as different tissue component. The estimation of depth-resolved attenuation coefficient improves tissue contrast, helping to identify tissue identity and isolating the effect of disordered structures of the same tissue. The proposed methodology shows that melanoma and Basal Cell Carcinoma (BCC) pathologies exhibit different optical parameters in depth. This enhances the identification of subsurface skin features. Bioengineering.

PDF Article

Depth-resolved attenuation coefficient estimation for skin cancer assessment with Optical Coherence Tomography

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ABSTRACT

Optical Coherence Tomography (OCT) is nowadays being widely employed as a diagnostic tool for skin cancer. It can produce feedback on tissue morphology alterations produced by different pathologies. OCT images are mainly produced by differences in refractive index and attenuation coefficient, providing in-depth information. Intensity OCT images display the effect of tissue alterations on backscattered light, but it does not represent real physical magnitude. In a number of occasions, morphology alteration events within the same tissue type, produce intensity variations in OCT images that can be misclassified as different tissue component. The estimation of depth-resolved attenuation coefficient improves tissue contrast, helping to identify tissue identity and isolating the effect of disordered structures of the same tissue. The proposed methodology shows that melanoma and Basal Cell Carcinoma (BCC) pathologies exhibit different optical parameters in depth. This enhances the identification of subsurface skin features.

Keywords: Optical Coherence Tomography, attenuation coefficient, skin cancer, melanoma, Basal Cell Carcinoma

INTRODUCTION

Early diagnosis is vital in skin cancer. Visual inspection and dermoscopy are the most spread procedures for the identification of different skin lesions. When lesions are suspected to be malignant, they are completely excised and biopsied providing the final diagnosis. Nowadays, OCT has become a commonly used technology by dermatologists as it allows in depth visualization [1]. Based solely on OCT backscattering images, tissue elements such as epidermis, dermis and dermal-epidermal junction, hair, blood vessels, fibrosis, inflammation and others can be identified in depth and explore their extension [2]. Some authors have developed a methodology to diagnose different types of skin lesions with OCT [3]. However, interpretation of OCT images of skin lesions is a subjective task that requires training and experience. In addition, skin varies its composition and thickness in different parts of the body.

MATERIALS AND METHODS

In this work, a swept source OCT setup (Thorlabs OCS1300) has been used in combination with epiluminescence dermoscopy (Heine). OCT central wavelength is of 1325 nm, providing a resolution of 12 microns in depth and 25 microns lateral. Melanoma and BCC lesions have been characterized, producing C-scans of dimensions 10 by 10 mm lateral and 3/n mm in depth, where n is the refractive index of skin, taking a value of 1.4 at 1300nm [4]. Intensity OCT is converted to depth-resolved attenuation coefficient, μ_t, according to Equation 1 presented by Vermeer et al [5].

$$\mu_t = \frac{I[i]}{2\Delta \sum_{k=i+1}^{\infty} I[k]} \quad (1)$$

Where Δ represents pixel dimensions in microns, I[i] represents the i-eth pixel in depth and the summation comprehends

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the rest of the pixels in depth. The attenuation coefficient is then used to segment the elements in ranges of known scattering coefficients according to bibliography (Table 1). At the central wavelength of the OCT, the attenuation coefficient, μt, can be considered mainly due to the scattering component.

Table 1. Scattering coefficient and absorption coefficient at 1300 nm for skin tissue and types of skin cancer [6]. Melanoma (*) is measured at 750 nm [7].

Tissue	Scattering coefficient (mm-1)	Absorption coefficient (mm-1)
Epidermis	2.5	0.11
Dermis	1.6	0.15
Infiltrating Basal Cell Carcinoma	1.04	0.27
Nodular Basal Cell Carcinoma	0.97	0.05
Squamous cell carcinoma	0.77	0.17
Dysplasia	4.0-6.0	-
Melanoma (*)	1.0 *	0.2*

RESULTS AND DISCUSSION

Dermoscopy images of BCC allow visualization of the surface of the lesion (Fig. 1a). Averaged OCT en-face image shows depth aggregated information with dermoscopy, that can be used to correlate features location (Fig. 1b). Raw OCT intensity gives information about tissue morphology (Fig. 1c), while the attenuation coefficient image provides a different contrast (Fig. 1d). Segmentation of known scattering coefficients help identifying differences in tissue composition (Fig. 1e) and identification of tissue components. In this case, the region affected by BCC presents a lower attenuation coefficient, shown in Fig. 1e, purple, in accordance with literature values shown in Table 1.

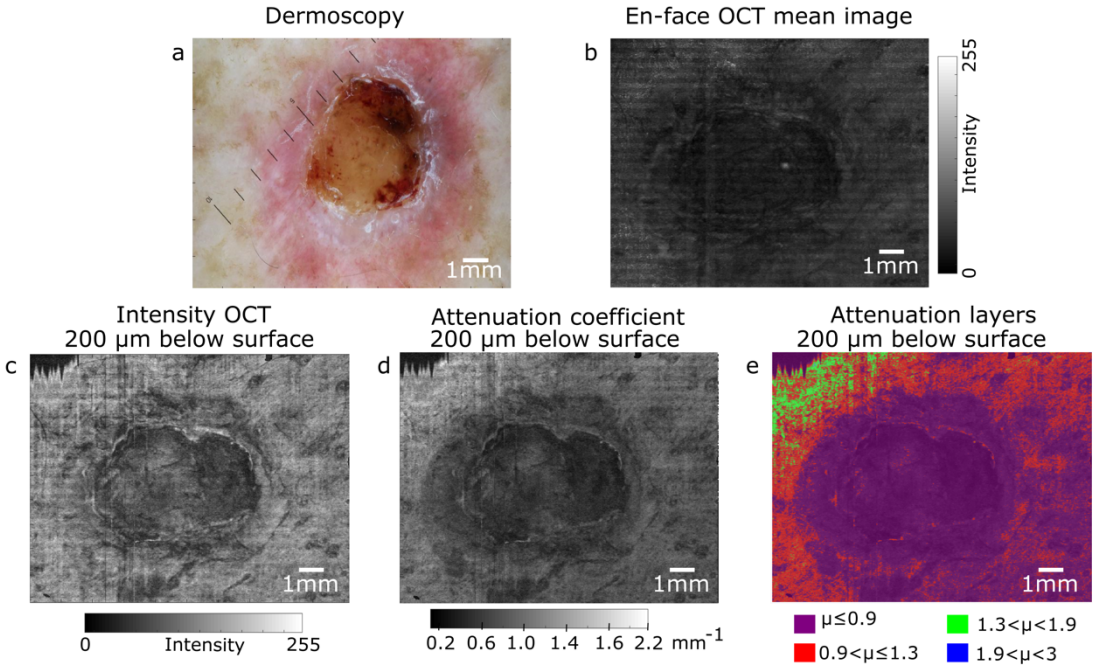

Figure 1. BCC imaged with dermoscopy (a) and OCT (b, c). Attenuation coefficient at a penetration of 200 microns under the surface (d) and its segmentation in ranges according to known tissue values (e) .

In the case of melanoma (Fig. 2), this type of tumor presents greater tissue alterations, affecting the dermis and epidermis, altering the morphology of the skin layers. Attenuation (Fig. 2d) presents complementary information to contrast OCT intensity (Fig. 2c) and segmentation highlights strong differences in tissue composition (Fig. 2e) that represents what may be epidermis and possible dysplasia (blue) and dermis (green).

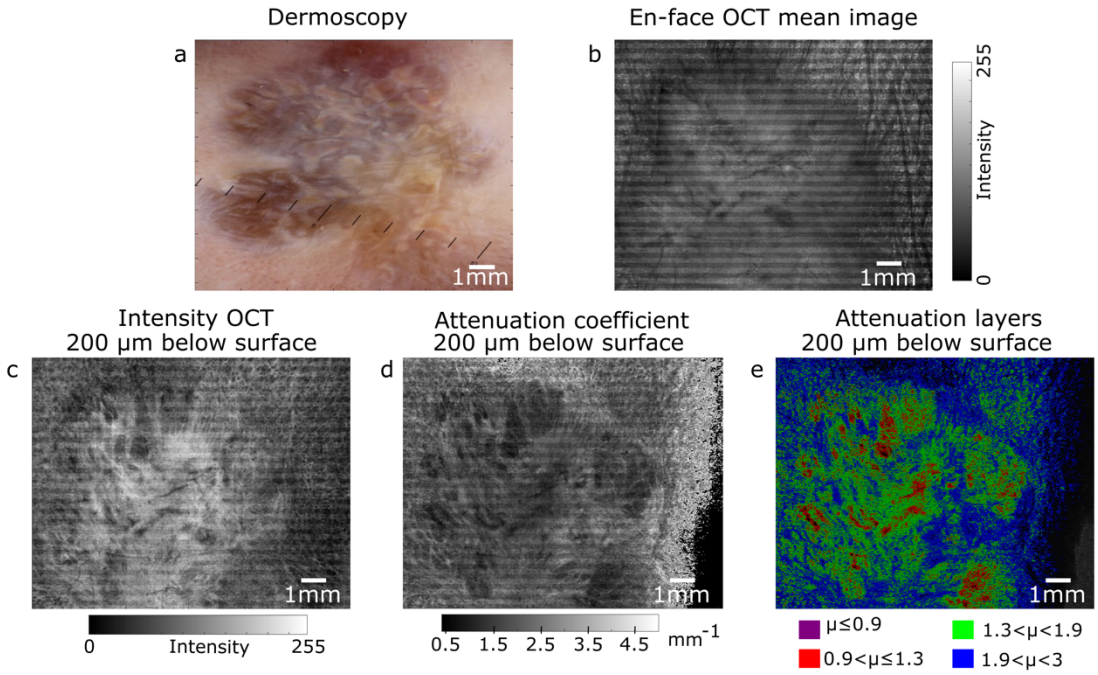

Figure 2. Melanoma imaged with dermoscopy (a) and OCT (b, c). Attenuation coefficient at a penetration of 200 microns under the surface (d) and its segmentation in ranges according to known tissue values (e) .

This methodology allows enhanced contrast in images acquired with OCT. The attenuation coefficient is an physical magnitude, that can provide segmentation values independent of OCT intensity values used for representation. This can lead to depth resolved tissue composition identification. Future work will be aimed to build a complete database of attenuation coefficients of different tissue components and skin pathologies, what will give more information about such pathologies and enhance components identification and segmentation.

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