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Diagnostic accuracy of optical coherence tomography in actinic keratosis and basal cell carcinoma

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ABSTRACT

Background: Early diagnosis of non-melanoma skin cancer (NMSC) is potentially possible using optical coherence tomography (OCT) which provides non-invasive, real-time images of skin with micrometre resolution and an imaging depth of up to 2 mm. OCT technology for skin imaging has undergone significant developments, improving image quality substantially. The diagnostic accuracy of any method is influenced by continuous technological development making it necessary to regularly re-evaluate methods.
Objective: The objective of this study is to estimate the diagnostic accuracy of OCT in basal cell carcinomas (BCC) and actinic keratosis (AK) as well as differentiating these lesions from normal skin.
Methods: A study set consisting of 142 OCT images meeting selection criterea for image quality and diagnosis of AK, BCC and normal skin was presented uniformly to two groups of blinded observers: 5 dermatologists experienced in OCT-image interpretation and 5 dermatologists with no experience in OCT. During the presentation of the study set the observers filled out a standardized questionnaire regarding the OCT diagnosis. Images were captured using a commercially available OCT machine (Vivosight ®, Michelson Diagnostics, UK).
Results: Skilled OCT observers were able to diagnose BCC lesions with a sensitivity of 86% to 95% and a specificity of 81% to 98%. Skilled observers with at least one year of OCT-experience showed an overall higher diagnostic accuracy compared to inexperienced observers.
Conclusions: The study shows an improved diagnostic accuracy of OCT in differentiating AK and BCC from healthy skin using state-of-the-art technology compared to earlier OCT technology, especially concerning BCC diagnosis.

1. Introduction

Non melanoma skin cancer (NMSC) is the most common type of cancer in the Western world with an incidence rate of >1 000/100 000 person-year for basal cell carcinoma (BCC) [1]. The clinical diagnosis of NMSC is on occasion difficult, and diagnostic accuracy in epidemiological studies show a sensitivity, specificity and positive predictive value (PPV) for NMSC of 56–90%, 75–90% and 49–73% respectively with highest values for BCC [2,3]. Histopathology of a punch biopsy is often used to confirm the clinical diagnosis of NMSC. This invasive procedure however entails discomfort for the patient as well as scarring and potential diagnostic delay. Furthermore a punch biopsy may not represent a specific tumour subtype, potentially impeding the optimal course of treatment [4].

Following the increasing demand for non-invasive treatments and swift diagnostic procedures, a number of skin imaging techniques have been developed. One of the promising tools is optical coherence tomography (OCT). OCT is based on interferometry using infrared light. In ophthalmology, the technique is used as a routine procedure for high resolution imaging of the retina and cornea. In dermatology, OCT was introduced in 1997 and has since then been studied in relation to a range of dermatological diseases and structures. OCT provides real time high resolution cross sectional 2D and 3D images measuring a skin area of up to 6 × 6 mm with a penetration depth of 1–2 mm [5].

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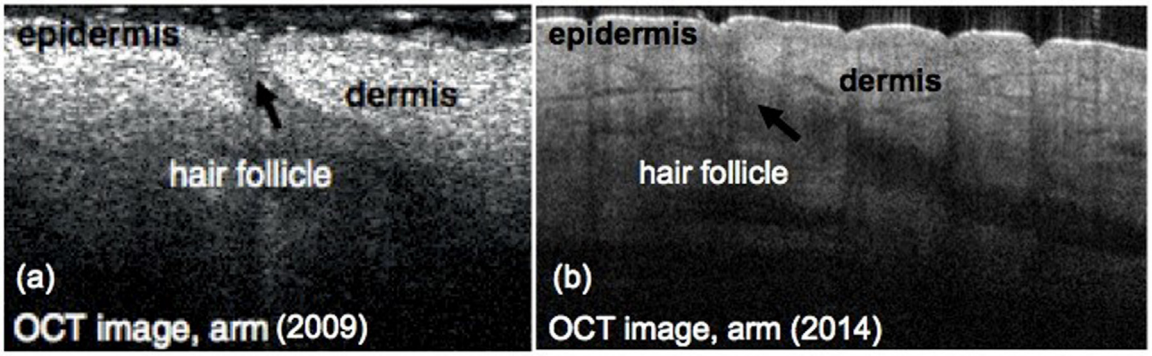

Fig. 1. In vivo OCT images of normal skin located on the arm. The figure exemplifies the improvement in image quality attained during the last five years. a) Image obtained in 2009 using an OCT system developed at the Technical University of Denmark with a resolution of 8 μm axial and 24 μm lateral. Reproduced by permission of Wiley-VCH, Mogensen, M., et al., *OCT* imaging of skin cancer and other dermatological diseases. J Biophotonics, 2009. 2(6–7): p. 442-51. b) Image obtained in 2014 using a "VivoSight" OCT system from Michelson Diagnostics, UK with a resolution of <5 μm axial and <7.5 μm lateral and a scan area of 6 × 6 mm.

NMSC has been a natural focus of OCT studies and thus most OCT research in dermatology has turned on diagnosis, delineation and treatment evaluation of NMSC. Diagnostic accuracy of OCT in NMSC has been evaluated in several different study designs. Newer studies focus on determining diagnostic accuracy based on scoring systems [6–8] and as an assisting tool in a clinical setting [9,10]. In early studies, the diagnostic accuracy was evaluated using only OCT-images without any adjunct scoring systems or clinical tools for comparative diagnosing the lesions [11,12]. These studies found, that the diagnostic accuracy of OCT in NMSC was less accurate than the clinical diagnosis, with difficulties in differentiating BCC from actinic keratosis (AK). This may suggest that the diagnostic features were too subtle and difficult to recognize in the OCT-images. Technology is however continuously evolving, and the OCT-systems have improved significantly over the past 6 years (i.e. higher resolution and penetration depth, larger scan areas and faster image acquisition) [9,11] which all have improved the quality of OCT-images of skin significantly (see Fig. 1). More recent studies also show strong correlation between OCT morphology and histopathology in NMSC [13,14]. These technological improvements suggest the need for a formal re-assessment of the method's diagnostic accuracy.

2. Materials & methods

The aim of this study is to determine the diagnostic accuracy of OCT in differentiating NMSC from healthy skin and BCC from AK (shared aetiology but different pathogenesis). In addition, we wanted to examine the diagnostic accuracy across two observer groups; one group consisting of dermatologists experienced with OCT-interpretation and one group of dermatologists with no experience in OCT prior to the study. A flowchart, describing the major steps in the study is shown in Fig. 2.

The two observer groups reviewed a data set consisting of OCT-images of histologically verified AK and BCC as well as clinically defined healthy skin of the same region. An example of each type of lesion is shown in Fig. 3. A suitable number of lesions were chosen (see Sample size paragraph). The OCT images in the study set were selected based on image quality, defined by minimal shadowing artefacts from hairs, hyperkeratosis and crustae. The OCT images were collected from the dermatological outpatient clinic at Roskilde Hospital, Denmark from 2010 to 2015. All patients had signed informed consent forms prior to enrolment in the study. No preparation of the skin (coupling agents, tape stripping, crusta removal, hair removal etc.) was done and no surgical or topical treatment had been performed three months prior to the scans.

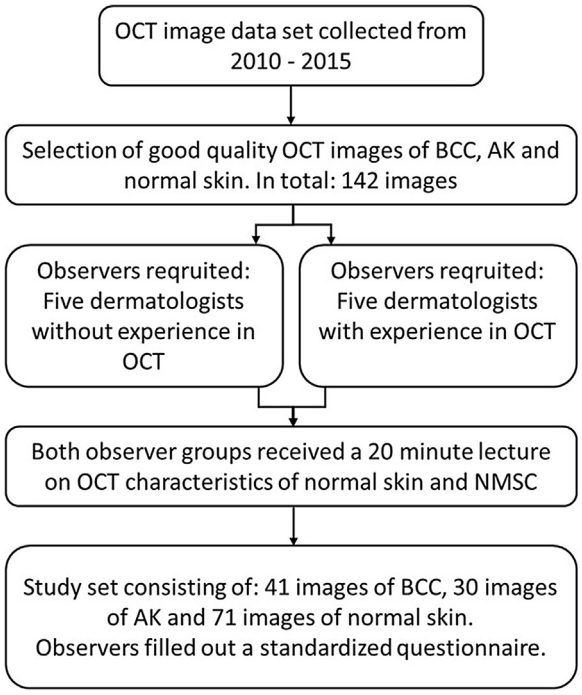

Fig. 2. Flowchart showing the major steps in the study.

A total of ten doctors with a least 1 year of experience in dermatology were included in the study as observers. Half of them had research experience in OCT, and the other half had no experience with OCT prior to the study. Before reviewing the images, all observers were given a twenty-minute lecture on OCT image interpretation with focus on key features in BCC, AK and normal skin. Former studies of OCT morphology have defined the following criteria for NMSC and normal skin, which were included in the introduction lecture [6,13,15,16]:

Normal skin:

- Entry signal showing a narrow hyperreflective band. In some skin areas stratum corneum can be identified just below this entry signal.
- A homogenous well-demarcated darker layer, epidermis.
- A clear transition to a lighter layer, dermis, with the dermo-epidermal junction (DEJ) seen as an unbroken fine hyperreflective line at the interface between epidermis and dermis.
- Other anatomical features such as hair follicles and blood vessels.