Quantification of the thermal signature of a melanoma lesion

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ABSTRACT

Melanomas are cancerous skin lesions that are notorious for their ability to metastasize at a relatively early stage of development. The key to improved survival in all affected individuals remains early diagnosis and treatment. We have recently developed a transient thermal (infrared − IR) imaging system that allows for accurate measurement of temperature differences on the skin surface to aid the detection and diagnosis of metabolically active or malignant skin lesions. The existence of a simple, quantitative, objective, and noninvasive in vivo screening and diagnostic tool for the evaluation of pigmented lesions would be invaluable for the early detection of melanoma in a variety of clinical settings. Therefore, we are currently conducting a patient study to verify the feasibility of the described IR imaging tool in distinguishing benign pigmented lesions from malignant ones and quantifying the malignant potential of lesions. In this paper, we compare data obtained by imaging benign and malignant pigmented lesions. Measured surface temperature distributions for characteristic time instants as well as temperatures of selected points on the surface of healthy skin are compared as a function of time. The results show a distinct difference in the thermal responses between healthy tissue and the malignant lesion for the cases considered in the paper. The thermal response of benign lesions was found to be similar to that of healthy skin tissue. This difference can be used to identify malignant lesions and quantify their malignant potential. Experimental data from the clinical study are compared with results obtained by simulating the thermal behavior of the skin lesion numerically using a computational model developed for this purpose. The computed results showed that the lesion parameters and properties can be estimated and the influence of malignant lesion on the transient thermal response can be quantified with our computational model.

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1. Introduction

Skin cancer is the most common form of cancer in the United States. According to the data reported by the Skin Cancer Foundation in 2010, each year there are more new cases of skin cancer than the combined incidence of cancers of the breast, prostate, lung, and colon. The most common form of skin cancer is basal cell carcinoma (2.8 million diagnosed annually in the US), which is rarely fatal, but can be disfiguring. The second most common form of skin cancer is squamous cell carcinoma (around 700,000 diagnosed each year in the US, leading to approximately 2500 deaths). Approximately 3% of skin cancer cases are melanomas, causing more than 75% of skin cancer deaths [1]. The incidence of cutaneous melanoma continues to rise worldwide, with the highest (incidence) in Australia and New Zealand. Melanoma is currently the sixth most common cancer in the United States and its incidence has more than tripled in the white population during the past 20 years [2]. The current

lifetime risk of developing invasive melanoma is 1 in 60 Americans, and this risk rises to 1 in 32 Americans if non-invasive melanoma in situ is included [3]. In 2010 approximately 68,720 melanomas will be diagnosed, with around 8,650 resulting in death. If melanoma is detected early, before the tumor has penetrated the epidermis, the survival rate is about 99%. The survival rate drops dramatically, to 15%, for patients with advanced disease [1]. At present, there are no systemic agents available that significantly extend the lifespan of patients with advanced melanoma [4,5], and the key to extended survival is early detection and treatment [6]. Since melanoma is an extremely aggressive form of cancer and metastasizes rapidly (patients can die within a few months of diagnosis), annual checkups in specialized clinics may not be sufficient to detect melanoma at a very early stage.

The vast majority of cutaneous melanomas are presented as pigmented skin lesions. Currently the detection of atypical lesions relies primarily on subjective ABCDE (Asymmetry, Border, Color, Diameter, Evolution) criteria, where the clinician checks the asymmetry (one half does not match the other half), the borders (irregular, ragged, blurred, or notched), the color (not the same throughout), the diameter (larger than 6 mm), and the evolution

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