Analysis of skin basalioma and melanoma by multispectral imaging

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ABSTRACT

A clinical trial involving multi-spectral imaging of histologically confirmed 8 basaliomas and 30 melanomas was performed. Parametric maps of the melanin index, erythema index and melanoma-nevus differentiation parameter have been constructed and mutually compared. Specific features of basalioma and melanoma images were analyzed and discussed.

Keywords: Multispectral and hyperspectral imaging, optical diagnostics for medicine.

1. INTRODUCTION

Basalioma or basal cell carcinoma is the most common skin cancer in humans. There are five clinical types of basalioma: nodular, ulcerating, pigmented, sclerosing, and superficial. Basalioma is locally invasive, aggressive, and destructive but slow growing, and there is very poor tendency to metastasize. Pigmented basaliomas may be brown, blue or even black. Surface of pigmented basaliomas usually are smooth, glistening, hard, and firm [1].

Cutaneous melanoma is the most malignant skin cancer. Melanoma arises from the malignant transformation of melanocytes at the dermal-epidermal junction or from the nevomelanocytes of dysplastic melanocytic nevi or congenital nevomelanocytic nevus that become invasive and metastasize after various time intervals. Melanomas are divided into two major groups: de novo melanomas (melanoma in situ, lentigo maligna melanoma, superficial spreading melanoma, nodular melanoma, acral-lentiginous melanoma, melanoma of the mucous membranes, desmoplastic melanoma) and melanomas that arise from precursors (melanoma arising in dysplastic nevomelanocytic nevi, melanoma arising in congenital nevomelanocytic nevi, melanoma arising in common)]1].

In oncologists practice there are cases when pigmented basaliomas may be indistinguishable from superficial spreading or nodular melanoma [1]. To avoid metastasizing of melanoma, relatively large area of healthy skin around melanoma has to be removed. Basalioma do not metastasize and surgery usually is not as severe as the cases of melanoma. Therefore, it is difficult to make the decision on further treatment of the patient.

Multispectral imaging is non-invasive optical method that can be used for skin pathology studies [2]. Images taken at different wavelengths can be combined to make composite images to assess blood supply, melanin concentration and other parameters of interest.

2. METHODS AND EQUIPMENT

2.1 Measuring equipment

Measuring equipment consisted of multispectral imaging camera (Nuance EX), ring of halogen lamps, diffuser, polarizing film, and computer (Figure 1). The Nuance Imaging Module contained a high-resolution, scientific-grade CCD imaging sensor, a solid-state liquid crystal filter with a polarizer, a wavelength tuning element, a spectrally optimized lens and internal optics [3]. Light from halogen lamps passed through diffuser and polarizing film and illuminated skin area. Reflected and back-scattered light from the skin passed through an objective lens into a multispectral imaging camera. To avoid artifacts from skin surface the polarization of the light from the light source was orthogonal to the orientation of polarizer located in the Nuance EX camera.
2.2 Measurement procedure

Clinical trial comprising 38 histologically approved pigmented oncological pathologies—8 pigmented basaliomas and 30 melanomas—was carried out in Latvian Oncology Center, with approval of local ethics committee. The melanomas had different thicknesses: 17 melanomas fell in the thickness range of 1-2 mm and 13 within the thickness range of 3-5 mm (Breslow’s depth).

Optical density images of entire spectral region 450 - 950 nm with step 10 nm were taken. The half-bandwidth of the color filter was 15 nm. To get images of optical density, at first, reflection intensities of white paper in whole spectral region were taken. White paper was placed on skin surface. The optical density images were obtained using the formula:

\[ \text{OD}(\lambda) = -\log \left( \frac{I(\lambda)}{I_0(\lambda)} \right), \]  

where \( I(\lambda) \) – intensity of the light reflected from skin area and \( I_0(\lambda) \) – intensity of the light reflected from the white paper (at the same distance).

To avoid artifacts caused by the motion, the image stabilization program ImageJ [4] with plugin TurboReg [5] was used. The entire measurement process took about 15 – 20 minutes:

- Patient relaxing in a comfortable recumbent position (about 1 – 3 minutes);
- Acquisition of the reference and image cube (about 1 – 2 minutes);
- Stabilization of the image cube, if necessary (about 5 minutes);
- Image processing (about 15 seconds).

2.3 Image processing

To compare melanoma with pigmented basalioma, melanin index, erythema index, and melanoma diagnostic parameter \( p \) were calculated.

Due to minimal influence of hemoglobin, the near infrared spectral region is well-adapted for determining the melanin index. Slope of the skin optical density spectrum in the range 620-720 nm is directly proportional to melanin content in the epidermis [6, 7]. Melanin index was determined as:

\[ M = 100 \left( \text{OD}_{650} - \text{OD}_{700} \right), \]  

where \( \text{OD}_{650} \) and \( \text{OD}_{700} \) optical densities at 650 nm and 700 nm.

Erythema index was found by comparison of skin optical density in the green and red spectral ranges. Two wavelengths were used: 560 nm near the absorption peak of hemoglobin and 650 nm near the hemoglobin absorption minimum. Erythema index was determined as [7]:

\[ E = 100 \left( \text{OD}_{560} - \text{OD}_{650} \right), \]
where OD_{560} and OD_{650} - optical densities at 560 nm and 650 nm.

Parameter \( p \) ensuring melanoma and nevus differentiation [8] was examined on basaliomas, as well, according to the formula:

\[
p = OD_{650} + OD_{950} - OD_{540},
\]

where OD_{540}, OD_{650}, and OD_{950} are the optical densities at 540 nm, 650 nm, and 950 nm. The wavelength 540 nm corresponds to the wavelength of maximum absorption of the blood hemoglobin [9], while at 650 nm hemoglobin absorption is minimal and melanin absorption is more pronounced [10], and 950 nm is the wavelength at which light penetrates the skin surface most deeply [11] in our measurement conditions.

3. RESULTS AND DISCUSSION

Figure 2 shows ordinary RGB images and melanin index (M), erythema index (E) and parameter \( p \) maps of a) melanoma and b) basalioma. Both melanoma and pigmented basalioma appear to have similar distribution of melanin (Figure 2; M maps). Distribution of melanin in malformation area is more even, in some cases containing areas with higher or lower E values. Melanoma differs from basalioma with irregular blood supply (Figure 2; E maps); there are regions that are well-supplied (high E values) and poorly supplied (low E values). Erythema index of basalioma over the surface is much smoother. It is possible to differentiate basalioma from melanoma using melanoma diagnostics parameter \( p \) (Figure 2; \( p \) maps). Melanomas have areas with higher \( p \) values while basaliomas have lower or similar \( p \) values than surrounding healthy skin.

![Figure 2. RGB images, melanin index (M), erythema index (E) and parameter \( p \) maps of a) melanoma and b) basalioma.](image)

To illustrate these results quantitatively, average minimal and maximal values of the parameters M, E and \( p \) were calculated by selecting a square area within each pathology that coincided with the region of lower values and with the region of higher values. To determine the specificity of healthy skin of each case, mean M, E, and \( p \) values of the surrounding healthy skin were calculated, too. To avoid a case-specific skin type, blood content, and other physical characteristics in surrounding healthy skin, normed parameters were calculated: M- M_0, E- E_0 and \( p - \ p_0 \), where M_0, E_0 and \( p_0 \) are melanin index, erythema index, and parameter \( p \) values calculated in the surrounding healthy skin.

Figure 3 represents the averaged minimal and maximal M- M_0, E- E_0 and \( p - \ p_0 \) values in melanoma cases. Graphs show that there is a big difference between normed values of erythema indexes and parameter \( p \) in different regions of the melanoma. In some cases there is a notable difference between the averaged minimal and maximal normed melanin index, too.
Figure 3. Averaged minimal (dark circles) and maximal (light triangles) a) normed melanin index $M - M_0$, b) normed erythema index $E - E_0$ and c) normed parameter $p - p_0$ values of the different melanoma regions.

Figure 4 represents the averaged minimal and maximal $M - M_0$, $E - E_0$ and $p - p_0$ values in basalioma cases. From the graphs it is clearly seen that in most cases the normed parameters $M - M_0$, $E - E_0$ and $p - p_0$ are distributed more evenly throughout the whole pathology area.

4. CONCLUSIONS

Our first results of 8 basalioma and 30 melanoma cases show that it is possible to differentiate these two pathologies using this multispectral imaging method. Distribution of erythema index and parameter $p$ in pathology shows the potential for further development of this multispectral method.

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