КАРАКТЕРИЗАЦИЈА ТУМОРА КОЖЕ ПРИМЕНОМ ОПТО-МАГНЕТНЕ ИМИЏИНГ СПЕКТРОСКОПИЈЕ
CHARACTERIZACION OF SKIN CANCER WITH OPTO-MAGNETI IMAGING SPECTROSCOPY

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Сажетак Меланом је најзлоћуднији тумор коже у људској популацији због касне детекције, велике инвазивности и брзе инфилтрације. Поред меланома, канцер коже чине базоцелуларни карцином, сквамоцелуларни карцином и други ретки карциноми као што су карцином Меркелових и Лангерхансових ћелија. Годишњи пораст оболелих од меланома у Србији је 6%, док у свету варира од 5% до 7%. Различите методе су се користиле за детекцију и диференцијацију тумора коже које се разликују по принципу рада и ефикасности детекције. Нова метода која се користи је опто-магнетна имиџинг спектроскопија базирана на интеракцији светлости и ткива. Детаљније, ова техника мери разлике у интеракцији коже са белом или поларизованом светлошћу у случајевима када зрачење пада нормално на кожу или под Брустеровим углом. Иста мерења се могу извршити и при озрачивању коже плавом и љубичастом светлошћу при фиксираном упадном углу. У овој студији, ОМИС се користио за детекцију и диференцијацију младежа и меланома, као и за диференцијацију меланома и немеланотичних карцинома коже. Истраживања су укључила 65 пацијената код којих су дермоскопски и хистопатолошки потврђене различите лезије. Показано је добро слагање између резултата добијених ОМИС методом и хистопатолошких дијагноза у узорку од 97% пацијената. Ово показује да опто-магнетна имиџинг спектроскопија може бити једна од метода за детекцију и диференцијацију различитих лезија коже.

Abstract: Melanoma is the most malignant skin cancer in human population due to late detection, high invasiveness and rapid infiltration. Beside melanoma, skin cancer includes Basal cell cancer (BCC), Squamous cell cancer (SCC), and other rare cancers like Mercel cell carcinoma and Langerhans cell carcinoma. The annual increase of melanoma patients in Serbia is 6%, while this number varies in rest of the world between 5% and 7%. Various techniques are used for detection and differentiation of skin cancers that differ in principle of operation and detection efficiency. A novel method is an opto-magnetic imaging spectroscopy (OMIS) based on light-tissue interaction. In more details, this technique measures the difference between responses of the skin when it is illuminated with white or polarized light under normal incidence or at Brewster angle. Different skin responses could be also measured under fixed incident angle of the blue and the violet light. In this study, OMIS is used for detection and differentiation between simple mole (naevus) and melanoma, and for differentiation between non-melanoma cancer and melanoma. Investigations have included 65 patients with dermoscopic and histopathology confirmed different lesions. It is shown that good agreement between the results of the OMIS method and histopathological diagnosis were obtained in the sample covering 97% of the patients. This demonstrates that OMIS method could be one of the diagnostic methods for detection and differentiation of skin lesions.

INTRODUCTION

Melanoma is the most malignant skin tumor. Besides melanoma, skin cancers include Basal cell carcinoma (BCC), Squamosus cell carcinoma (SCC), rare tumors such as Mercel cell carcinoma, Langerhans cell carcinoma and precancerous lesions such as Morbus Bowen, actinic keratosis and lentigo maligna. Melanoma is an invasive tumor and is rarely detected in time due to the absence of symptoms that indicate disease. Sunburns, a measure of excess sun exposure, have been identified as a risk factor for the development of melanoma [1]. Different investigations found that UVA causes DNA damage via photosensitized reactions that result in the production of oxygen radical species [2,3]. In 1992 International Agency for Research on Cancer (IARC) classified solar radiation as carcinogenic for humans [4], and in 2009 IARC declared sun bed cancirogenic [5]. The annual increase of melanoma patients in Serbia is 6% [6], while this number varies in rest of the world between 5% and 7% [7].

Various techiques are used for detection and differentiation of skin tumors, that differ in principle of operation and detection efficiency. Among them are optical techniques such as Raman spectroscopy, Near Infrared spectroscopy (NIR), Fourier Transform infrared spectroscopy (FTIR) etc. It was shown that Raman spectroscopy method can differentiate malignant from bening tumors [8]. This technique is based on the detection of protein and amide bonds [9]. In the NIR spectroscopy, the transmitted or reflected light in the wavelength range of 780-2500 nm is measured. Therefore, it was possible to see the characteristics of the molecular changes in the composition and structure of biological tissues such as the skin [10].

The gold standard for definite diagnosis is histopathology. It is a subjective, invasive and expensive method. The existence of an alternative method that is simple, non-invasive, rapid, automated and cost-effective is an ideal solution for primary screening of the skin, and specially skin tumors.

In this paper, we present novel method for detection and differentiation of skin lesion called Opto-magnetic imaging spectroscopy (OMIS) [11]. This method is based on light-tissue interaction using white and reflected polarized light under Brewster angle.

METHOD

In this method, the light with wavelength in the range 400-700 nm is used. Light is an electromagnetic wave consisting of coupled electric and magnetic fileds perpendicular to each other. Under certain circumstances, these fields can be separated in the process known as light polarization. Light could be polarized via interaction with a material, when light is incident to the material under certain angle.
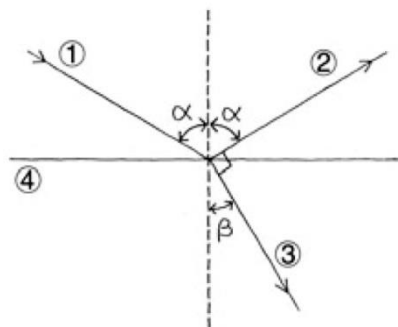

Figure 1. An illustration of the incident (1), reflected (2), and refracted light rays (3) with respect to the boundary between the two media (4). The incident and the reflected angles are denoted as α, while β is the angle of refraction. If α is equal to the Brewster angle, than equality α+β=90˚ holds.

The light can be polarized under reflection or refraction from a border between the two media. If the light beam is incident to a sample made from material of interest under particular angle, called «Brewster angle», then the sample will polarize the refelected light. The longitudinal wave of reflected light will only have an electrical component which properties will depend on an electrical state of the surface. However,

magnetic component of reflected light will be as transfersale wave and will not have significant effect on sensor (digital camera). Therefore, the electrical properties of a material can be obtained by measuring the reflected light.
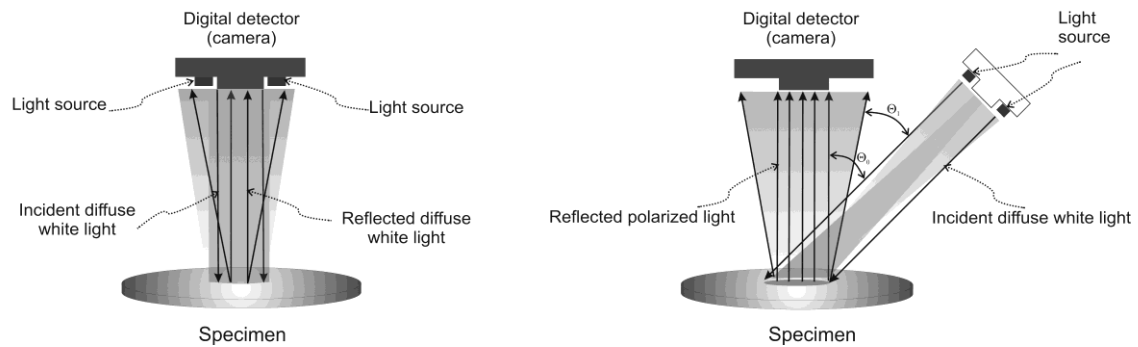

Figure 2. The principle of operation of a device in the opto-magnetic imaging spectroscopy. [11].

If the incident light angle is equal to Brewster angle, the linear polarization of reflected wave is achieved. Further, the propagation directions of reflected and refracted rays are perpendicular. However, under normal light incidence on a material, the reflected light will contain the information about both electrical and magnetic properties of a sample. If one performs the measurements of a reflected light from the same sample under Brewster angle and under normal incidence, respectively, then the magnetic properties of a material surface can be obtained by subtracting the first reflection from the second one. This is a key principle of an opto-magnetic imaging spectroscopy (OMIS) [11].

From the spectra obtained by the OMIS method, different material properties that depend on the spatial distribution of valence electrons as well as on the chemical bond strength for hydrogen bonds, ion-ion, and ion-dipole bonds, can be obtained. In our research we used NL-B53 devices (NanoLab, Faculty of Mechanical Engineering, University of Belgarade).

MATERIALS

Our study included 65 patients with skin lesion. All these lesions are devided into several groups based on dermoscopic and histopathological criteria . Devided groups are moles, melanoma and BCC. Pictures of lesion were taken in Hospital for Plastic and Reconstructive Surgery (ORS Hospital, Belgrade). Each lesion was taken 10 time with both white and polarized light. Then all the pictures were processed with algorithm specially made for OMIS [11]. The diagrams were obtained by comparing the number of peaks, the intensity and the wavelength difference of the same peaks. The main reason is comparison of the peak areas to determine whether there is a difference between peaks and what is their significance.

RESULTS

By applying the OMIS method, diagrams are obtained for each skin changes and typical representatives are shown in Figure 3 for two different types of males, in Figure 4 for two melanoma and in Figure 5 for two typical Basal cell carcinoma (BCC).
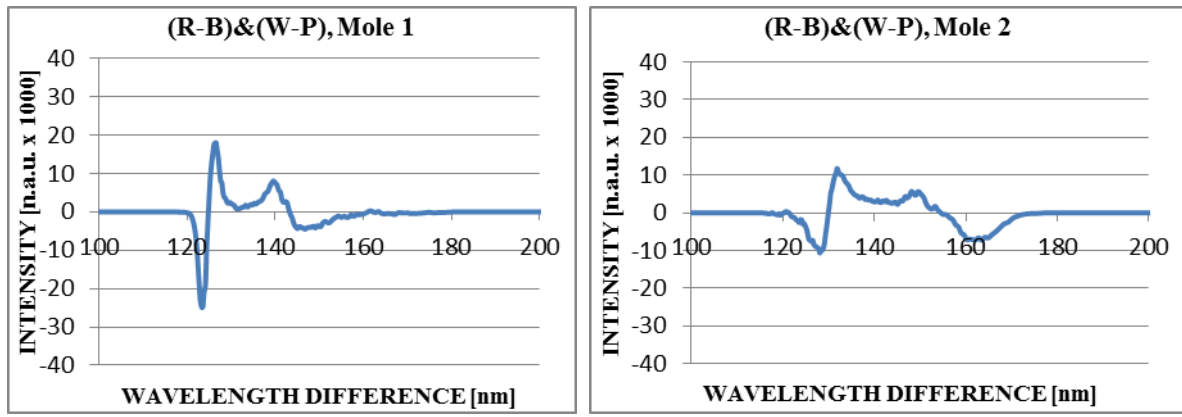
Figure 3. The Opto-magnetic spectra diagrams of the two different samples of moles
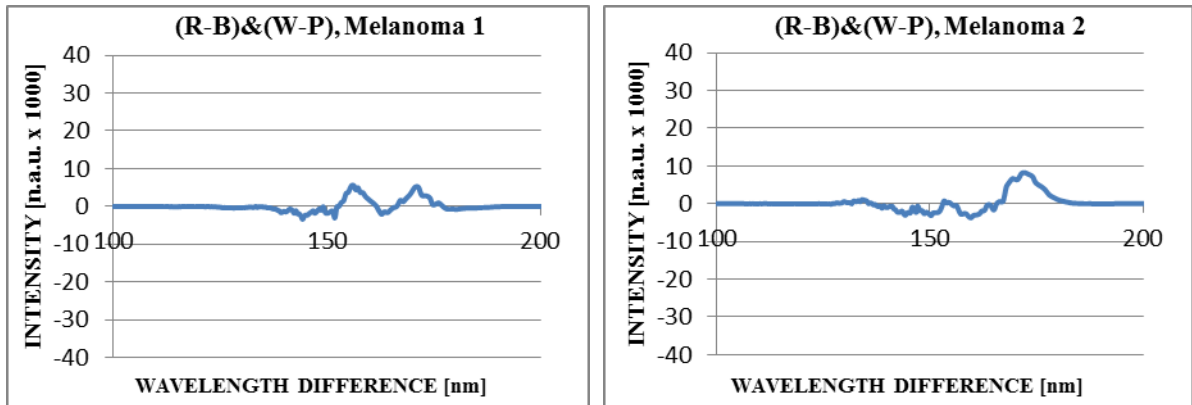

Figure 4. The Opto-magnetic spectra diagrams of the two samples of melanoma.
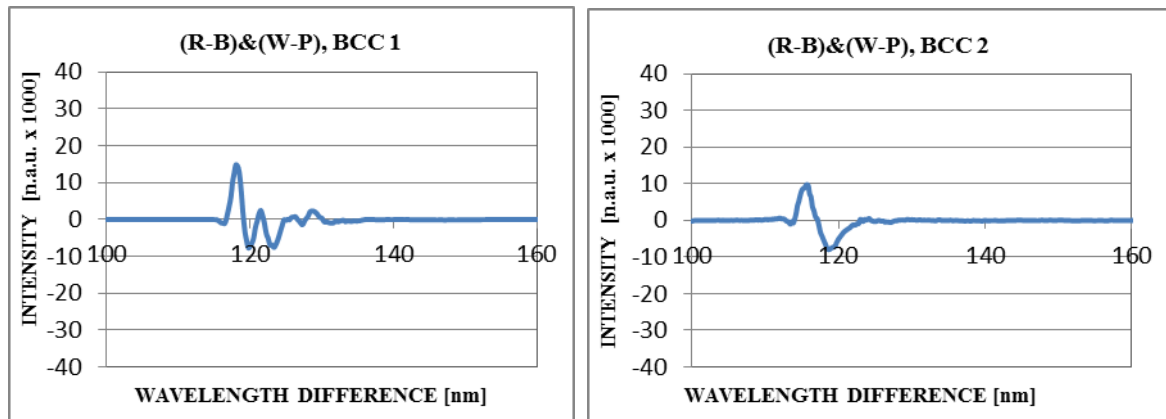

Figure 5. The Opto-magnetic spectra diagrams of the two sample of Basal cell carcinoma (BCC).

By comparing the obtained diagrams for all lesions, it can be seen that the OMIS spectra differ significantly between the groups, while the diagrams of a same group have significant overlaps (similarity). The obtained differences between leasions are the number of peaks, peaks' intensity, and their wavelenght difference.

On the first diagram in Figure 3 it can be seen the presence of four peaks, two positive (126.106/17.57, 138.403/5.507) and two negative (122.973/-22.99, 143.875/-1.72). On the second diagram there are also presence of four peaks, two positive peaks (131.393/9.80, 146.794/4.30) and two negative (126.106/-7.38, 158.994/-5.34). Reason for small differences in two diagrams is the histological structure of different types of moles. Diagrams of melanoma are also very similar. On the first diagram in Figure 4 one can see the presence of three peaks, two positive (154.457/3.43, 169.299/2.96) and one negative (160.845/-0.88), while on the other diagram there are also presence of three peaks (152.783/0.79, 169.896/6.50,

157.233/-2.72). In case of BCC diagrams, there are differences but with two characherteristic peaks on both diagrams (positive peaks 117.737/12.19 and 114.76/6.78 and negative peaks 119.22/-5.05 and 118.712/-4.730). Reasons for the differences in diagrams are different histological structures of bcc, stage of disease, localization etc.

CONCLUSION

Melanoma is the most malignant skin tumor because of the absence of symptoms, followed by rapid infiltration and high invasiveness. Basal cell carcinoma is malignant skin tumor with slow growth and which rarely gives metastasis. Annual increase of melanoma in the world is between 5% and 7%.

Various techniques are in use for detection and differentiation of skin lesions. We used novel method Opto-magnetic imaging spectroscopy (OMIS). OMIS method is based on light-tissue interaction using white and polarized light.

Investigation have included 65 patients with dermoscopic and histopathological diagnosis. It is shown that good agreement between the results of the OMIS method and histopathological diagnosis were obtain in the sample covering 97% of the patients.

Our study is coisistent with previous results [12-14] and demonstrate that OMIS method could be one of the diagnostic method for detection and differentiation of skin lesions.

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