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CHARACTERIZACION OF SKIN CANCER WITH OPTO-MAGNETIC IMAGING SPECTROSCOPY

Gorana V. Nikolić[1,3,], Jadran Bandić[2], Dejan Oprić[3], Jovana Šakota[1], Lidija Matija[1]*

[1] University of Belgrade, Faculty of Mechanical Engineering, Nano Lab, Kraljice Marije 16, 11000 Belgrade, Serbia
[2] ORS Medical Practice, Bokeljska 7, 11000 Belgrade, Serbia
[3] University of Belgrade, School of Medicine, Institute of Pathology, Dr Subotića 1, 11000 Belgrade, Serbia

Abstract: Melanoma is the most malignant skin cancer in human population due to late detection, high invasiveness and rapid infiltration. Besides 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 in the rest of the world varies between 5% and 7%. Various techniques are used to detect and differentiate skin cancers; these techniques differ in the 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 under Brewster angle. Different skin responses can also be measured under a 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 whom different lesions were confirmed by dermoscopy and histopathology. 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 can be one of the diagnostic methods for detection and differentiation of skin lesions.

Keywords: melanoma, OMIS, histopathology, dermoscopy.

1. 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, the International Agency for Research on Cancer (IARC) classified solar radiation as carcinogenic for humans [4], and in 2009 IARC declared the sun bed carcinogenic [5]. The annual increase in melanoma patients in Serbia is 6% [6], while this number varies in the rest of the world between 5% and 7% [7].

Various techniques are used to detect and differentiate skin tumors; these techniques differ in the 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 has been shown that Raman spectroscopy method can differentiate malignant from benign tumors [8]. This technique is based on the detection of protein and amide bonds [9]. In NIR spectroscopy, transmitted or reflected light in the wavelength range of 780−2500 nm is measured. Therefore, it was possible to see the characteristics of molecular changes in the composition and structure of biological tissues such as the skin [10].

Histopathology is the gold standard for definite diagnosis. It is a subjective, invasive and expensive method. The existence of an alternative method

[*] Corresponding author: gorana.nikolic03@gmail.com

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 a novel method for detection and differentiation of skin lesions called Opto-magnetic imaging spectroscopy (OMIS) [11]. This method is based on light-tissue interaction using white and reflected polarized light under Brewster angle.

2. 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 fields perpendicular to each other. Under certain circumstances, these fields can be separated in the process known as the light polarization. Light can be polarized via interaction with a material, when the light is incident to the material at a certain angle.

Light can be polarized under reflection or refraction from a border between two media. If the light beam is incident to a sample made from material of interest under a particular angle, called „Brewster angle“, then the sample will polarize the reflected light. The longitudinal wave of reflected light will only have an electrical component which properties will depend on the electrical state of the surface. However, magnetic component of reflected light will be as transverse wave and will not have a significant effect on sensor (digital camera). Therefore, the electrical properties of the material can be obtained by measuring the reflected light.

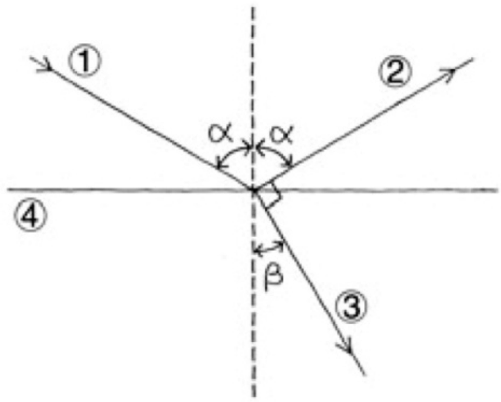

Figure 1. An illustration of the incident (1), reflected (2), and refracted light rays (3) with respect to the boundary between the two media (4). The incident and the reflected angles are denoted as α, while β is the angle of refraction. If α is equal to the Brewster angle, than equality α + β = 90˚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

If the incident light angle is equal to Brewster angle, linear polarization of reflected wave is achieved. Further, the propagation directions of reflected and refracted rays are perpendicular. However, under a 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].

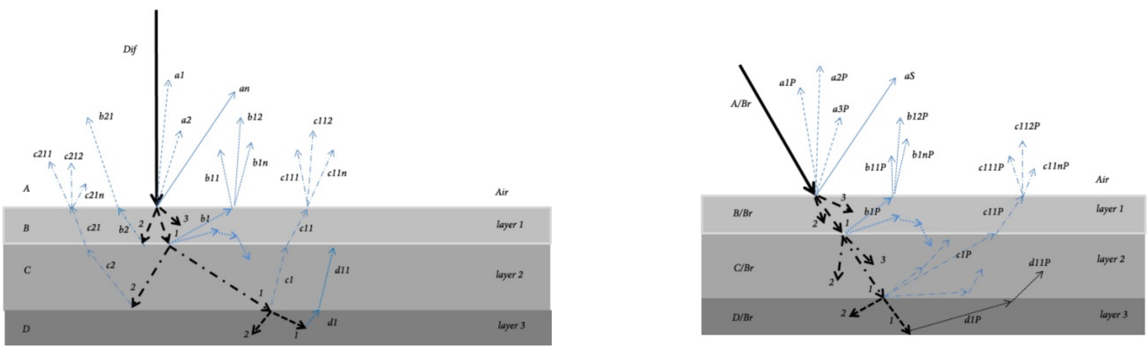

Figure 2. The principle of operation of the opto-magnetic imaging spectroscopy: (left) *An illustration of the incident diffuse light (Dif) perpendicular to sample, reflected diffuse light (a, b, c);* (right) *An illustration of the incident light under Brewster angle (A/Br), reflected polarized light (an P, b1nP, s11nP), and refracted light rays (B2-3; C2-3; D-2) with respect to the boundary between the two media (layers)*

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 Belgrade).

3. MATERIALS

Our study included 65 patients with skin lesion. All these lesions are divided into several groups based on dermoscopic and histopathological criteria. Divided 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 times with both white and polarized light. Then all the pictures were processed with an algorithm especially 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.

4. RESULTS

By applying the OMIS method, diagrams are obtained for each skin change and typical representatives are shown in Figure 3 for two different types of moles, in Figure 4 for two melanoma and in Figure 5 for two typical Basal cell carcinoma (BCC).

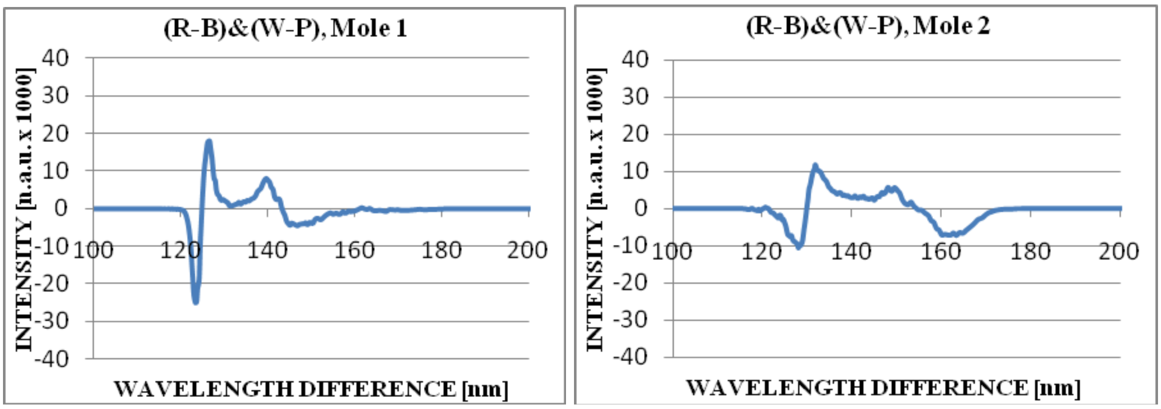

Figure 3. The Opto-magnetic spectra diagrams of the two different samples of moles

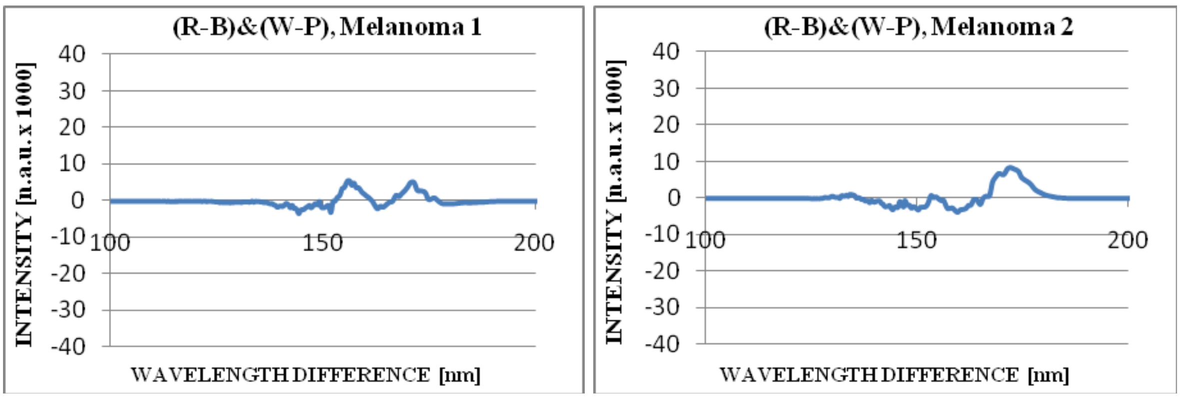

Figure 4. The Opto-magnetic spectra diagrams of the two samples of melanoma

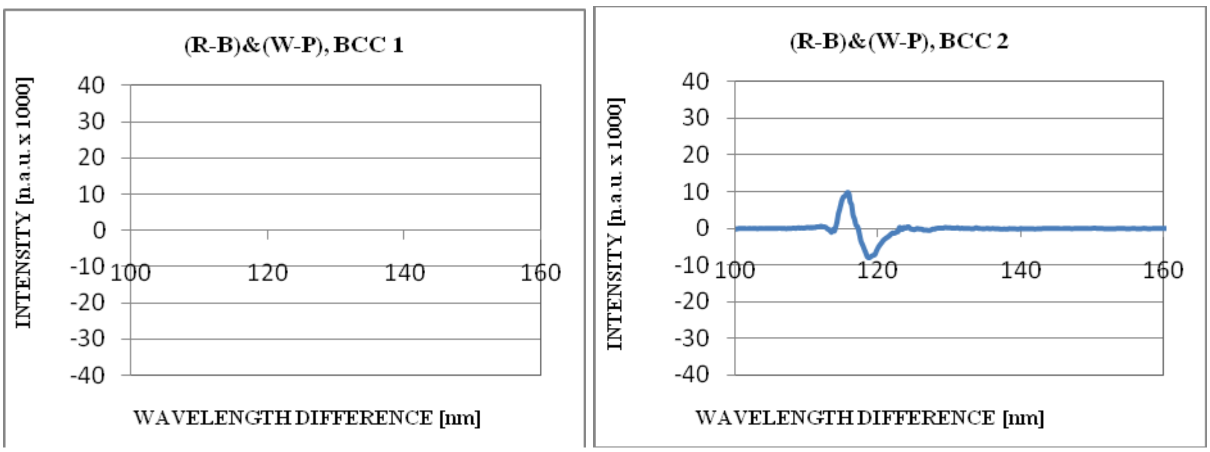

Figure 5. The Opto-magnetic spectra diagrams of the two sample of Basal cell carcinoma (BCC)

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

On the first diagram in Figure 3 the presence of four peaks is observed, 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 four peaks are also present, two positive peaks (131.393/9.80, 146.794/4.30) and two negative (126.106/-7.38, 158.994/-5.34). A reason for small differences in two diagrams lies in 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 three peaks are present too (152.783/0.79, 169.896/6.50, 157.233/-2.72). In case of BCC diagrams, there are differences but with two characteristic 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 a difference in diagrams include different histological structures of bcc, stage of disease, localization etc.

5. CONCLUSION

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

Various techniques are used 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.

Investigations 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 obtained in the sample covering 97% of the patients.

Our study is consistent with the previous results [12−14] and demonstrates that the OMIS method can be one of the diagnostic methods for detection and differentiation of skin lesions.

6. ACKNOWLEGMENT

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КАРАКТЕРИЗАЦИЈА ТУМОРА КОЖЕ ПРИМЈЕНОМ ОПТО-МАГНЕТНЕ ИМИЏИНГ СПЕКТРОСКОПИЈЕ

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 ријетки карциноми као што су карцином Меркелових и Лангерхансових ћелија. Годишњи пораст оболелих од меланома у Србији је 6%, док у свијету 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 свјетлости и ткива. Ова техника мјери разлике у интеракцији коже са бијелом или поларизованом свјетлошћу у случајевима када зрачење пада нормално на кожу или под Брустеровим углом. Иста мјерења се могу извршити и при озрачивању коже плавом и љубичастом свјетлошћу 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.

Кључне ријечи: меланом, OMIS, хистопатологија, дермоскопија.