ORIGINAL ARTICLES

MODERN DIAGNOSTIC TECHNOLOGIES IN ONCODERMATOLOGY

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Abstract

Skin tumors occupy the first place in terms of incidence in the structure of oncological neoplasms. The WHO estimates that 60,000 people die each year from malignant neoplasms of the skin: 48,000 from melanoma and 12,000 from skin cancer. Timely diagnosis of skin cancer makes it possible to achieve a cure for cancer patients with long periods of relapse-free follow-up after the completion of specialized treatment. The introduction of high-tech optical methods for diagnosing skin neoplasms into clinical practice has significantly increased the specificity, sensitivity, and accuracy of diagnostics. The review is devoted to a discussion of such methods for diagnosing skin neoplasms as fluorescent diagnostics, digital dermatoscopy, SIA-scopy, and confocal microscopy. The features of the application of each of the methods are discussed, the results of the most significant Russian and foreign studies in this field are presented, as well as our own results of the practical application of a number of high-tech optical diagnostic methods at the P.A. Herzen Moscow Oncology Research Center.

Keywords: fluorescent diagnostics, digital dermatoscopy, SIA-scopy, confocal microscopy, melanoma, skin cancer.

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СОВРЕМЕННЫЕ ТЕХНОЛОГИИ ДИАГНОСТИКИ В ОНКОДЕРМАТОЛОГИИ

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Резюме

Опухоли кожи занимают первое место по заболеваемости в структуре онкологических новообразований. По оценкам ВОЗ, ежегодно от злокачественных новообразований кожи (ЗНО) умирает 60 000 человек: 48 000 с диагнозом меланома и 12 000 – рак кожи. Своевременная диагностика ЗНО кожи позволяет достигать излечения онкологических больных с длительными сроками безрецидивного наблюдения после завершения специализированного лечения. Внедрение в клиническую практику высокотехнологичных оптических методов диагностики новообразований кожи позволило значительно повысить специфичность, чувствительность и точность диагностики. Обзор посвящен обсуждению таких методов диагностики новообразований кожи, как флуоресцентная диагностика, цифровая дерматоскопия, СИА-скопия, конфокальная микроскопия. Обсуждены особенности применения каждого из методов, приведены результаты наиболее значимых российских и зарубежных исследований в данной области, а также собственные результаты практического применения высокотехнологичных методов диагностики в МНИОИ им. П.А. Герцена.

Ключевые слова: флуоресцентная диагностика, цифровая дерматоскопия, СИА-скопия, конфокальная микроскопия, меланома, рак кожи.

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Introduction

Skin tumors occupy first place among oncological neoplasms: in 2021 in Russia, the share of malignant skin tumors (except melanoma) was 11.8%, the share of melanoma was 2.0%. The incidence of skin cancer and melanoma has increased significantly over the past few decades. Thus, in 2011, 65,675 newly diagnosed cases of malignant skin tumors (except melanoma) and 8,718 newly diagnosed cases of melanoma were registered in Russia. In 2021, these numbers were 68,459 (10-year increase 4.2%) and 11,412 (10-year increase 30.9%), respectively [1]. Globally, 2 to 3 million cases of skin cancer and 132,000 cases of skin melanoma are diagnosed annually. The World Health Organization estimates that 60,000 people die each year due to prolonged sun exposure: 48,000 from melanoma and 12,000 from skin cancer [2].

For any localization of malignant neoplasms (MN), early diagnosis provides opportunities for cure or achieving long survival periods. If skin cancer is suspected, the first specialist to whom patients turn is a dermatologist, or less often an oncologist-dermatologist. Skin examination begins with a clinical examination. In clinical practice, three main algorithms for the clinical diagnosis of pigmented skin tumors are used: the ABCD rule, the 7-point Glasgow system, and the Fitzpatrick scale. The "ABCD" rule for diagnosing skin tumors was proposed in 1985 by R. Friedman [3,4]. It includes the assessment of pigmented skin tumors using 4 parameters: A – asymmetry of the pigment spot; B – border roughness; C – uneven coloring; D – diameter more than 6 mm. The presence of 3 or more signs indicates a malignant tumor. Since 1999, the ABCD rule has additionally introduced parameter E, intended for repeated dynamic monitoring of individuals at risk. Parameter E evaluates the dynamics of changes in color, shape and size of pigmented skin formations. The Fitzpatrick scale [4] includes six signs characteristic for melanoma: shape – rising above the skin level; change in size, acceleration of growth; the borders are irregular, the edges are jagged; asymmetry – one half of the tumor is different from the other; the size is large – the diameter of the tumor usually exceeds 5 mm; coloring is uneven. The Glasgow 7-point system [4], developed by researchers from the University of Glasgow (Scotland) in 1989, includes an assessment of seven signs of a neoplasm by which it can be characterized as malignant, three of which are basic, 4 are additional.

Timely diagnosis of malignant skin tumors with assessment of the exact boundaries and spread of tumor lesions across the skin allows for specialized treatment of patients that is adequate in scope. The primary diagnosis of skin tumors is based on the clinical picture obtained during a visual external examination of the patient. To confirm the diagnosis, various instrumental methods are used. The use of high-tech optical techniques significantly increases the sensitivity and specificity of diagnosis in patients with malignant skin tumors.

Diagnosis of skin tumors using optical instruments

The history of the use of optical instruments for diagnostics goes back more than 300 years. In 1663 J. Ch. Kolhaus was the first to use a microscope to study the blood vessels of the nail bed. In 1879, S. Hueter used a microscope to study in detail the blood capillaries of the lower lip. The next stage in the development of diagnostic microscopy was the creation of stationary models of monocular and binocular microscopes for skin capillaroscopy according to the drawings of O. Muller (1916-1920). In 1920, the results of research work on the diagnostic use of a binocular microdermatoscope were published, and the first hand-held monocular dermatoscope appeared in 1989 [5,6].

Dermatoscopy is still the gold standard for the primary diagnosis of skin neoplasms. The method is widely used, which in most cases allows patients to be timely referred for surgical treatment. However, the effectiveness of the technique depends on the experience of the dermatologist and, in some cases, does not allow correctly recognizing the lesion and making an accurate diagnosis [2]. The most accurate diagnostic method remains a biopsy with histological examination of the biopsy material. However, the widespread use of biopsy to diagnose all suspicious tumors is limited by the complexity and cost of the procedure. The use of optical diagnostic methods makes it possible in many cases to avoid performing unnecessary biopsies and to assess with high accuracy, quickly and simply the presence of signs of a malignant nature of the formation under study [2].

High-tech optical methods for diagnosing skin tumors

Currently, among modern highly effective technologies for diagnosing skin cancer, fluorescence diagnostics, digital dermatoscopy, SIA-scopy, and confocal microscopy are distinguished.

Fluorescence diagnosis (FD) makes it possible to identify non-melanocytic skin tumors and clarify the boundaries of tumor lesions by specific fluorescence that appears in tumor cells after the use of a special compound – a photosensitizer.

Digital dermatoscopy allows automatic mapping of the patient's body, creating a series of photographs that are then analyzed by artificial intelligence (AI).

Spectrophotometry (SIA-scopy) is a non-invasive method for examining the skin, helping to carry out differential diagnosis of melanocytic skin neoplasms.

Confocal microscopy is a type of light optical microscopy with increased optical resolution and microphoto contrast.

Fluorescence diagnostics

FD is a method for diagnosing non-melanocytic skin tumors, which makes it possible to identify clinically undetectable foci of skin cancer and clarify the boundaries of the spread of the tumor process. For fluorescence diagnosis, drugs based on 5-aminolevulinic acid (5-ALA) and its esters are most often used [7]. The high specificity and sensitivity of FD in relation to tumor and pretumor pathology of the skin, its clarity, ease of examination and interpretation of results have been confirmed by numerous studies (Table 1).

As can be seen from the data presented in Table. 1, FD has high specificity and sensitivity for many tumors: BCC, squamous cell skin cancer, actinic keratosis, extramammary Paget's cancer, etc. Most often, drugs based on 5-ALA and its esters are used for FD of skin tumors.

In the P.A. Herzen Moscow Oncology Research Center an FD method with 5-ALA in patients with skin cancer of various locations was developed, including visual assessment of fluorescence and local fluorescence spectroscopy. The distribution of 5-ALA-induced protoporphyrin IX after oral administration of the drug was studied by local fluorescence spectroscopy; The values of spectral-fluorescence diagnostic parameters characterizing foci of cancer and benign skin tumors were determined. Using the developed medical technologies, 237 skin cancer patients were examined (507 lesions). FD allowed to clarify the boundaries of tumor skin lesions in 100% of cases, which influenced the choice of resection boundaries during surgical treatment or the planning of radiation fields during PDT. In 64 (27.0%) of 237 patients, occult foci of skin cancer were diagnosed. The sensitivity of the method was 100%, specificity 61.5%, diagnostic accuracy 67.8%. Adverse reactions (skin phototoxicity) were noted in only 1 (0.04%) patient.

Conducted at P.A. Herzen Moscow Oncology Research Center research has shown that FD with 5-ALA is an effective method for clarifying the boundaries of skin cancer when planning specialized antitumor treatment. This method makes it possible to effectively identify hidden foci of cancer, especially in the group of patients with multiple tumor lesions of the skin against the background of multiple focal lesions of an unspecified morphological structure, and at the same time it is a safe research method (Fig. 1). FD with 5-ALA is indicated for patients before specialized antitumor treatment, mainly in the group of patients with head and neck skin cancer and patients with multiple tumor lesions.

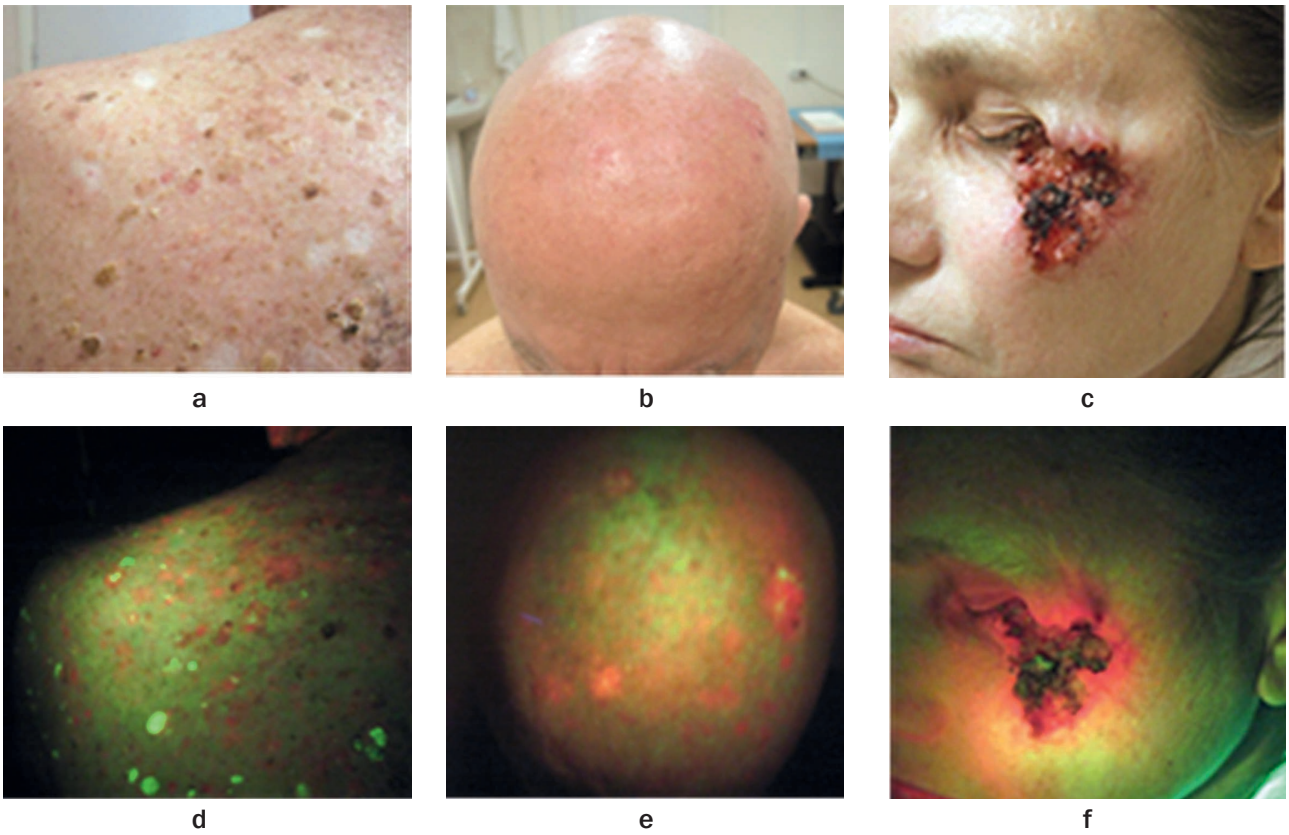


Рис. 1. Осмотр больных раком кожи в белом свете (a – пациент Б., 60 лет; b – пациент Э., 71 год; c – пациент П., 64 года) и в режиме флуоресценции (d – пациент Б., 60 лет; e – пациент Э., 71 год; f – пациент П., 64 года).
Fig. 1. Examination of patients with skin cancer in white light (a – patient B., 60 years old; b – patient E., 71 years old; c – patient P., 64 years old) and in fluorescence mode (d – patient B., 60 years old; e – patient E., 71 years old; f – patient P., 64 years old).

Таблица 1
Эффективность флуоресцентной диагностики у пациентов с немеланоцитарными опухолями кожи
Table 1
Efficiency of fluorescence diagnostics in patients with non-melanocytic skin tumors

	Авторы Authors	Число пациентов Number of Patients	Диагноз Diagnosis	Фотосенсибилизатор Photosensitizer	Результаты Results
1	Won et al., 2007 [8]	10	БКРК BCC	МЭ-АЛК 20% мазь MAL 20% ointment	Чувствительность – 82,6% Специфичность – 94,1% Sensitivity – 82.6% Specificity – 94.1%
2	Smits et al., 2007 [9]	14	86 очагов, в том числе 3 ПКРК, 67 актинический кератоз (32 KIN I, 18 KIN II, 17 KIN III), 10 нормальная кожа 86 lesions, including 3 SCC, 67 actinic keratosis (32 KIN I, 18 KIN II, 17 KIN III), 10 normal skin	5-АЛК 20% мазь 5-ALA 20% ointment	В исследовании показано отсутствие значимой разницы в показателях интенсивности флуоресценции между различными стадиями актинического кератоза. У большинства пациентов с болезнью Боуэна флуоресцентная контрастность была выше, чем у пациентов с актиническим кератозом в стадиях KIN I и KIN I The study shows no significant difference in fluorescence intensity between different stages of actinic keratosis. Most patients with Bowen's disease had higher fluorescence contrast than patients with actinic keratosis in stages KIN I and KIN I
3	Neus et al., 2008 [10]	28	БКРК BCC	5-АЛК 20% мазь 5-ALA 20% ointment	Чувствительность – 79% Специфичность – 100% Sensitivity – 79% Specificity – 100%
4	Van der Beek et al., 2012 [11]	30	БКРК Актинический кератоз BCC Actinic keratosis	5-АЛК 5-ALA	Показано преимущество использования для диагностики нормированной флуоресценции по сравнению с ненормированной флуоресценцией: специфичность и чувствительность при оценке нормированной флуоресценции составили 100% и 97% по сравнению с 27% и 39% The advantage of normalized fluorescence for diagnosis compared to non-normalized fluorescence is shown: specificity and sensitivity when assessing normalized fluorescence are 100% and 97% compared to 27% and 39%, respectively
5	Andrade et al., 2014 [12]	43	54 очагов (21 БКРК, 22 актинический кератоз, 11 себорейный кератоз) 54 lesions (21 BCC, 22 actinic keratosis, 11 seborrheic keratosis)	5-АЛК 5% раствор 5-ALA 5% solution	В очагах БКРК отмечено достоверное увеличение интенсивности флуоресценции в 3 раза через 1 час после нанесения раствора 5-АЛК. В очагах актинического и себорейного кератоза интенсивность флуоресценции в течение 1 ч после нанесения раствора 5-АЛК оставалась на уровне аутофлуоресценции In the lesions of BCC, a significant increase in fluorescence intensity by 3 times is noted 1 hour after application of the 5-ALA solution. In the foci of actinic and seborrheic keratosis, the fluorescence intensity remains at the autofluorescence level for 1 hour after application of the 5-ALA solution
6	Filonenko et al., 2015 [13]	227	БКРК, ПКРК, метатипический рак кожи BCC, SCC, metatypical skin cancer	5-АЛК 20% раствор для приема внутрь 5-ALA 20% oral solution	Чувствительность – 100,0% Специфичность – 55,6% Sensitivity – 100.0% Specificity – 55.6%
7	Wu et al., 2021 [14]	36	ВМРП EMPC	5-АЛК 20% раствор 5-ALA 20% solution	Визуальный осмотр – 63,8% ложноотрицательных результатов, ФД – 35,4% ложноотрицательных результатов, ФД + конфокальная микроскопия – 20,8% ложноотрицательных результатов By visual examination – 63.8% false negative results, FD – 35.4% false negative results, FD + confocal microscopy – 20.8% false negative results

МЭ-АЛК – метиловый эфир 5-аминолевулиновой кислоты, БКРК – базальноклеточный рак кожи, ПКРК – плоскоклеточный рак кожи, ВМРП – внемаммарный рак Педжета
MAL – methyl ester of 5-aminolevulinic acid, BCC – basal cell carcinoma, SCC – squamous cell carcinoma, EMPC – extramammary Paget's cancer

Digital dermatoscopy

Dermatoscopy using AI allows for photographic recording with an expert assessment of the condition of dermoscopic structures. AI based on a convolutional neural network is actively used in modern medicine for image recognition. In dermato-oncology, ultra-precise deep learning neural networks are used to recognize images obtained using a digital dermatoscope [15]. Numerous studies demonstrate the high effectiveness of digital dermatoscopy (Table 2).

The sensitivity and specificity of digital dermatoscopy varies significantly, as can be seen from the Table. 2. The sensitivity of the method is quite high regardless of the device used: up to 97.1%. The specificity for skin melanoma with the Melafind® dermatoscope (USA) is generally significantly lower (5.4-9.9%) than for FotoFinder® (Germany) (76.7-95.3%).

The authors [21], who used MelaFind, explain these results of the specificity of the method by the fact that it is intended for use in lesions with 1 or more clinical signs of melanoma, i.e. for any atypical lesions. If all atypical lesions were biopsied to rule out melanoma, the biopsy yield ratio (the number of false-positive biopsies per true-positive study) of approximately 200:1 would be very high. In a study [21], the biopsy ratio for MelaFind was 10.8:1 for melanomas and 7.6:1 for melanomas and borderline neoplasms. Moreover, the specificity of digital dermatoscopy with MelaFind exceeded the specificity of routine medical examination of patients in the same study (3.7%).

The authors also note that the rather low specificity of routine testing and MelaFind in this clinical trial does not mean that the specificity of clinician testing and MelaFind will be low in the general population. This is simply a reflection of the fact that almost all of the lesions in this study were atypical enough to be selected for biopsy to rule out malignant melanoma.

In P.A. Herzen Moscow Oncology Research Center a technique for digital dermatoscopy of skin tumors was introduced. We present two clinical examples demonstrating the effectiveness of this approach to the diagnosis of skin melanoma.

Clinical observation 1

Patient D., 66 years old, has been under observation for 5 years for breast cancer. During a follow-up

Таблица 2
Эффективность цифровой дерматоскопии меланомы кожи
Table 2
Effectiveness of digital dermatoscopy for skin melanoma

	Автор Authors	Количество образований Number of Neoplasmes	Используемый прибор Device	Результаты Results
1	MacLellan et al., 2020 [16]	209	FotoFinder® (Германия/Germany) Melafind® (США/USA) Verisante AuraTM (Канада/Canada)	Чувствительность и специфичность: MelaFind® 82,5% и 5,4%, соответственно Verisante Aura TM 21,4% и 86,2%, соответственно FotoFinder® 88,1% и 78,8%, соответственно Sensitivity and specificity: MelaFind® 82.5% and 5.4%, respectively Verisante Aura TM 21.4% and 86.2%, respectively FotoFinder® 88.1% and 78.8%, respectively
2	Sies et al., 2020 [17]	1981	FotoFinder® (Германия/Germany)	Чувствительность – 77,6% Специфичность – 95,3% Sensitivity – 77.6% Specificity – 95.3%
3	Fink et al., 2020 [18]	72	FotoFinder® (Германия/Germany)	Чувствительность – 97,1% Специфичность – 78,8% Sensitivity – 97.1% Specificity – 78.8%
4	Fujisawa et al., 2019 [19]	1142	GoogLeNet DCNN model	Чувствительность – 96,3% Специфичность – 89,5% Sensitivity – 96.3% Specificity – 89.5%
5	Haenssle et al., 2019 [20]	100	FotoFinder® (Германия/Germany)	Чувствительность – 95% Специфичность – 76,7% Sensitivity – 95% Specificity – 76.7%
6	Monheit et al.,2011 [21]	1632	Melafind® (США/USA)	Чувствительность – 95,6% Специфичность – 9,9% Sensitivity – 95.6% Specificity – 9.9%

examination, the oncologist identified a suspicious pigmented formation on the skin of the right cheek. According to the patient, the formation has been noted for a long time and has no complaints. The patient underwent digital dermatoscopy (Fig. 2). Automatic AI score – 0.88. According to the histological report performed after an excisional biopsy, epithelial pigment cell, nonulcerated lentigo melanoma *in situ* with moderate subepithelial lymphoid plasma cell infiltration was diagnosed (Fig. 3). The patient was diagnosed with stage 0 melanoma pTisN0M0 of the skin of the right cheek.

Clinical observation 2

Patient V., 60 years old, noted the presence of a pigmented formation on the skin of the back for a long time. Over the past three weeks noticed a change in the color of the neoplasm and felt discomfort in the area of the tumor, thus independently consulted an oncologist. The patient underwent digital dermatoscopy (Fig. 4). Automatic AI assessment – 0.9-1.0. According to the histological conclusion a superficial spreading pigment epithelial cell melanoma in the horizontal growth phase was revealed, Clark level II invasion, Breslow thickness less than 0.5 mm, resection margins intact (Fig. 5). The patient was diagnosed with IA stage pT1aN0M0 skin melanoma of the back.

Spectrophotometry (SIA-scopy)

SIA-scopy is a method for diagnosing skin tumors, which is based on the analysis of a spectrophotometric intradermal image. SIA-scopy allows to assess the state of dermal collagen, the severity of blood flow in the papillary layer of the dermis, and diagnose the level of localization of dermal and epidermal melanin [22]. The use of SIA-scopy demonstrates high sensitivity and specificity for skin tumors (Table 3).

As can be seen from the Table. 3, the sensitivity of SIA-scopy ranges from 66.6-100%. Only one study obtained abnormally low results for assessing the sensitivity of the technique – 24% [27]. The authors concluded that diagnosis based on SIA-scopy has low diagnostic accuracy for melanoma, individual signs of SIA-scopy do not provide reliable diagnostic information regarding the internal structure of lesions during histopathological examination, and SIA-scopy cannot be used as a guide

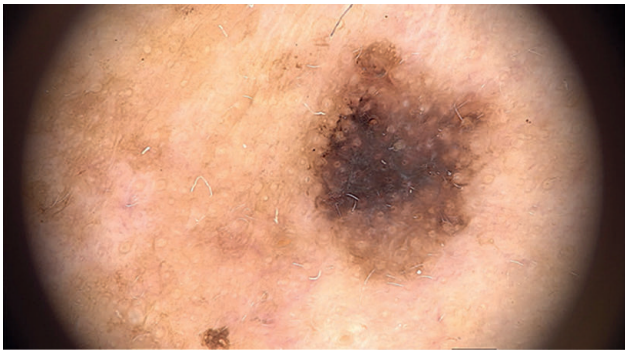


Рис. 2. Результаты цифровой дерматокскопии меланомы кожи правой щеки (FotoFinder®, Германия).
Fig. 2. Results of digital dermatoscopy of melanoma of the skin of the right cheek (FotoFinder®, Germany).

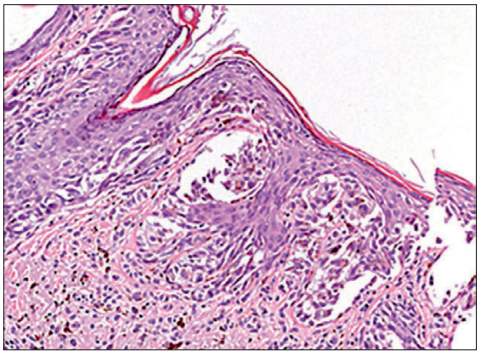


Рис. 3. Гистологическое исследование меланомы кожи правой щеки.
Fig. 3. Histological examination of melanoma of the skin of the right cheek.

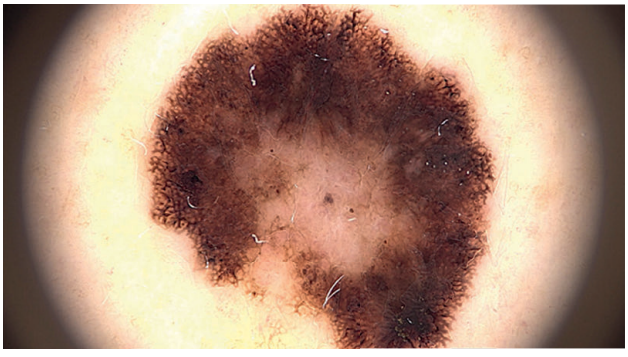


Рис. 4. Результаты цифровой дерматокскопии меланомы кожи спины (FotoFinder®, Германия).
Fig. 4. Results of digital dermatoscopy of melanoma of the skin of the back (FotoFinder®, Germany).

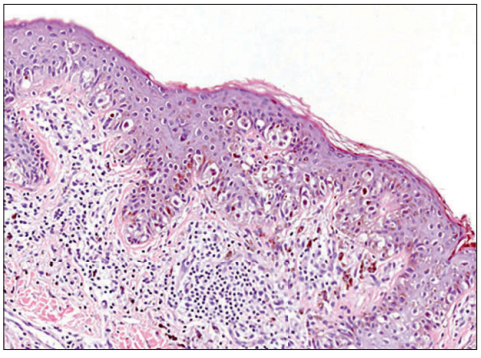


Рис. 5. Гистологическое исследование меланомы кожи спины.
Fig. 5. Histological examination of melanoma of the skin of the back.

Таблица 3
Эффективность СИА-скопии
Table 3
Efficiency of SIA-scopy

	Автор Authors	Количество образований Number of Neoplasmes	Используемый прибор Device	Результаты Results
1	Moncrieff et al., 2002 [22]	348 пигментированных образований кожи (включая 52 меланомы) 348 pigmented skin lesions (including 52 melanomas)	SIAscope (Великобритания Great Britain)	Чувствительность – 82,7% Специфичность – 80,1% Sensitivity – 82.7% Specificity – 80.1%
2	Haniffa et al., 2007 [23]	881 пигментное образование (включая 31 меланому) 881 pigmented lesions (including 31 melanomas)	1. Дерматоскоп 2. SIAscope (Великобритания/ Great Britain)	Добавление СИА-скопии не изменило показатели чувствительности и специфичности дерматоскопии – 94% и 91%, соответственно The addition of SIA-scopy did not change the sensitivity and specificity of dermatoscopy – 94% and 91%, respectively
3	Carrara et al., 2007 [24]	1966 (287 меланом) 1966 (287 melanomas)	SIAscope (Великобритания/ Great Britain)	Чувствительность – 88% Специфичность – 80,0% Sensitivity – 88% Specificity – 80.0%
4	Ascierto et al., 2010 [25]	54	Spectroshade® (Италия/Italy)	Чувствительность – 66,6% Специфичность – 76,2% Sensitivity – 66.6% Specificity – 76.2%
5	Glud et al., 2009 [26]	83	SIAscope (Великобритания/ Great Britain)	Чувствительность – 100% Специфичность – 59% Sensitivity – 100% Specificity – 59%
6	Terstappen et al., 2013 [27]	60 (42 меланомы, включая 13 in situ) 60 (42 melanomas, including 13 in situ)	SIAscope (Великобритания/ Great Britain)	Чувствительность – 24% Специфичность – 84% Sensitivity – 24% Specificity – 84%
7	Sgouros et al., 2014 [28]	188 (18 меланом) 188 (18 melanomas)	SIAscope (Великобритания/ Great Britain)	Чувствительность – 85,7% Специфичность – 65,4% Sensitivity – 85.7% Specificity – 65.4%

to determine the maximum tumor thickness during histopathological examination.

In all other studies, the authors emphasize the high diagnostic value of SIA-scopy. Probably, an important role in the correct interpretation of the results of SIA-scopy is played by the proven methodology and algorithms for evaluating SIA-scans. Therefore, at the P.A. Herzen Moscow Oncology Research Center a work that made it possible to develop the semiotics of SIA-scopic images was carried out, which significantly increased the efficiency of using this method.

Using a developed SIA-scopy algorithm 327 pigmented skin formations in 147 patients were analyzed. The study results were assessed by comparing data from spectrophotometric analysis with data from routine histological examination of 327 lesions. The semiotics of the spectrophotometric image was determined and a working classification for assessing the spectrophotometric image for 2, 3, 4, 5 SIA scans was developed.

Significant criteria for the malignancy of pigmented neoplasms were determined using the spectrophotometric analysis technique, which made it possible to non-invasively diagnose skin melanoma with sensitivity – 96%, specificity – 100%, and diagnostic accuracy – 99%. The most informative SIA scans in the non-invasive diagnosis of melanoma have been identified, characterizing the amount of melanin in the papillary layer of the dermis, and the state of blood vessels and collagen fibers: SIA scans 3, 4, 5 (Fig. 6).

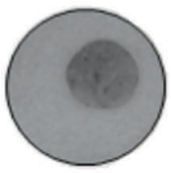
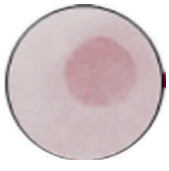
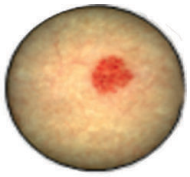
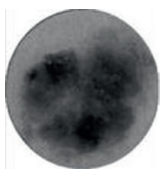
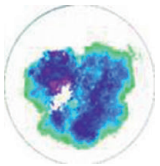
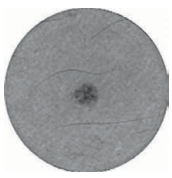
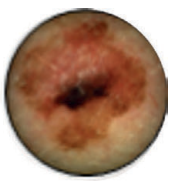
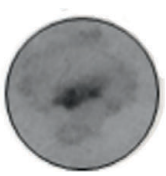
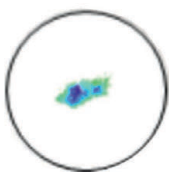
Диагноз Diagnostic	СИА-скопические изображения SIA-scopic images				
	СИА-1 SIA-1	СИА-2 SIA-2	СИА-3 SIA-3	СИА-4 SIA-4	СИА-5 SIA-5
Кератома Keratoma					
Гемангиома Hemangioma					
Меланома Melanoma					
Невус Nevus					
Меланома in situ Melanoma in situ					

Рис. 6. СИАскопические изображения.
Fig. 6. SIAscopic images.

Confocal microscopy

Confocal microscopy (confocal laser scanning microscopy) is a type of optical light microscopy. It allows to increase the optical resolution and contrast of a microphotography by using a pinhole diaphragm to block out-of-focus light or glare during image formation. The advantages of confocal microscopy also include the ability to obtain a series of sequential optical sections from thick samples, the thickness of which exceeds the immediate plane of focus, and then reconstruct a three-dimensional image of the sample from these series [29,30].

Confocal microscopy is carried out in two modes: reflective (the highest signal intensity usually occurs during the transition between air and the surface of the sample; more suitable for visualizing the topography of surfaces) and fluorescent (allows to visualize not only the general structure of the skin, but also individual target molecules in skin cells) [29].

A number of studies demonstrate the high efficiency of using both modes of confocal microscopy in clinical practice for the diagnosis of skin tumors (Table 4).

Confocal microscopy shows sensitivity and specificity comparable to other high-tech optical methods for diagnosing skin tumors, up to 100% and 95%, respectively. At the same time, the specificity for pigmented melanoma was slightly lower than for other neoplasms – 65%.

Conclusion

Thus, the diagnosis of skin tumors with high-tech optical techniques allows for primary and clarifying

Таблица 4
Эффективность конфокальной микроскопии
Table 4
The efficiency of confocal microscopy

	Автор Author	Количество образований Number of formations	Режим Mode	Результаты Results
1	Guitera et al., 2009 [30]	Меланома, невус >300 Melanoma, nevus >300	Отражательная конфокальная микроскопия Reflectance confocal microscopy	Пигментированная меланома: Специфичность – 65% Чувствительность – 92% Беспигментная меланома Специфичность – 84% Чувствительность – 85% Pigmented melanoma: Specificity – 65% Sensitivity – 92% Amelanotic melanoma Specificity – 84% Sensitivity – 85%
2	Guitera et al., 2012 [31]	Меланома, БКРК, невус, пигментированные пятна на лице, другие опухоли >700 Melanoma, BCC, nevus, pigmented spot on face, others tumors >700	Отражательная конфокальная микроскопия Reflectance confocal microscopy	Специфичность – 88,5% Чувствительность – 100% Specificity – 88.5% Sensitivity – 100%
3	Segura et al., 2012 [32]	Меланома, БКРК, ПКРК, кератоз, невус >150 Melanoma, BCC, SCCC, keratosis, nevus >150	Отражательная конфокальная микроскопия Reflectance confocal microscopy	Специфичность – 95,3% Чувствительность – 86,1% Specificity – 95.3% Sensitivity – 86.1%
4	Horn et al., 2008 [33]	Актинический кератоз, здоровая кожа с высоким риском развития новообразований 30 Actinic keratosis, healthy skin with a high risk of developing tumors 30	Отражательная конфокальная микроскопия Reflectance confocal microscopy	Специфичность – 88,3% Чувствительность – 93,3% Specificity – 88.3% Sensitivity – 93.3%
5	Gareau et al., 2009 [34]	БКРК, здоровая кожа >40 BKRK, healthy skin >40	Флуоресцентная конфокальная микроскопия Fluorescence confocal microscopy	Специфичность – 89,2% Чувствительность – 96,6% Specificity – 89.2% Sensitivity – 96.6%

diagnosis of skin cancer with high efficiency. Depending on the medical technology used, it is possible to perform early diagnosis of latent foci of malignant neoplasms of melanocytic and non-melanocytic nature, assess the extent and boundaries of the tumor along the surface of the skin in non-melanocytic tumors, as well as remote consultation of clinical observations using telemedicine technologies.

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