Complex application of fluorescence imaging and digital diaphanoscopy methods for screening pathological conditions of the oral mucosa and the maxillary sinus tissues

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ABSTRACT

Worldwide, 600 thousand cases of malignant neoplasms of the oral mucosa (for example, squamous cell carcinoma) are observed annually, which develop due to untimely diagnosis of potentially malignant diseases (precancerous). There is a high correlation between the development of oral mucosa and maxillary sinus pathologies due to the close proximity of tissues.

It is known that the development of oral mucosa lesions is characterized by changes in the endogenous fluorophores' concentration [1]. Preliminary experimental studies have shown that the FAD signal makes the greatest contribution to the formation of the high level of autofluorescence intensity observed in pathology in the blue-green spectrum [2]. At the same time, for diagnostic purposes, it is very important to know which flavin proteins format such a signal. For this purpose, we performed studies on human skin fibroblasts, as well as primary neuron-glial culture using a Zeiss LSM 900 laser scanning confocal microscope (excitation wavelength – 488 nm, autofluorescence registration – 505-550 nm). It was revealed that cell cultures with metabolic disorders had a high intensity of FAD autofluorescence compared with healthy cells due to overactivation of complex II of mitochondrial ETC and the activity of monoamine oxidase. At the same time, death of high-intensity cells was observed only after 24 hours. The results obtained showed the prospects of using the fluorescence imaging method to diagnose oral mucosa pathologies. In this connection, the high level intensity of FAD can be a marker of a precancerous condition, and the low level intensity of FAD – a marker of the beginning of the process of cell degeneration into tumor (malignancy process) [3].

To diagnose the condition of maxillary sinus tissues, a digital diaphanoscopy technology was previously developed, including an LED applicator for probing maxillary sinus tissues (650 and 850 nm), a CMOS camera for recording diaphanograms and software. The software based on the classification model allows to detect the presence of pathology with sensitivity of 0.88 and specificity of 0.98 [4,5]. An upgrade of the digital diaphanoscopy device with the addition of fluorescent imaging channel is proposed. That channel includes microLEDs in the blue spectrum (450 nm, 0.5 mW) to excite FAD in the oral mucosa and a microcamera for autofluorescence visualization. The use of convolutional neural networks will allow binary classification of the oral mucosa condition into classes of presence or absence of pathology, and differentiate various maxillary sinus pathologies. Thus, the probability of a false negative diagnosis will be reduced and diagnostic effectiveness will be increased.

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