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# Simulation of the effect of purulent content of the maxillary sinuses on the transillumination signal

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## ABSTRACT

In this paper the optical properties of the purulent content of the maxillary sinuses were obtained by spectrophotometry. Based on the obtained absorption and reduced scattering coefficients, a numerical simulation by Monte Carlo method was performed to determine the pattern of light scattering passing through the maxillary sinus with purulent contents. The results of the simulation showed that in transillumination methods for the detection of purulent pathological changes, it is more informative to use the radiation sources with 980 nm.

**Keywords:** optical diagnostics, diaphanoscopy, spectrophotometry, maxillary sinuses, inflammatory diseases, purulent sinusitis, optical properties, Monte Carlo simulation.

## 1. INTRODUCTION

Nowadays, optical diagnostic methods are increasingly used in medicine due to their portability, cost-effectiveness and non-invasiveness. Although the use of optical radiation in comparison with x-ray radiation is tools to determine tissue structure only conditionally, at the same time, optical methods based on tissue transmission in the visible and infrared spectral ranges do not have a radiation exposure, which makes it possible to reconduct studies, as well as conduct rapid screening diagnostics.

One of these methods is digital diaphanoscopy (or transillumination) of the maxillary sinuses<sup>1-4</sup>. This method has a long history of usage<sup>4,5</sup>, especially in ophthalmology<sup>6</sup> and urology<sup>7</sup>. The previously conducted studies of pathological changes in the maxillary sinuses by digital diaphanoscopy<sup>1,2</sup> have shown that the diagnostic results are determined primarily by the optical properties of the studied area and their changes in various anatomical and gender characteristics of patients, as well as by the presence of various pathologies (cyst, tumor tissue). To clarify the magnitude of signal attenuation during its passage through the sinus with pathology, a numerical simulation by the Monte Carlo (MC) method was previously performed. Note, as optical characteristics of the cystic fluid of the maxillary sinuses, the characteristics of the cystic fluid of the breast tissues were used, while modeling for the case of purulent sinusitis was not carried out<sup>2,8</sup>.

The aim of this work was to refine the optical characteristics of a pathological changes (purulent sinusitis) by spectrophotometry and numerical simulation of the study area, taking into account the registered optical characteristics.

## 2. MATERIAL AND METHODS

Numerical simulation by the MC method is associated with the identification of the optical characteristics of biological tissues used in the model, in particular, the absorption and scattering coefficients. To achieve the work aim, namely, to determine the optical characteristics of the purulent contents of the maxillary sinuses, measurements were made using the Shimadzu UV 2600 spectrophotometer (Japan) with an integral sphere module for wavelengths of 400-1200 nm with a step of 1 nm. The absorption and reduced scattering coefficients were calculated by the “addition-doubling” method.

The refined numerical simulation was performed by the MC method in the TracePro software environment (Lambda Software) using the obtained coefficients for the case of the presence of pus in the sinus. This method is one of the most effective simulation tools when dealing with biological tissues<sup>9,10</sup>. At the same time, the size of the sinuses and the thickness of the biological layers were averaged within the same sex and age, since these values can vary greatly depending on these two factors<sup>11-17</sup>. Additionally, the optical characteristics corresponded to the characteristics selected in the previous simulation<sup>2,8</sup>.

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