Optical methods of medical diagnosis. Spectroscopic evidence of the photostability of life. Breast tissue diagnostic by Raman spectroscopy

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The optical medical diagnostics based on optical spectroscopy and optical imaging are in the early stage of development in comparison with the traditional clinical spectroscopic and imaging methods such as PET (Positron emission tomography), MRI (Magnetic Resonance Imaging), or CT (computed tomography) and routine imaging tool used to screen for breast cancer such as mammography or ultrasound imaging.

Optical methods, including the methods of laser-induced fluorescence, Raman spectroscopy, and mid-IR spectroscopy, offer several significant advantages over the above mentioned clinical spectroscopic and imaging methods, including: a) non-invasiveness through the use of safe, non-ionising radiation, b) display of contrast between soft tissues based on optical properties, c) a facility for continuous bedside monitoring. Among the optical methods of diagnostics Raman spectroscopy seems to be potentially the most important due to the following reasons:

1. extremely high spatial resolution is possible for optical imaging
2. Raman spectra and autofluorescence of the sample can be directly probed
3. Catheter-based microtransducer advancements and optically fiber coupled spectrometers are extending the modality's reach intraluminally
4. A new generation of activatable fluorescent contrast agents is extending its reach into Raman optical imaging enabling target detection with fluorescence down to the \(10^{-8}\) molar concentration level.
5. Providing novel imaging protocols that paired with contrast enhancing probes active in Raman spectroscopy can monitor report gene expression
6. Raman spectroscopy provides direct biochemical information (vibrational fingerprint)
7. Raman spectroscopy can monitor biological tissue without any contrast agents.
because display of contrast between soft tissues is based on Raman cross section scattering properties

8 Resonance Raman effect may amplify the probe's signal to the point that it can be detected. It is especially important to identify specific gene products and intracellular processes. Minimizing the size and the concentration of probe molecules is essential, because they must overcome biocompatibility, vascular, interstitial, and cell membrane barriers to deliver the imaging probes to their molecular target. The typical concentrations are micro- or picomolar levels. Because so small concentrations are involved, novel strategies must be created to amplify the probe's signal to the point that it can be detected. Resonance Raman spectroscopy seems to be one of the best modern strategies.

9 Carefully chosen Raman and fluorescence contrast agents may identify specific gene products and intracellular processes, both those requiring the probe to cross cell membranes to access the enzyme target and those that monitor how reporter genes works by encoding cell surface proteins or receptors.

10 Raman polarization methods provides the tool for visualization of various structures and pathology loci in tissue. This results from the fact that the laser beam of different polarizations propagates in tissues differently.

The most important feature of Raman spectra is that they act as a very sensitive biochemical marker through the unique vibrational fingerprint spectra. This statement is based on the understanding that disease pathology is always related to biochemistry, consequently biochemistry will become much more important to general medical diagnostic than they are today. The current research focuses on examination of Raman markers – the characteristic Raman peaks and the autofluorescence of the breast tissue sample that can be useful for the preclinical and clinical in vivo breast tissue applications.

To the best of our knowledge, the results obtained in our laboratory are the most statistically reliable reports (400 spectra from 70 patients) on Raman spectroscopy-based diagnosis of breast cancers among the world women population. The results clearly illustrate good discrimination of the normal and the pathological breast tissue as well as the ability of Raman spectroscopy to accurately diagnose the breast cancer.