Medical Diagnosis by Infrared Spectral Cytopathology (SCP)

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Over the past 5 years, more than a quarter million infrared spectra of individual exfoliated human cells have been collected. The origin of these cells was the urinary tract, the cervix, the esophagus and the oral and nasopharyngeal cavities. The overall aim of this research was to establish SCP as a more accurate and reliable method for medical diagnosis of exfoliated cells and as an early indicator of disease, especially cancer. In particular, the influence of factors such as cell morphology, fixation procedures, hormonal variations, and life-style factors (smoking, alcohol and over-the-counter medication) on the cellular spectra was investigated. The largest of these studies, the screening for oral disease, enrolled 120 subjects, about 25 clinical cases and 95 volunteers recruited on-campus.

All data acquisition was carried out by imaging a sparse monolayer of cells, created by liquid-based cytological methods, by infrared imaging spectrometers (Perkin-Elmer Spotlight 400) and reconstructing cellular spectra from pixel spectra by a method referred to as the PapMap^{P} algorithm [1]. All cellular spectra were signal-enhanced using the NA-PCA method [2] and water-vapor corrected by an MSC algorithm [3]; finally, dispersive line shapes due to sample morphology was accounted for by phase correction [4].

The overall results from these studies can be summarized as follows. (1) Fixation of exfoliated cells by methods used in classical cytopathology produces very small, but consistent spectral changes that do not confound the analysis as long as the fixation method is consistent. (2) Squamous and columnar cells do exhibit small spectral changes. (3) Cancerous cells exhibit quite distinctly different spectra from normal cells; dysplastic cells may exhibit spectral patterns in-between those of normal and cancerous cells. (4) The majority of morphologically normal cells from sampled diagnosed as abnormal by classical cytopathology exhibit spectral patterns that are already slightly abnormal. This observation was first reported in the late 1990s [5] and confirmed in both Raman and IR spectroscopy. These spectral changes are referred to as “malignancy associated changes” or “field cancerization”, but may also have viral origin.

This last result holds a strong promise for the early detection of disease by spectral methods: whereas in classical histopathology, less than 1 % of cells show abnormal morphology in a sample from a patient with disease, the majority of cells show abnormality by SCP methods. Thus, a more sensitive and less subjective test procedure can be designed based on SCP.

References:

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