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Raman Spectroscopy: A Powerful Medical Diagnostic Tool for Early Assessment Of Cancer

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ABSTRACT:

Cancer is the leading cause of death with the highest incidence rates occurring in the most developed regions of the world. According to the World Health Organization, cancer is responsible for one in six deaths, which makes it the second most common cause of death globally. Affecting people of all ages, cancer cuts through society, causing suffering on a global scale. Early detection of cancer through a non-invasive technique is still a big challenge for the entire world. Raman spectroscopy is a powerful non-invasive method to detect quantitative molecular information of any biological specimen such as bio fluids, cells and tissues.

INTRODUCTION:

Till now, most cancers are diagnosed by biopsy followed by histopathological examination which is an invasive, time consuming and expensive technique. Also the histopathological examination has a major drawback which is interobserver variation that leads to confusion and controversy thus delaying diagnosis and treatment **[1].** Mounted section examination to assess the morphological changes in tissue never dictates the levels of lesions/tumours or assertively diagnose the pre-cancerous changes. Also in many tissues that inherently possess a complex structure as that of breast tissue, which is consequently heterogeneous, the cancerous areas are often difficult to identify with certainty **[2]**. Consecutively a non-invasive method that studies the tissue in its entirety without requirement of tissue removal, is safe, less time consuming and pocket friendly would be ideal and is the need of the hour. One such technique that seems to fit the bill is Raman Spectroscopy in combination with IR probe, which may prove to be advantageous over these traditional routine clinical techniques.

THE THEORY:

Raman spectroscopy if complimented with an imaging technique using contact fibre optic probe with IR could be used as non-invasive technique to detect cancer cells with accuracy. For stimulation of biomolecules optic cables could be connected to infrared laser beam which is further governed by software to elucidate the Raman scattering signals in computers attached. When the probe will be held against tissue under investigation it will measure the Raman scattered signals which would be compared with pre-standardised Raman signals (graphs) from the normal tissues.

EVALUATION OF THE THEORY:

Every molecule is composed of atoms bonded together which are in incessant motion (electronic, vibrational, rotational, or translational). Thus the molecule possesses energy which can be used to attain its structural and compositional information via the processes of absorption and scattering of light. When light, with insufficient energy to cause excitation is imposed on a molecule, some light is scattered at frequencies that differ from the incident radiation and is termed inelastic scattering. This inelastic scattering involves a net energy transfer between the incident photons and the material and causes Raman Effect **[3].**It specifically sensitizes the concentrations of bio-molecules such as lipids, proteins, carbohydrates, and nucleic acids with high precision in concern with the alterations in biomolecule configurations e.g., the ratio of protein to lipid within a normal cell or higher nucleic acid concentrations in tumour tissue **[4]**. Significant biochemical changes visualized in Raman Spectra of cells and tissues may detect and dictate the reason of the disease.

EMPERICAL DATA:

In previous studies, Raman spectra exhibited that lipids and carotenoids are reduced in breast carcinomas as compared to breast tissue with benign disease affirming that the key differences between normal and cancer tissues were in spectral regions associated with vibrations of carotenoids, fatty acids and proteins **[5-11]**. In chondrogenic tumours also Raman spectroscopy proved to be effective when subjected to histopathological analysis **[12]**. Review on living brain cancer cells in vitro and in situ, ex vivo tissues and in vivo animal models revealed that the combination of different microscopic and spectroscopic techniques has been important in diagnostics of brain tumours **[13]**.

Raman imaging could also be a milestone in understanding cancer pathogenesis in greater depth. The high accuracy of Raman imaging has received a great deal of attention as a potential diagnostic tool to understand biochemical composition (lipid droplets, mitochondria, cytoplasm, nucleus, or membrane) of cells and tissues without injuring them. The spectral analysis of breast cancer tissues (removed surgically) differs at more than eleven peaks including methyl group vibrations (1378 cm^{-1}) with broader band peaks (2854-2985 cm^{-1}) and intense amide peaks **[14].** But since these techniques use tissue removed surgically they are invasive. Secondly in concern of invasive cancer removal surgery especially in case of brain cancer residual invasive cancer cells often remain undetected during surgery which may lead to recurrence of the disease.

CONSEQUENCES AND DISCUSSION:

It is our contention that these spectroscopic methods can be implemented as it does not require the cell disruption protocols for isolation of DNA, proteins, lipids or organelle from cells or tissues as in case of long practised genomics and proteomics in routine oncology practice and diagnosis and may well be a harbinger of enhanced accuracy, sensitivity and specificity along with reduction in many associated factors viz. cost, TAT ultimately leading to better patient outcome at lesser cost. Thus if we can develop a referral model of Raman Spectral data which can discriminate between normal, benign and malignant tissues of all types at different vibrational peaks; it will be a breakthrough in cancer research that will ultimately translate into a design bringing relief to the cancer patients and by extension to their families.

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