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Skin Cancer Diagnosis using FT-Raman Spectroscopy

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Abstract

Raman scattering has been employed for a while to examine the chemical makeup of biological systems. In the past ten years, Raman scattering has been extensively used in cancer screening, diagnosis, and intraoperative surgical guidance because to its high chemical specificity and noninvasive detection capacity. Coherent Raman scattering and surface-enhanced Raman scattering have lately been used in the study of cancer to overcome the weak signal of spontaneous Raman scattering. This study focuses on cutting-edge research on Raman scattering's use to cancer diagnostics and its potential to go from the bench to the bedside.

Clinical oncology still faces many obstacles when it comes to early cancer detection. Skin lesion detection has recently been done using Raman spectroscopy. The use of FT-Raman spectroscopy, a contemporary analytical method, for cancer diagnosis will benefit the patient in a number of ways, including real-time and less intrusive diagnosis. The main goal of this research was to identify spectral differences between benign and malignant (basal cell carcinoma - BCC) skin tissues using FT-Raman spectroscopy. These spectrum shifts can reveal crucial details about the metabolic changes that occur in these two different types of tissues. We compared eight sets of samples histopathologically identified as BCC with five sets of samples identified as benign tissue by FT-Raman analysis. We discovered that the shift regions between 1220 and 1300 cm-1 and between 1640 and 1680 cm-1 were where these samples' primary spectrum differences were. The amide III and amide I vibrations, respectively, are represented by the vibration bands in these locations. With 100% sensitivity and specificity, principal component analysis performed on all 13 samples could determine the type of tissue.

Keywords: Raman spectroscopy; Skin cancer; Skin cancer; Histopathologically; Basal cell carcinoma; Clinical oncology

Introduction

The biggest problem facing the planet is still cancer. New methods for cancer detection, diagnosis, and intraoperative surgical guidance must be developed immediately. Raman scattering can therefore noninvasively and without labelling detect changes in molecular fingerprints in a cell or tissue that has undergone pathological transformation. Raman spectroscopy may prove to be a useful technique for cancer diagnosis. Nevertheless, because spontaneous Raman scattering has a limited cross section (1030 cm2 per molecule), it takes a long time to integrate, which limits its use in biology and medicine [1].

Coherent Raman scattering (CRS) microscopy has been created to increase the Raman scattering signal level. The majority of CRS imaging investigations employ two excitation fields, referred to as pump (p) and Stokes (s), as seen in Figures 1(b) and 1(c). Coherent anti-Stokes Raman scattering (CARS) at the frequency of "(ps+p)" and stimulated Raman scattering (SRS) at the frequency of "s" or "p" both take place concurrently when the beating frequency (ps) coincides with a molecular vibration mode. CRS imaging is 1000 times faster than line-scan Raman microscopy and 10,000 times faster than point-scan Raman microscopy due to the high signal level in CRS microscopy. The benefit of SRS over CARS is that SRS microscopy is a highly sensitive and quantitative technique for biochemical imaging since the SRS signal is entirely free of the nonresonant background. Moreover, SRS can function in natural light. Parallel to this, quick developments in nanotechnology have given rise to surface-enhanced Raman scattering (SERS), which may greatly boost Raman signals but does so in a labelling way [2].

The most prevalent cancer in Americans is nonmelanoma skin cancer (NMSC). Ultraviolet (UV) radiation exposure is the key risk factor for the development of NMSC. Dietary AOs may reduce free radical-mediated DNA damage and cancer secondary to UV exposure. Some dietary AOs have demonstrated substantial promise in the prevention of skin cancer in numerous laboratory experiments. Animal research has supported these findings. Researchers have examined both dietary consumption of AOs through whole foods and oral AO supplementation in human trials. In this review, we highlight four specific dietary AOs and give a general overview of the role of AOs in preventing carcinogenesis. We examine the findings of studies comparing dietary AOs intake from whole foods to oral AOs supplements. Even though these particular supplements haven't demonstrated their effectiveness, consuming AOs through whole meals has showed some promise. Future study design may benefit greatly from the knowledge gained from the field of hypertension research. It is necessary to conduct more study on the effect of dietary AOs in the prevention of NMSC, with a particular emphasis on intake from whole food consumption [3].

Initiation, promotion, and advancement are the three stages of NMSC tumorigenesis, which is a protracted, multistage process. Free radical damage is known to have a part in the start of this process. Free radicals are produced as a result of UV radiation and environmental pollutants. Both UVA and UVB radiation cause DNA damage,

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however UVA radiation is more frequently linked to damage caused by free radicals.

Free radicals are molecules with unpaired electrons that cause oxidative damage to DNA, proteins, and lipids directly. Reactive oxygen species are the most prevalent kind of free radicals in the body (ROS). DNA's nucleotides and deoxyribosyl backbone have been found to sustain damage by ROS. More specifically, single strand DNA breakage and oxidised pyrimidine base synthesis are two ways that free radicals (mostly as singlet oxygen or hydroxyl radicals) harm DNA. Tumor development may result from this Genetic damage [4].

In addition to DNA, free radicals also harm cellular proteins and lipids. Enzymatic proteins that are directly oxidised activate pathways that result in the production of new proteins. Both inflammation and cell proliferation may be accelerated by these activities. The phospholipid bilayer of the cell is actively destroyed by lipid peroxidation caused by free radicals. It has been discovered that the build-up of oxidative stress encourages apoptosis through several pathways.

Moreover, exposure to UV radiation can cause immunosuppression, which impairs the capacity of immune cells to detect and destroy cancerous cells. Several biochemical alterations that occur when cancer develops can lead to enhanced angiogenesis and tumour invasion potential. AOs fight against these processes. They function via a variety of methods that stop these oxidative processes and the resulting DNA and cellular damage. Some have also been demonstrated to work by increasing the expression of genes for ROS-neutralizing enzymes. The skin contains a variety of naturally occurring AOs, and there is a gradient of diminishing concentration of these compounds from the epidermis to the dermis. These intrinsic skin AOs include nonenzymatic compounds like vitamin C and vitamin E as well as enzymes like glutathione peroxidase and superoxide dismutase [5].

Although the body contains defences against ROS, chronic oxidative stress from UV exposure can overwhelm these defences. Hence, researchers have turned to exogenous AOs. According to preliminary human investigations, people with BCC have lower serum levels of dietary AOs and higher serum markers of oxidative stress. As a result, the effectiveness of dietary AOs in lowering UVA-induced photocarcinogenesis has been examined.

AOs are reported to protect against skin cancer in numerous animal experiments, some of which go back decades. While some have concentrated on various combinations, some have focused on AO supplementation with a single AO. A considerable decrease in the frequency of malignant and precancerous lesions was observed in hairless mice exposed to UV light when supplemented with vitamin C in the diet. In a different experiment, beta-carotene and vitamin E supplements both reduced the number of tumours in mice given a topical carcinogen by 32% and 25%, respectively. Selenium supplementation in the diet before and during UV exposure to mice was demonstrated in another investigation to offer considerable dose-dependent protection against skin cancer [6].

Discussion

The most prevalent cancer in Americans is nonmelanoma skin cancer (NMSC). NMSC, which encompasses squamous cell carcinoma (SCC) and basal cell carcinoma (BCC), has more cases than breast, lung, prostate, and colon cancer put together. The main risk factor for the occurrence of skin cancer is ultraviolet (UV) exposure. Although public health efforts have had some success in changing the behaviours that promote UV exposure, there is still significant exposure from purposeful tanning, using tanning beds, and inadvertent exposure. Because of this, researchers have looked at alternative methods of preventing skin cancer, such as dietary changes that increase the consumption of antioxidants (AOs) [7].

We give a general summary of the role that dietary AOs play in inhibiting carcinogenesis in this review. Several mechanisms of action have been described and have showed promise in laboratory and animal investigations. Four AOs have been thoroughly assessed in the few big, longer-term human investigations that have been conducted. Researchers have recently begun to analyse the dietary consumption of AOs via whole foods. Even though these particular supplements haven't demonstrated their effectiveness, consuming AOs through whole meals has showed some promise. Future study design may benefit greatly from the knowledge gained from the field of hypertension research. In this review, we give a general overview of the function of dietary AOs in tumorigenesis prevention. Studies conducted in laboratories and on animals have shown potential mechanisms of action and have been promising. There have only been a few substantial, longer-term human investigations, and these have thoroughly assessed four AOs. Moreover, studies have started to look into AOs' nutritional consumption from whole foods. Consumption of AOs through ingestion of whole foods has showed some promise, even if these particular supplements have not demonstrated benefit. The design of future studies may benefit greatly from the lessons acquired in the field of hypertension research [8].

The Xie group has made enormous contributions to the creation of innovative coherent Raman scattering microscopy for neuropathological diagnostics. Five years later, developed multi-coloured coherent Raman imaging to visualise signals of lipids and protein originated from CH2 and CH3 vibrations in fresh brain tissues, when compared to the comparable histopathology pictures, these multicolour coherent Raman images revealed nearly equivalent morphological information. The authors used CARS imaging to map the C-H molecular vibration zone in human glioblastoma and an orthotropic mouse model of the brain [9]. Using information from the lipid content, they were able to map the tumour margins and infiltrations with cellular precision. Most recently, used SRS microscopy to examine the invasion of human brain tumours in 22 neurosurgical patients' fresh, unprocessed surgical materials. This study found that SRS and H&E staining had excellent agreement in detecting tumour infiltration. The authors also developed a classifier that had 97.5% sensitivity and 98.5% specificity for detecting tumour infiltration by quantitatively evaluating cellularity, axonal density, and protein: lipid ratio [10].

Conclusions

Raman scattering-based techniques provide reliable tools for cancer diagnosis since they can analyse biomolecules in situ without labels and with great sensitivity. Raman scattering-based techniques are typically used intraoperative, on the skin, in the gastrointestinal system, or other accessible tissue surfaces using fiber-optic-based light supply and collecting. The great sensitivity and specificity of Raman scattering allow for quick and precise discrimination between malignant or premalignant tissues and normal tissues. Finding very specific molecular markers for many types of human tumours would still be a difficulty for Raman spectroscopy-based cancer diagnostics. To find new molecular markers for cancer diagnosis, hyperspectral SRS microscopy, which can quantitatively map various species of molecules, is a good method.

We would forecast three positive directions for the future. One

is the two-colour SRS fast histology, which can be employed in the operating room during cancer surgery. The second method involves performing in-situ molecular-based diagnoses using portable rapid Raman imaging techniques, such as handheld Raman spectroscopy or hyperspectral SRS microscopy. The third is a multimodal imaging and spectroscopy system that combines the benefits of each modality and might provide a more accurate cancer diagnosis.

Conflicts of Interest

None

Acknowledgment

None

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