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A REVIEW ON SPECTROSCOPIC TECHNIQUES FOR THE SKIN CANCER DETECTION

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Abstract:

The most prevalent kind of cancer in the world, skin cancer is caused by aberrant skin cell development. Successful therapy can result from early discovery. Unrepaired DNA damage in skin cells, frequently brought on by exposure to ultraviolet (UV) radiation, is the main cause of this disorder. The two most serious types of skin cancer are non-melanoma skin cancer (NMSC) and malignant melanoma (MM). Skin cancer can be detected using a range of commercial diagnostic instruments and supplementary techniques. A visual inspection of the skin lesions usually initiates the clinical diagnosis. By utilizing the spectrum characteristics of tissues, a number of sophisticated spectroscopic methods have been created to help with the diagnosis of skin cancer. The following are notable techniques: Fluorescence Spectroscopy, Diffuse Reflectance Spectroscopy (DRS), Terahertz Spectroscopy, Raman Spectroscopy, Multi-Spectral Imaging, Hyperspectral Imaging, and Elastic-Scattering Spectroscopy. Raman spectroscopy is one of these that has a lot of potential for non-invasively diagnosing non- melanoma skin cancer (NMSC). Several spectroscopic techniques for identifying skin cancer will be reviewed. In this review, we go over the use of fluorescence, raman, terahertz, hyperspectral and elastic imaging methods in cancer research.

KEY WORDS: *skin cancer, hyper spectral imaging, melanoma, skin lesions, spectrograph.*

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INTRODUCTION:

Millions of people worldwide suffer from skin cancer, the most prevalent type of carcinoma. It grew longer as a result of aberrant cell proliferation. Other body parts may be invaded by these cells. Over 90% of instances are brought on by UV light exposure. The visual examination and biopsy of worrisome lesions serve as the foundation for the clinical diagnosis of skin cancer. Due to increased skin exposure to UV radiation, skin cancer is a major issue for nations with hot climates [1]. The most dangerous type of skin cancer is thought to be melanoma. However, squamous cell carcinoma (SCC) and basal cell carcinoma (BCC) are extremely harmful and need to be detected early for better clinical results. Numerous commercial diagnostic instruments and auxiliary [2].

Elastic scattering spectroscopy, hyperspectral engineering, diffuse reflectance spectroscopy (DRS), multispectral scanning, and other techniques are used to treat non-invasive skin cancer. By identifying circulating cancer cells or cancer biomarkers in biofluids, Raman and fluorescence spectroscopies enable early-stage cancer diagnosis. Hyperspectral imaging (HSI) offers spectral and spatial information about the sample in addition to these methods[3]. This method can be readily used to detect malignancies in external organs like the skin and head because of the imaging depth limits.

In this review, we go over the use of fluorescence, Raman, terahertz, hyperspectral, and elastic imaging methods in cancer research, along with the related uses.

Skin physiology

The skin is one of the largest and most important organs in the body and comprises approximately 16% of the human body weight, composed of five layers, avascular as it covers the entire body it is essential that all surgeons have a basic understanding of the basic physiology of the skin. In figure 1 schematic presentations of the epidermis layer of the skin is given [1&4].

The skin is continuous with the membranes lining the body orifices and in certain areas contains accessory structures such as glands, hair and nails. A detailed description of the structure of the skin is given on pages 1–7 of this issue. The skin is the interface between the body and the environment. It has a number of physiological functions that are essential to maintaining homeostasis, protection and social interaction.

It is important to understand the layers of our skin so that we can understand how healing occurs differently based on depth. The skin has two principal layers, the epidermis and the dermis.

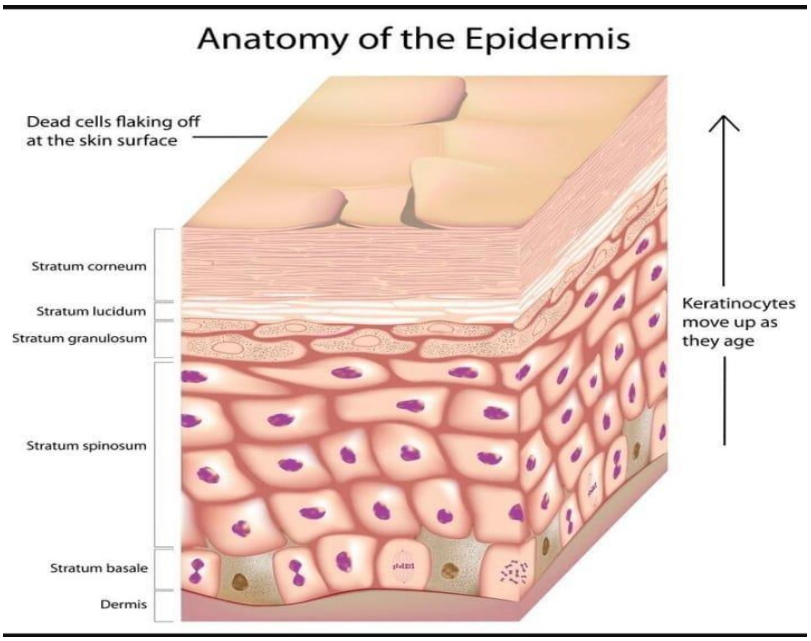

Figure1: Schematic presentations of the epidermis layer of the skin.

Its thickness varies based on location. For example, it is thickest on the heels and thinnest the eyelids. Areas that have increased use from friction or weight bearing can build up thicker layers of skin (e.g., where a pencil rubs your writing finger or shoe rubs against your foot).

It has no nerves, but free nerve endings from the dermis do extend into the mid layers of the epidermis [1&5].

Five layers of the epidermis (most to least superficial):

Stratum corneum

Composed of 15 to 30 layers of keratinocytes called squamous or corneocytes. These are dead keratinocytes. They contain a high concentration of keratin which provides a waterproof barrier for the skin, hair, and nails. This layer is continually being shed from the body. Shed cells are replaced via the process of skin cell migration from the stratum basale. This process takes an average of 30 days, but this varies based on age and certain health conditions.

Stratum lucidum

Contains two to three layers of keratinocytes and is not living. It can be penetrated or shaved off without awareness. It is only found in areas of thick skin, like the palms of the hand and the soles of the feet. Present in calluses [6].

Stratum granulosum

This layer contains the greatest concentration of free nerve endings that extend from the dermis. Free nerve endings are unencapsulated dendrites originating from a sensory neuron. They are the most common nerve endings in skin and provide sensory information about painful stimuli, hot and cold.

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Stratum spinosum

Contains Langerhans cells and lymphocytes which play an important role in the immune system.

Stratum basale

The only layer that undergoes continuous mitosis to produce new cells. Keratinocytes are constantly being produced in the stratum basale and they move up through the layers until they reach the outermost layer. Keratinocytes are the most dominant cell type in the skin. They play a critical role in wound healing as they are structural cells and they perform important immune functions.

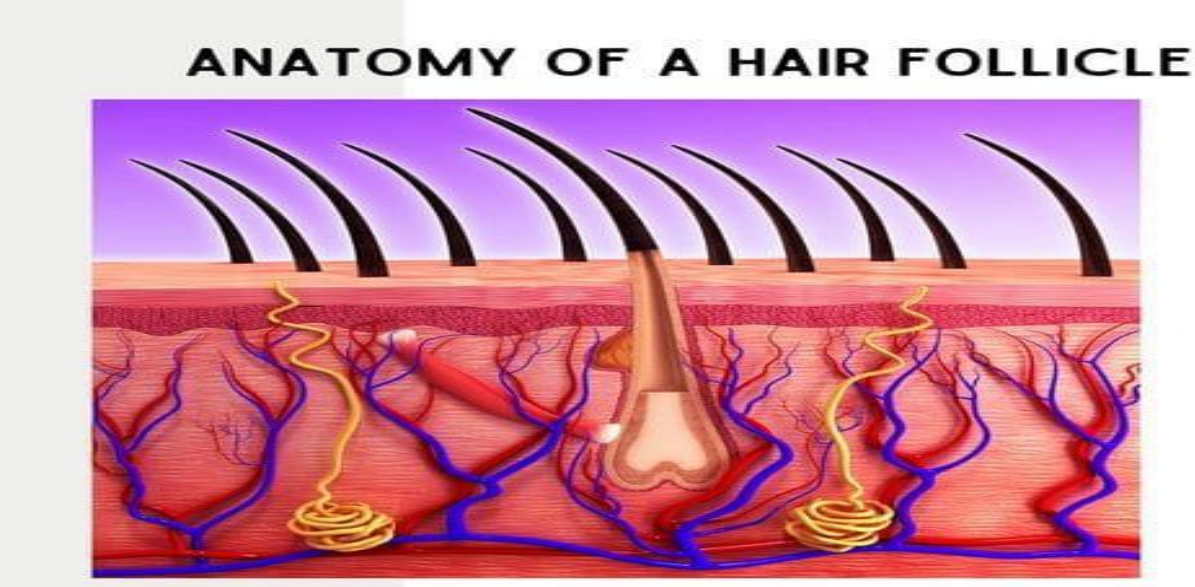

Figure 2. Anatomy of Hair follicle showing different sections of epidermis.

Hair follicles, sebaceous glands and sweat glands undergo constant cellular turnover to replace senescent cells and those exfoliated from the surface of the skin shown in figure 2.

Efforts to regenerate skin from hair follicles was attempted as early as 1875 when Ernst Schweninger, Assistant Professor at the Institute of pathology in Munich, "grafted" hairs pulled out with their roots and placed these onto granulating wounds. observed that within 3–5 days epithelial islands formed around the hair roots. His investigations might have received more attention with the advantage of modern imaging technology [8].

Classifications of skin cancer

1. Basal cell carcinoma (BCC)
2. Squamous cell carcinoma (SCC)
3. Malignant melanoma (MM)

1. Basal cell carcinoma

Derived from keratinocytes that resemble the basal cells of the epidermis, it is the least aggressive type of non-melanoma skin cancer. BCC resembles a pimple or a pinkish area on the skin. BCC can form in bones and nerves and spread throughout the body. BCC is caused by sun exposure, particularly in areas like the face, head, neck, arms, and abdomen that are exposed to the sun. Its mortality rate is minimal. Simple therapies like radiation therapy and drugs like fluorouracil can heal it [4&8].

2. Squamous cell carcinoma

People with pale, light skin were more likely to have it. It is brought on by excessive sun exposure. SCC manifests as scaly, red, hard lumps. It is generally located in areas like the back, chest, face, and ears. SCC affected almost a million individuals, and 800,000 of them lost their lives. UV radiation is carried by BCC and SCC, which directly harm DNA. The growth of invasive squamous cells that can infiltrate other tissues is a hallmark of SCC. The second most prevalent type of cancer worldwide is SCC.

3. Malignant melanoma

Specialized pigmented cells known as melanocytes are widely distributed in the basal layer of the epidermis. Melanocytes are the source of melanoma. There are four main histological subtypes that have been identified: lentigo malignant melanoma (13%), nodular melanoma (15%), superficial spreading melanoma (70%), and acral lentiginous (2–3%). It became absorbed as a dark patch on the skin's epidermis. Although it was the deadliest type of cancer, it is curable in its early stages. Typically, radiation, chemotherapy, and targeted therapy were used to treat it [5&9].

Epidemiology and risk factors

The most aggressive type of skin cancer is malignant melanoma, which occurs often. Malignant melanoma is the most common cause of cutaneous cancer-related deaths and the 19th most common cancer diagnosis globally. Melanoma is the cause of 65% of skin cancer-related deaths, despite making up less than 5% of skin cancer diagnoses. While some estimates for the western world state that one in every 50 persons is at risk of acquiring cutaneous melanoma, figures from the United States state that the average lifetime risk of cutaneous melanoma is one in 56 for men and one in 37 for women. There are several anatomical sites where melanoma can develop, including the leptomeninges or uvea, however cutaneous melanoma is known to be responsible for more than 90% of diagnoses and a significant global difference in occurrence between continents and nations, with the highest diagnosis rates in Australia and the lowest in Central Asia. Fair-skinned individuals and regions with high levels of sun exposure have the highest incidence of cutaneous melanoma in the US, white people have been reported to account for over 98% of occurrences [10].

Principle and mechanism of spectroscopic methods

The principle of spectroscopic methods for skin cancer detection revolves around how the light interacts with skin tissues. Each method measures these interactions to gather information about the molecular and structural composition of the skin.

1. Fluorescence Spectroscopy: This technique involves exciting the skin with specific wavelengths of light, causing the skin cells to emit fluorescence. The emitted light reveals biochemical changes in the tissues, aiding early melanoma detection.

2. Raman Spectroscopy: Raman spectroscopy measures the scattering of laser light by skin molecules. The scattered light provides a unique spectral fingerprint, revealing the molecular composition of the tissue.

3. Diffuse Reflectance Spectroscopy: DRS measures how light is reflected of the skin different tissue types reflect light differently, allowing for the identification of abnormal tissue.

4. Elastic Scattering Spectroscopy: ESS measures the light scattering by the skin. The patterns of scattered light help distinguish between normal and abnormal tissues based on their scattering characteristics.

5. Hyperspectral imaging: Is a powerful tool for skin cancer detection due to its ability capture detailed spectral information from skin tissues. HSI can differentiate between healthy and cancerous tissues based on their spectral signatures This noninvasive method provides detailed information about the physical and chemical properties of skin lesions,

aiding in early detection and accurate diagnosis.

6. **Multispectral imaging:** For skin cancer detection involves capturing images of the skin at different wavelengths of light to analyze the tissue's properties. The skin is sequentially illuminated with light of various wavelengths, ranging from visible to near infrared. Each wavelength interacts differently with the skin's components, such as melanin, hemoglobin, and water [10&11].

Conventional methods for the diagnosis of skin cancer

- Raman spectroscopy
- Fluorescence spectroscopy
- Diffuse reflectance spectroscopy

Innovative methods for the diagnosis of skin cancer

- Terahertz spectroscopy
- Hyper spectral imaging (HIS)
- Multi spectral imaging (MSI)
- Elastic spectral scattering (ESS)

Methods and techniques:

Raman spectroscopy

One method for finding different modes in a system that includes rotational, vibrational, and other low-frequency modes is Raman spectroscopy. In the visible, near-infrared, and near-UV ranges, it relies on the Raman scattering of monochromatic radiations, often from a laser. In Raman scattering, the photons of an irradiating laser beam collide inelastically with the molecules of the sample (or tissue). At the moment of measurement, automated feedback can be provided by processing and analyzing the acquired spectra. Better tissue differentiation sensitivity is offered by this system [12].

Figure 3 represents the method of Raman spectroscopy. Images (a) and (b) illustrate the hand-held probe and the Raman spectroscopy method, respectively.

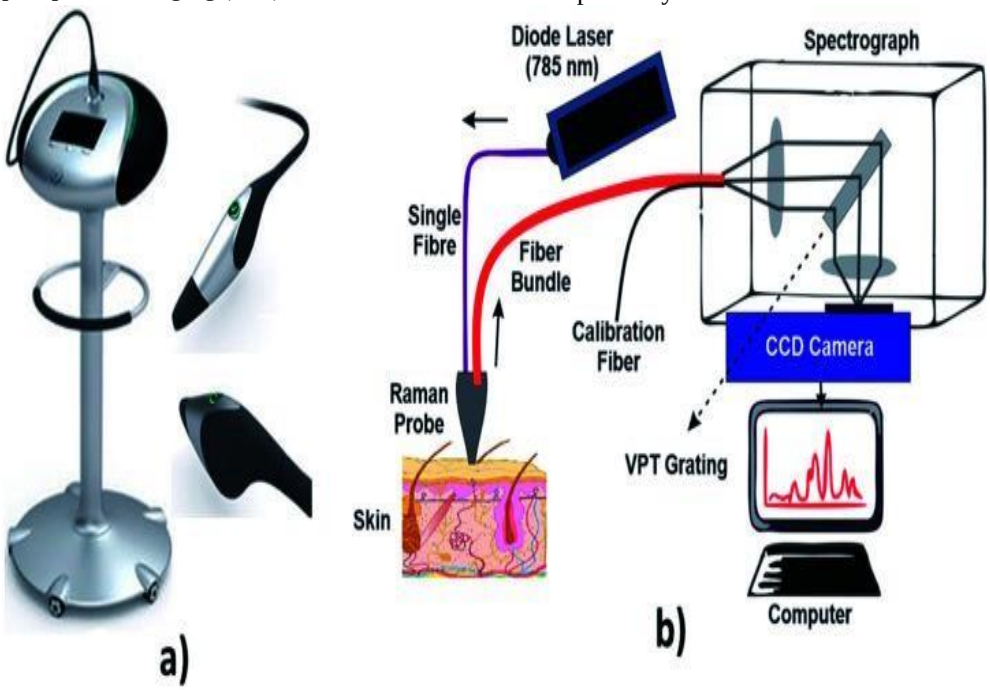

Figure.3 Raman spectroscopy technique in image(a) showing hand held probe, and (b) showing the Raman spectroscopy mechanism.

The majority of Raman micro spectroscopy is carried out in vivo. It is an automated, real-time, non-invasive method of diagnosing non-melanoma skin cancer, including BCC and SCC, and it can calibrate a sample in less than a second. In order to analyze the pathological condition, the Raman spectra of 21 suspected non-melanoma skin malignancies in 19 people with corresponding normal skin spectra were gathered using a handheld probe and a confocal Raman system. The skin lesions are identified by their small, characteristic bands, which match certain Raman spectra of proteins and lipids. Partial least regression and discriminant analysis can be used to analyze the Raman spectra of different substances. The study of the static and dynamic characteristics of biologically relevant molecules in solution, living cells, and cell culture is greatly aided by Raman spectroscopy [13]. In order to analyze skin cancer in the tissue regions, a linear least square fitting model

can be used to estimate the contribution of different bio- compounds, such as lipids and proteins, in the tissue. Additionally, Raman spectroscopy can be a useful diagnostic technique in medicine. It is possible to decrease the fluorescence components seen in normal cells by moving the excitation energy of Raman spectroscopy from the visible to the near-infrared regions. Software techniques have been created to diagnose the afflicted tissue regions by interpreting the tissue's spectra. categorization of cancerous Raman spectra of malignant from tumor cells.

Fluorescence spectroscopy

Electromagnetic spectroscopy that analyzes a sample's fluorescence is called fluorescence spectroscopy, or fluorometry. The fluorescence from the samples is examined once the electrons in the molecules are excited by the light source utilized in this method. Numerous biological, biochemical, and environmental applications have made use of this technique. Skin cancer is detected in vivo using laser-induced fluorescence spectroscopy. spectroscopy of fluorescence. With the use of fluorophores, it is used to identify skin cancer. Reprinted from Elsevier with permission. According to a fluorescence spectroscopy study by E. Borisova and his colleagues, excitation spectra usually resemble absorption spectra because fluorescence intensity is directly proportional to absorption. With the use of a CCD camera to identify tumor cells and a tunable monochromatic light source, the fluorescence polarization imaging approach is utilized to diagnose non-melanoma skin cancer. Two fluorophores are found in tumors during this procedure. Another technique for detecting skin cancer is called hyperspectral fluorescence, which uses two ultrafast lasers with a wavelength of 355 nm to stimulate the auto-fluorescence of biomolecules in skin tissue. Images of pigmented skin lesions are captured using the auto-fluorescence technique, which analyzes both fluorescence and reflectance. The excitation source in this technique is a fiber-coupled laser operating at 785 nm. For fluorescence imaging, the illumination is filtered using a bandpass filter, and for reflectance imaging, a long-pass filter. Furthermore, the auto-fluorescence method helps choose sampling locations for Raman spectroscopy, which is subsequently utilized to categorize different skin conditions. Using fluorescent agents, fluorescence spectroscopy aids in determining the dispersion of biological molecules. Using fiber optic probes and excitation sources, this method examines tissue while recording data with a spectrograph. Furthermore, using fluorescence spectra, fluorescence spectroscopy may differentiate between benign and malignant tumors shown in figure 4. The approach can distinguish between cancerous and non- cancerous cells since normal tissues fluoresce at 440 nm and non-melanoma tissues light at 436 nm [14&15].

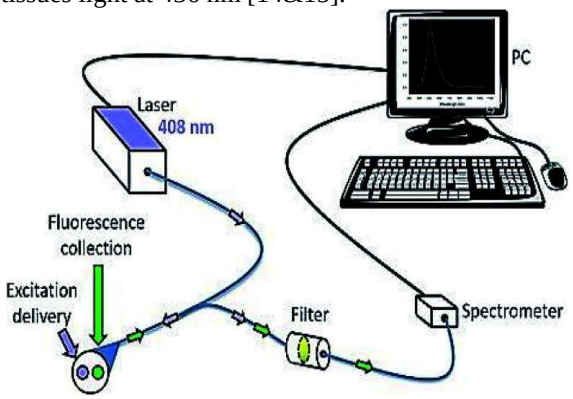

Figure.4 Fluorescence spectroscopy. It is used to detect the skin cancer with the help of fluorophores. Reprinted with permission from Elsevier.

Diffuse reflectance spectroscopy

A non-invasive optical method called diffuse reflectance spectroscopy has the potential to improve the existing cancer diagnostic standard by giving real-time input on the best biopsy site prior to tissue removal. The tissue's absorption and scattering characteristics are reflected in the diffuse reflectance spectrum. This method is quick, quantifiable, and sensitive to changes in the biochemistry and structure of tissues. Numerous studies have shown that diffuse reflectance spectroscopy has a high sensitivity and specificity for early epithelial carcinoma diagnosis. A quick, inexpensive, and non-invasive technique that may help in cancer diagnosis is diffuse reflectance spectroscopy (DRS). Our physiological model, a computerized Monte Carlo lookup table inverse model, was tested for its capacity to diagnose nonmelanoma skin cancer we used this model to extract vascular radius, oxygen saturation, blood volume fraction, and scattering parameters from a clinical DRS dataset. We discovered that the model could accurately represent physiological data related to skin cancer. We classified BCC, SCC, against actinic keratosis (AK) and against normal using the collected parameters. Classifiers trained on physiological model-extracted parameters produced an area under the receiver operating characteristic curve that is similar to classifiers trained on Principal Component Analysis- extracted features. According to our research, DRS can identify the physiologic features of the skin, and compared to a purely statistical study, this physiologic model provides more diagnostic flexibility for skin cancer. The diagnosis of nonmelanoma skin cancer using physiological characteristics taken from diffuse reflectance spectra data Tissue is thought to be a

homogenous semi-infinite turbid medium with reduced scattering coefficients and absorption, respectively, when light strikes its surface. The tissue is also identified by its refractive index. A portion of transmitted light is absorbed by the tissue, while the remaining portion undergoes several scatterings before emerging as diffuse reflectance from the tissue surface [14&16].

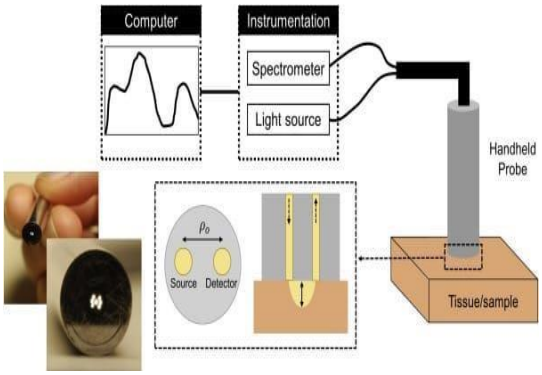

Figure:5 Schematic of typical diffuse reflectance spectroscopy system, showing hands held probe, separation between source and detector fibers, light source, spectrometer and spectral output.

Multi spectral imaging

Multispectral imaging or MMS, multiple linear polarizers with varying wavelengths are employed. The multispectral image spectrometer simultaneously records the spectral and spatial information of the samples. The multimodal spectroscopy setup for skin cancer diagnosis is demonstrated by processing the acquired images from a monochrome camera using spectral and polarization filtering to produce high contrasting images that are helpful in identifying the pathological and morphological features of the suspicious skin lesion. Hagen Nathan and Kudenov Michael reported on multispectral imaging using spectral bands. This involves automatically analyzing the images and using pattern recognition to find lesions, which aids in subsequent biopsies. It is crucial in the detection of skin cancer since it considers characteristics including texture, asymmetry, and uneven borders. Using a charge-coupled camera and eight narrow band filters that range in wavelength from 450 nm to 800 nm at 50 nm intervals, the images are taken from the skin's afflicted areas. Principal components analysis is used to extract the image's features. The spatial grey level co-occurrence matrix is used to distinguish between the characterizations of benign and malignant tumors. Spectroscopy in several modes. The MMS and hand-held probe setup is seen in picture (a), and the exploded view in image (b) shows the optical components, including the front lens and filters, as well as the collection and delivery fibers for each of the three modalities [17].

Methods that evaluate images at equal wavelength intervals between 483 nm and 950 nm are included in the multispectral imaging methodology. Multispectral imaging uses a neural network classifier to automatically diagnose skin cancer. With a sensitivity of 80.4%, the neural network can distinguish between benign and malignant tumors. The automatic segmentation algorithm in the multispectral imaging system is used to distinguish the pigmented skin lesions. Pictures of skin lesions are typically analyzed as 2-dimensional and 3-dimensional pictures using multispectral imaging techniques, which use wavelengths ranging from visible to infrared. The examination of skin lesions, vascular depth, and subcellular pigmentation is made easier by the multispectral imaging technique. It analyzes the cancerous growth using radiometric measurements. A The spectral ranges between 450 and 950 nm are used to analyze the images in order to distinguish between nevus cells and melanoma. Self-developed software is employed in a non-contact multispectral imaging technique to analyze skin chromophores. By considering characteristics like the melanin index and erythema index, the multispectral imaging approach can be used to diagnose melanoma skin cancer. Additionally, it offers the option to use a multispectral digital skin lesion analysis (MSDSLA) instrument to biopsy the pigmented lesion [18]. By examining the vascular depth of the skin lesion, the multispectral imaging approach improves the diagnosis. Six layered skin models can be used to interpret the vascular depth.

Hyper spectral imaging

One of novel and developing technique for the diagnosis and identification of solid tumors is hyperspectral imaging. It combines spectroscopy and conventional imaging to concurrently and non-invasively gather spectral and spatial information from tissues. The foundation of this imaging technique is the idea that various tissues have distinct spectrum reflectance responses that manifest as distinct spectral fingerprints is shown in figure 6. These composition-specific fingerprints are captured by HSI to distinguish between healthy and malignant tissues. From label-free histopathological analysis to real-time intraoperative support, it emerges as a viable tool for tumor diagnosis and detection. The fundamentals of HSI are presented in this study, along with an overview of its technique and the most current developments in solid tumor identification. To demonstrate its potential for clinical usage, the

benefits of HSI applied to solid tumors are specifically addressed. The epidermis, eye mask, cervix, tongue, and micro vasculature are among the freely accessible areas where HSI is employed because of the limitations on optical penetration depth. However, with the use of endoscopy, it can also be applied to some inside organs. The skin is the most researched organ in the body since it is the largest. Skin imaging can distinguish between several growths, including psoriasis, basal cell carcinoma, malignant melanoma, common nevus, and spits nevus. In the past, the quickest method for obtaining skin photographs was dermoscopy [19].

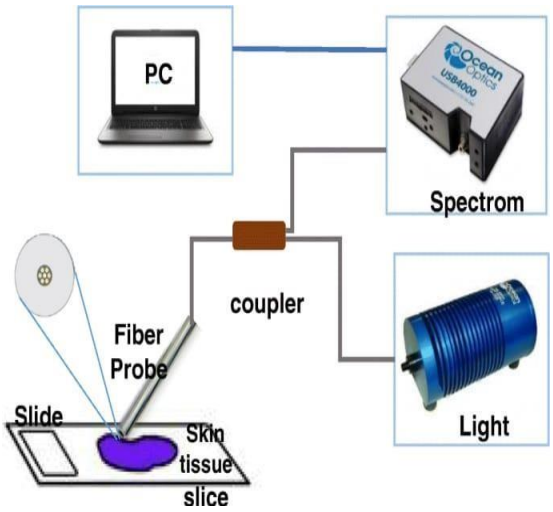

Figure 6- schematic representation of spectral properties of light reflected from tissue surfaces

Elastic scattering spectroscopy

Elastic scattering spectroscopy (ESS) Skin cancer can be detected with ESS, a relatively new and promising technique1. The light scattering characteristics of skin tissues are measured with a portable instrument. Without requiring tissue removal, this noninvasive method may differentiate between normal and aberrant tissues in vivo. According to studies, ESS devices may identify skin cancer with high sensitivity and specificity, which is frequently on part with dermatologists' and dermatopathology's' diagnostic precision. In figure 7 shown that Elastic Scattering Spectroscopy created by Derma Sensor. The device yields the output "Investigate Further" after classifying lesions as either high risk or low risk for malignancy using an algorithm. In the near-infrared window, elastic scattering spectroscopy was used to track the tumor's morphological and physiological changes throughout a 36-week period as the carcinogen-induced tissue changed toward higher phases, there was a noticeable decrease in tissue scattering over the 700–950 nm wavelength range. On the other hand, when the number of laser irradiation sessions for the treated tumors grew, the lowered scattering coefficient notably rose. For changed tissue, there were notable differences in the relative changes in the elastic scattering signal. Additionally, there were notable differences in the elastic scattering signal intensity for tissue treated with lasers. By changing the number of sessions, which we can forecast using spectroscopic optical feedback, the treatment outcome might be improved. At the end of the experiment, the reduced scattering coefficient of treated tissue showed about 80% recovery of its normal skin value. This study demonstrates that ESS can quantitatively provide functional information that closely corresponds to the degree of pathologic transformation. ESS may well be a viable technique to optimize systemic melanoma and non- melanoma skin cancer treatment based on non-invasive tumour systems [16&19].

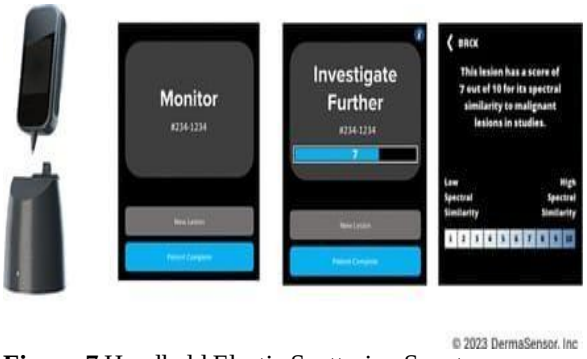

Figure.7 Handheld Elastic Scattering Spectroscopy created by Derma Sensor.

Terahertz spectroscopy

The spectroscopic technique known as terahertz (THz) spectroscopy is used to detect and regulate the electromagnetic properties of materials that fall within the frequency range of a few hundred GHz to several THz. It is an imaging method for identifying malignancies of the epithelium. Diseased and healthy tissues can be distinguished using time domain analysis, which is statistically significant. There is a strong correlation between a tumor's location and higher terahertz absorption. Using in vivo methods and terahertz pulsed imaging (TPI), frequency domain analysis in Terahertz spectroscopy is used to diagnose skin cancer. The spectral information pertaining to depth is then ascertained by data processing. The dielectric characteristics of human skin are examined using pulsed THz spectroscopy. This method was used to determine the difference between healthy, normal skin and BCC. When

compared to normal, healthy skin, the THz material parameter can encounter both dysplastic and non-dysplastic nevi pigmentation. For the THz wavelength, a skin tissue model has been created and calculated for a Monte Carlo simulation of the scattering and polarized light. To diagnose skin cancer, investigations were conducted using the Mueller matrices.

According to the new optical system, images of both cancerous and healthy colon tissue are taken with a wavelength-limited spatial resolution. The carcinoma tissues were studied using a 584 GHz frequency. THz technology is crucial for diagnosing illnesses. By using a plasmonic photoconductive antenna with a high sensitivity, T waves can also be used in both electrical and optical methods to diagnose skin cancer. By combining an infrared camera with an infrared detector, THz spectroscopy is also utilized to analyze biological tissues. It is possible to distinguish between diseased and non-cancerous cells using THz imaging at 1.39–1.63 THz. Additionally, it expanded it use in the biomedical field, encompassing everything from cells and tissues to biomolecules like lipids, proteins, and amino acids. It is employed in sensing applications, including THz cancer screening, explosive identification detection, space exploration, and the detection of hidden objects. Current developments in THz spectroscopy methods for diagnosing skin cancer are compiled [20].

Figure 8 represents Terahertz Spectroscopy. In this technique the properties of matters are probed with short pulses of THz radiations. In the above image (i) showing TPI handheld probe system, (A) main unit with computer monitor, handheld imaging probe and black umbilical cord (visible on the right), (B) close up of the handheld imaging probe, (C) close up of the head of the imaging probe showing the black quartz window.

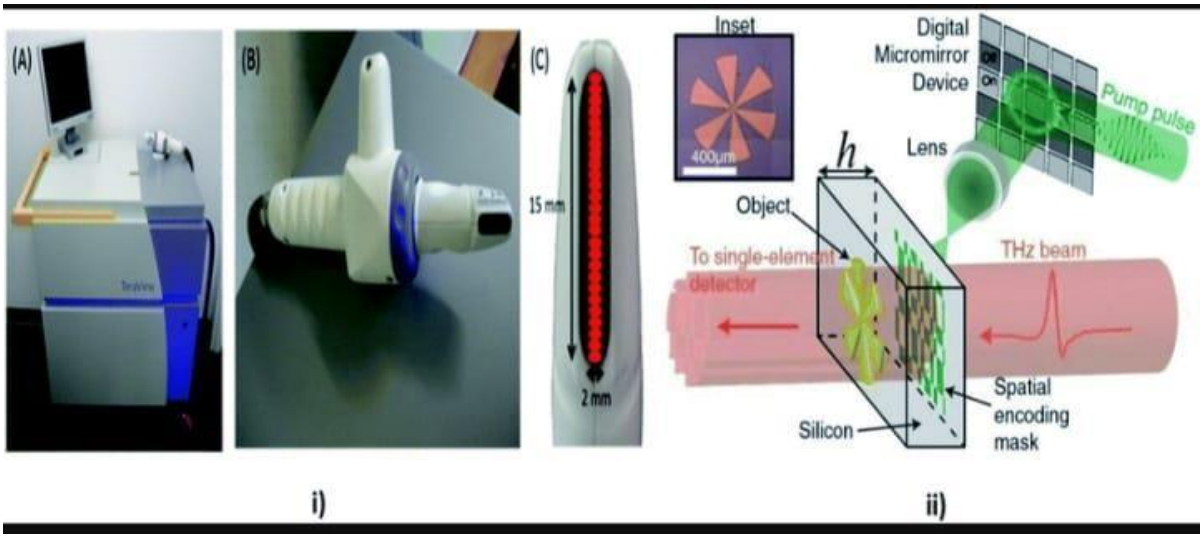

Figure 8 -Terahertz Spectroscopy. In this technique the properties of matters are probed with short pulses of THz radiations

Applications

Spectroscopic methods have a wide range of applications in the detection skin cancer, offering noninvasive and highly accurate diagnostic tools. Here are some key applications:

1. **Early Detection:** Spectroscopic methods like Raman spectroscopy and multispectral imaging can detect subtle changes in skin tissues, allowing for the early identification of malignant lesions.

2. Differential Diagnosis: These techniques help differentiate between benign and malignant lesions by analyzing the spectral signatures of skin tissue reducing the need for invasive biopsies.

3. Monitoring Treatment Response: Spectroscopic methods can be used to monitor the effectiveness of treatments by tracking changes in the spectral properties of skin lesions over time.

4. Guiding Surgical Interventions: Techniques like optical coherence tomography (OCT) and confocal microscopy provide high resolution imaging that can guide surgeons during the removal of skin tumours ensuring complete excision.

5. Telemedicine: Portable spectroscopic devices enable remote diagnosis and monitoring of skin cancer, making it easier for patients in remote areas to access specialized care.

6. Research and Development: Spectroscopic methods are used in research to better understand the molecular and structural changes associated with skin cancer, leading to the development of new diagnostic and therapeutic approaches [17&21].

These applications highlight the versatility and effectiveness of spectroscopic methods in improving the detection, diagnosis, and treatment of skin cancer.

CONCLUSION:

By offering non-invasive, extremely accurate, and effective techniques that greatly improve early detection and treatment outcomes, spectroscopic technologies have revolutionized the detection and diagnosis of skin cancer. The distinction between benign and malignant lesions is made possible by the comprehensive molecular and structural information provided by methods like Raman spectroscopy, fluorescence spectroscopy, and hyperspectral imaging. These methods facilitate surgical decision-making, reduce the need for invasive biopsies, and improve diagnostic accuracy. As technology develops, spectroscopic methods combined with artificial intelligence and machine learning should further increase accuracy and accessibility, which will ultimately enhance patient care and treatment results for skin cancer. extremely accurate, and effective techniques that greatly improve early detection and treatment outcomes, spectroscopic technologies have revolutionized the detection and diagnosis of skin cancer. The distinction between benign and malignant lesions is made possible by the comprehensive molecular and structural information provided by methods like Raman spectroscopy, fluorescence spectroscopy, and hyperspectral imaging. These methods facilitate surgical decision-making, reduce the need for invasive biopsies, and improve diagnostic accuracy. As technology develops, spectroscopic methods combined with artificial intelligence and machine learning should further increase accuracy and accessibility, which will ultimately enhance patient care and treatment results for skin cancer.

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MM-Malignant Melanoma Bcc -Basal Cell Carcinoma
SCC- Squamous Cell Carcinoma HIS- Hyper Spectral Imaging ESI- Elastic Spectral Imaging Tz -Terahertz Spectroscopy
MSI- Multi Spectral Imaging
DRS -Diffuse Reflectance Spectroscopy