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Novel Method of Detecting Cervical Cancer Using Microwaves

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***Abstract*— This paper reports a novel method of detecting cervical cancer based on the measurement of the dielectric properties of female ejaculate at microwave frequencies. The microwave measurements were performed by rectangular cavity perturbation in the S-band of microwave frequency with the female ejaculate samples from healthy persons as well as from cancerous patients. It is observed an appreciable change in the dielectric properties of cancerous samples with the normal healthy samples and these measurements were in good agreement with clinical analysis. This measurement technique is simple and the collection of female ejaculate is painless and nonsurgical in nature. The results show a new method of diagnosing cervical cancer using microwave measurement without any surgical procedures and suggest an alternative to Papanikolaou test or Papanicolaou test.**

***Index Terms*— cervical cancer, female ejaculate, dielectric properties, clinical analysis**

I. INTRODUCTION

The survival rate is increased in cancer patients based on the earlier detection of cancerous cells. Numerous diagnostic procedure are still in practice for the detection of cancerous cells but fails on detect on the reported high false-negative rates [1] and high false-positive rates [2]. These concerns augment the search for new techniques that can find other physical tissue properties or metabolic changes on the onset of cancer.

In gynecology, the Papanikolaou test or Papanicolaou test is a medical screening method, primarily designed to detect premalignant and malignant processes in the ectocervix. It also detects infections and abnormalities in the endocervix and endometrium. The test remains an effective, widely used method for early detection of cervical cancer and pre-cancer [3]. About 5% to 7% of pap smears produce abnormal results, indicating a pre-cancerous condition. The present study reports a new method of detecting cervical cancer based on the measurement of the dielectric properties of female ejaculate using cavity perturbation technique in the S-band of microwave frequencies [4-7].

Medical science has advanced greatly in the last century, there is still much that is not understood about the way the human body interacts with many things, including microwaves. The potential for medical uses of microwaves lies in two areas therapeutic and diagnostic field and many new medical microwave devices are also developed [8,9]. All the known therapeutic uses of microwaves involve the heating of tissue. Carefully controlled, microwave-generated heat can have a therapeutic effect on a number of ailments. Microwave medical devices ability depends upon how far microwaves can deeply penetrate into living tissues. The depth to which microwaves can penetrate tissues is primarily a function of the dielectric properties of tissues and of the frequency of the microwaves. Lower the water content of the tissue the deeper a wave at a given frequency and lower the frequency the deeper is the depth of penetration into tissues with given water content. Thus, there is a need to study the interaction of microwave with tissues especially its effect on biological materials. The key element in the microwave study is the determination of the absorbed energy. The amount of energy absorbed is a function of the complex permittivity of a material [10]. Hence, it is crucial to know the dielectric properties of biological materials and the various constituents thereof. Exhaustive studies of dielectric parameters of various human tissues and body fluids at different RF frequencies have been reported [11-13]. Different measurement techniques are used to measure the complex permittivity of a material and the chosen technique depends on various factors such as the nature of the sample and the frequency range used [14-17]. When only very small volumes of the sample are available, the cavity perturbation technique is an attractive option as it requires only minute volumes for the measurement [18]. This makes it suitable for the dielectric study of female ejaculate, as only very small volumes can be only be extracted by procedure. The rectangular cavity perturbation technique has been employed for the measurement of the dielectric parameters of female ejaculate samples obtained from healthy persons as well as from cancerous patients in this work, at the frequency range 2 to 3 GHz. It is noticed that a remarkable change in the dielectric properties of cancerous samples with that of normal healthier samples and these measurements were in good agreement with clinical analysis. This microwave measurement procedure is simple and extraction of female ejaculate from persons is nonsurgical in nature. These results prove an alternative to Papanikolaou test or Papanicolaou test without any surgical procedures.

II. SAMPLE PREPARATION

The women who were not in the menstrual period to lie on back with feet raised and supported by stirrups with clothes taken off below the waist and without douche or tampons, or use of vaginal medicines for 24 hours before the collection of sample. A smooth, curved speculum is inserted into vagina which spread apart the vaginal walls and the samples of fluid inside the vagina are taken after orgasm by masturbation with a swab or wooden spatula. The samples were then filled in the sample holder and kept at 1°C. Measurements were carried out on samples which were less than one day old.

III. MATERIAL AND METHODS

The experimental set-up consists of a transmission type S-band rectangular cavity resonator, HP 8714 ET network

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analyser. The cavity resonator is a transmission line with one or both ends closed. The numbers of resonant frequencies are determined by the length of the resonator. The resonator in this set-up is excited in the TE_{10p} mode. The sample holder which is made of glass in the form of a capillary tube flared to a disk shaped bulb at the bottom is placed into the cavity through the non-radiating cavity slot, at broader side of the cavity which can facilitate the easy movement of the holder. The resonant frequency f_o and the corresponding quality factor Q_o of the cavity at each resonant peak with the empty sample holder placed at the maximum electric field are noted. The same holder filled with known amount of sample under study is again introduced into the cavity resonator through the non-radiating slot. The resonant frequencies of the sample loaded cavity is selected and the position of the sample is adjusted for maximum perturbation (i.e. maximum shift of resonant frequency with minimum amplitude for the peak). The new resonant frequency f_s and the quality factor Q_s are noted. The same procedure is repeated for other resonant frequencies.

IV. THEORY

When a material is introduced into a resonant cavity, the cavity field distribution and resonant frequency are changed which depend on shape, electromagnetic properties and its position in the fields of the cavity. Dielectric material interacts only with electric field in the cavity

According to the theory of cavity perturbation, the complex frequency shift is related as [18]

$$-\frac{d\Omega}{\Omega} \approx \frac{(\bar{\varepsilon}_r - 1) \int_{V_s} E \cdot E_0^* \, dV}{2 \int_{V_c} \left|E_0\right|^2 dV} \qquad (1)$$

But $$\frac{d\Omega}{\Omega} \approx \frac{d\omega}{\omega} + \frac{j}{2}\left[\frac{1}{Q_s} - \frac{1}{Q_0}\right] \qquad (2)$$

Equating (1) and (2) and separating real and imaginary parts results

$$\varepsilon_r' - 1 = \frac{f_o - f_s}{2 f_s}\left(\frac{V_c}{V_s}\right) \qquad (3)$$

$$\varepsilon_r'' = \frac{V_c}{4V_s}\left(\frac{Q_o - Q_s}{Q_o Q_s}\right) \qquad (4)$$

Here, $\bar{\varepsilon}_r = \varepsilon_r' - j\varepsilon_r''$, $\bar{\varepsilon}_r$ is the relative complex permittivity of the sample, ε_r' is the real part of the relative complex permittivity, which is known as dielectric constant. ε_r'' is the imaginary part of the relative complex permittivity associated with the dielectric loss of the material. V_s and V_c are corresponding volumes of the sample and the cavity resonator. The conductivity can be related to the imaginary part of the complex dielectric constant as

$$\sigma_e = \omega\varepsilon'' = 2\pi f \varepsilon_0 \varepsilon_r'' \qquad (5)$$

V. RESULTS AND DISCUSSION

The microwave studies of female ejaculate samples were done using cavity perturbation technique collected from healthy donors as well as from the cancerous patients and the results are shown in Figures 1 to 2. Clinical evaluation of the female ejaculate samples is also done and the results are tabulated in Table 1. From Fig 1 it is noticed that the cancerous female ejaculate samples exhibit higher dielectric constant than that of the normal samples. The increase in dielectric constant in cancerous samples is due to the presence of higher level of fructose than in the normal samples. In Fig. 2 the variation of conductivity of normal and cancerous female ejaculate samples are plotted. It is observed that cancerous samples show higher conductivity than normal samples. The increase in conductivity in cancerous female ejaculate samples is due to the presence of higher level of pH than the normal samples. Thus in the specified band of frequencies, normal and cancerous female ejaculate samples were studied and exhibit distinct variation of dielectric constant as well as conductivity with frequency.

VI. CONCLUSION

The microwave characterisation of the female ejaculate samples is done using cavity perturbation technique. The cavity perturbation technique is quick, simple, and accurate and it requires very low volume of sample for measuring the dielectric properties of tissue samples like female ejaculate samples. It is observed that a remarkable change in the dielectric properties of cancerous female ejaculate samples with the normal healthy samples and these measurements were in good agreement with clinical analysis. This measurement technique is simple and the collection of female ejaculate is painless and nonsurgical in nature and suggests an alternative to Papanikolaou test or Papanicolaou test without any surgical procedures.

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Sample	Colour	Presence of			Degeneration Cellular	pH	Fructose µmol	Pus cells
		Leucocyte	Eritrocyte	Mucus				
FEN-1	bloody	Yes	Yes	Yes	No	4.3	13	2-4/hpf
FEN-2	pale	No	Yes	No	No	3.9	12	1-2/hpf
FEN-3	white	Yes	No	Yes	No	4.2	13	2-3/hpf
FEN-4	pinky	No	Yes	No	No	3.6	13	2-4/hpf
FEC-5	straw	No	No	No	Yes	5.9	18	2-3/hpf
FEC-6	pinky	No	Yes	Yes	Yes	4.6	17	1-2/hpf
FEC-7	white	Yes	No	Yes	Yes	5.5	17	2-3/hpf
FEC-8	bloody	Yes	Yes	No	Yes	5.3	18	1-2/hpf

Table 1. Variation of constituents in female ejaculate samples

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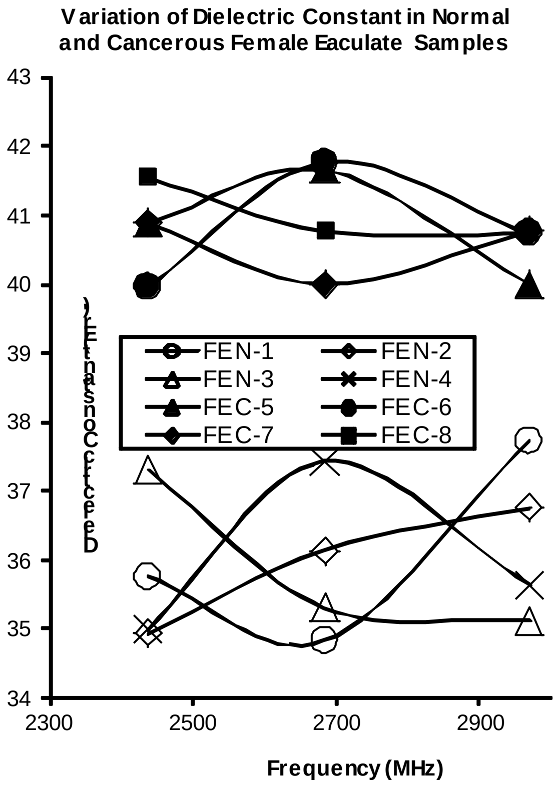

Figure 1. Variation of Dielectric Constant in Normal and Cancerous female ejaculate samples

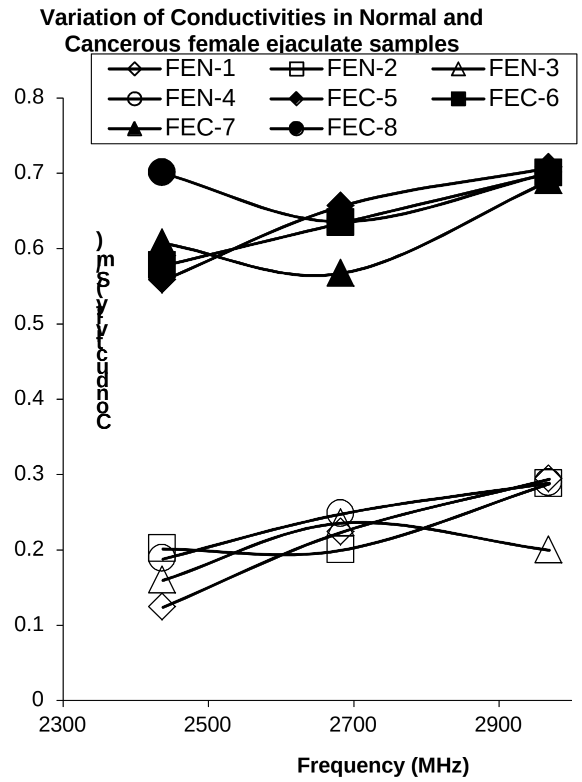

Figure 2. Variation of Conductivities in Normal and Cancerous female ejaculate samples

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