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Microwaves and Mobile waves: Future of Oral Cancer Diagnosis and Treatment

Abstract

Oral Squamous Cell Carcinoma (OSCC) is the eleventh most common malignancy worldwide. Dielectric relaxation studies have been carried out for saliva of patients having tobacco habit but no squamous cell carcinoma (SCC) and those having tobacco habit with SCC using picoseconds time domain reflectometry over the frequency range of 10 MHz to 20 GHz at room temperature. The above two groups were compared with the control group. Dielectric parameters have been obtained by fitting complex permittivity spectra to Debye equation. In the present study, a total of 88 (48 oral cancer and 40 healthy) subjects were assessed and compared for the salivary dielectric properties (Parameters) The values of dielectric parameters were compared with the histopathological grades and clinical stages of malignancy. The results also show change in dielectric parameters with change in histopathological grades and clinical stage of the OSCC biopsy sample.

Key Words

Conductivity; dielectric properties; oral squamous cell carcinoma; permittivity; saliva; relaxation time; time domain reflectometry

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INTRODUCTION

Oral cancer is one of the 11 most frequently occurring cancers worldwide and has a higher proportion of deaths per number of cases than breast cancer or cervical cancer because of late detection. In India, oral cancer is highly prevalent, comprising 35-40% of all malignancies, due to habit of tobacco chewing.[1-5] The 90% of oral cancers are oral squamous cell carcinoma. This cancer, when found early, has an 80 to 90% survival rate. Despite this fact and the great treatment advances, the World Health Organization has reported oral cancer as having one of the highest mortality ratios.[6-12] The routine clinical practice to detect oral cancer is initially made by visual inspection, followed by biopsy of any suspicious lesions found. New methods for reliable, low-cost, noninvasive, and real-time screening or detection of oral cancer are thus warranted.[13-18] The intention of this study was therefore to investigate a new approach, namely bioimpedance, for reliable, low-cost, noninvasive, and real-time screening or detection of oral cancer. Bioimpedance is the measurement of the bioimpedance signal, which is obtained by injecting low-level sinusoidal current in the tissue and measuring the voltage drop generated by the tissue impedance. The electrical properties of tissue vary with the frequency of the applied electric field as seen from alpha, beta and gamma dispersion. The present study was carried out in the microwave frequency range from 10 MHz-20 GHz.

MATERIALS & METHODS

The patients visiting the out patient Department of Government Dental College and Hospital, Aurangabad, subjects diagnosed histopathologically, to have oral squamous cell carcinoma and who had not received any therapy prior to study were included in the oral squamous cell carcinoma (OSCC) group, and the remaining were excluded. The control group mucosal specimens were harvested after informed consent from individuals, who were admitted for incidental elective surgery. These biopsies were all harvested from clinically normal mucosal sites. Accordingly, the subjects for the study were grouped as follows: Group I (Control): This control group was divided

Table 1. Values of permittivity, conductivity and relaxation time for the control (C) group, control subjects having tobacco habit but no lesion (CT) group and patients of oral squamous cell carcinoma (OSCC) group.

	Permittivity			Conductivity (S/m)			Relaxation time (ps)		
	C	CT	OSCC	C	CT	OSCC	C	CT	OSCC
Min.	65.05	52.42	11.87	0.1414	0.0514	0.1173	8.77	11.08	6.86
Max.	77.98	79.86	90.36	0.2928	0.2781	0.5064	12.7	13.59	38.74
N	20	20	48	20	20	48	20	20	48
Mean	74.54	77.099	74.81	0.1939	0.1684	0.2527	11.30	12.39	12.91
S.D.	±3.1133	±5.9407	±16.1001	±0.0436	±0.0581	±0.0850	±1.009	±0.6706	±4.6760

Table 2. Values of permittivity, conductivity and relaxation time for different histopathological grades of oral squamous cell carcinoma (OSCC).

	Permittivity		Conductivity (S/m)		Relaxation time (ps)	
	Grade I	Grade II	Grade I	Grade II	Grade I	Grade II
Min.	11.70	11.87	0.1175	0.1172	10.22	6.86
Max.	82.22	82.12	0.5064	0.4881	38.74	21.32
N	9	39	9	39	9	39
Mean	67.62	70.71	0.2345	0.2569	16.50	12.07
S.D.	±25.2678	±13.5778	±0.1152	±0.0777	±8.000	±2.5806

Table 3. Values of permittivity, conductivity and relaxation time for different clinical stages of oral squamous cell carcinoma (OSCC) group.

	Permittivity				Conductivity (S/m)				Relaxation time (ps)			
	Stage I	Stage II	Stage III	Stage IV	Stage I	Stage II	Stage III	Stage IV	Stage I	Stage II	Stage III	Stage IV
Min.	11.87	69.89	50.40	26.93	0.1799	0.1768	0.1172	0.1799	9.99	8.43	8.92	6.86
Max.	75.70	75.57	90.36	82.22	0.2909	0.3654	0.5064	0.3255	21.32	12.46	38.74	15.54
N	5	6	29	8	5	6	29	8	5	6	29	8
Mean	47.76	73.14	73.35	70.18	0.2333	0.2644	0.2567	0.2412	16.20	10.66	13.04	12.02
S.D.	±32.90	±2.345	±9.6963	±18.27	±0.0557	±0.0800	±0.0987	±0.0502	±4.9767	±1.6827	±5.2227	2.9098

into two subgroups i.e. l(a) and l(b). First group considered of controls (C) i.e. 20 healthy age and sex matched subjects free from any other systemic disease and tobacco related habits. L (b) subgroup consisted of controls (CT) i.e. 20 age, sex and tobacco habit matched subjects (with SCC group) but having no lesion. Group II (OSCC): 48 (age, sex and habit matched) patients having oral squamous cell carcinoma and verrucous carcinoma. A total number of 48 cases of OSCC and verrucous

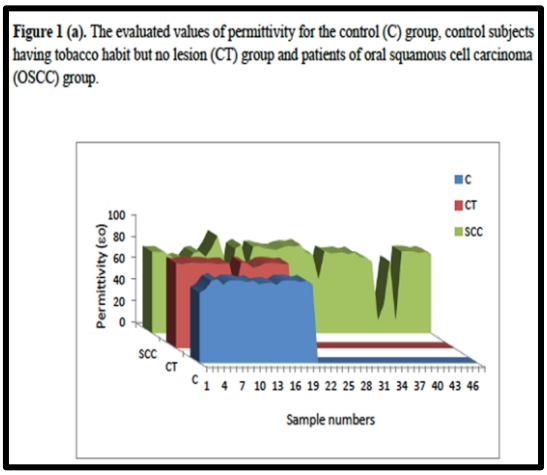

Figure 1 (a). The evaluated values of permittivity for the control (C) group, control subjects having tobacco habit but no lesion (CT) group and patients of oral squamous cell carcinoma (OSCC) group.

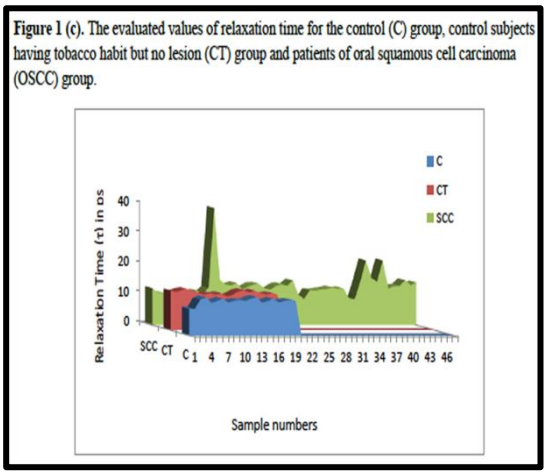

Figure 1 (c). The evaluated values of relaxation time for the control (C) group, control subjects having tobacco habit but no lesion (CT) group and patients of oral squamous cell carcinoma (OSCC) group.

carcinoma cases were screened and all consented to biopsy. Punch biopsies were taken from the representative sites after achieving anesthesia by 2% lignocaine with 1: 80.000 adrenaline. Procedure for collection of resting (unstimulated) whole (mixed) saliva: Saliva was allowed to accumulate in the patient's mouth for 5 min and then they were to spit in 30 ml borosil glass air sealed bottles. Then the saliva was poured in centrifuging tubes and immediately centrifuged by using Remi-DGL-721 centrifuging machine at 1000 rpm for 10 minutes. Dielectric property measurements were performed immediately after the collecting the saliva. The elapsed time from excision to measurement was between 15-20 minutes. The Time domain reflectometery technique in reflection mode as developed at Dr. Babasaheb Ambedkar Marathwada University has been used for the measurement of dielectric parameters. Frequency range used during the measurements was 10 MHz to 20 GHz. The data was analyzed by Fourier transformation method and values of dielectric parameters i.e. dielectric permittivity, relaxation time, relaxation time and conductivity were

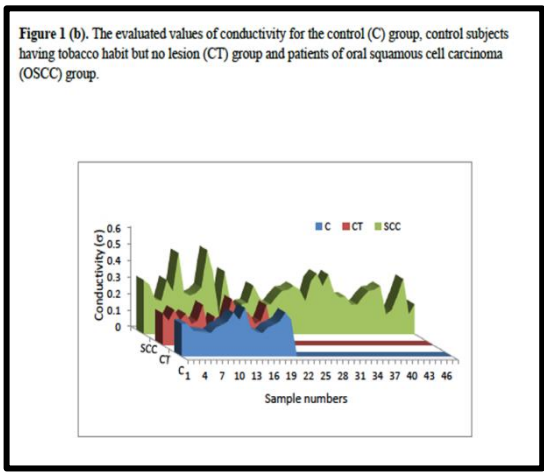

Figure 1 (b). The evaluated values of conductivity for the control (C) group, control subjects having tobacco habit but no lesion (CT) group and patients of oral squamous cell carcinoma (OSCC) group.

obtained and compared with the histopathological grades and clinical stages of the malignancy.

RESULT

In the present study the evaluated values of permittivity, relaxation time and conductivity are represented in Figure 1(a), 1(b) and 1(c), respectively. Comparison of the values of permittivity, conductivity and relaxation time according to the group showed in Table 1. The differences between the mean values of conductivity, relaxation time and permittivity of different histopathological grades were calculated and statistical evaluation was done using 't' test are recorded in Table 2. Comparison of the values of permittivity, conductivity and relaxation time according to the clinical stages in OSCC group showed in Table 3. As stated previously, increase in conductivity causes an increase in microwave absorption.[13-18] The microwave absorption of cancer cells being greater than that of normal cells. Thus, from the present study it could be inferred that the differences in microwave absorption of normal and cancer saliva can help us to develop techniques for diagnosis oral cancer.

DISCUSSION

OSCC comprises 90-95% of all oral malignancies.[19-24] Thus early detection of OSCC not only increases the survival rate but also improves the quality of life by reducing the need for aggressive and disfiguring treatments. Histological and biochemical changes always precede visible signs. The cellular changes in malignancy are also reflected in their electrical properties like permittivity, conductivity and relaxation time. The behavior of biological tissues, cell suspensions and saliva at radio frequencies and microwave frequencies is largely determined by the electro-chemical behavior of cells and its cellular structure

as well as the intra-cellular fluid in which the cells are suspended and the internal cellular elements, including the nucleus. Moderate variations in the permittivity and conductivity values are reflected by various types of normal tissue, saliva etc. In contrast to these rather homogenous observations, malignant tissues demonstrate substantially increased permittivity and conductivity. These differences are probably attributable to: 1) The physico-chemical bulk properties. 2) Microstructural properties. 3) The amount of extracellular fluid. 4) Membrane properties and packing density. 5) Orientation of malignant cells. 6) Changes in the water content of tumour tissues. 7) The rate of necrosis. At audio and radio frequencies substantial differences are expected between normal and neoplastic tissues, in particular those associated with necrosis in tumour nodules.The Gamma dispersion was observed at high frequencies and was mainly due to rotation of permanent dipoles of water molecules. The conductivity also exhibited frequency dependence. The beta dispersion was observed at medium frequencies.

CONCLUSION

Salivary Dielectric Properties in Oral Cancer (OSCC) Through Time Domain Reflectometry at Microwave Region have been reported. The present study shows that the salivary conductivity of squamous cell carcinoma patients is more than that of the normal subjects. Hence, the microwave absorption of squamous cell carcinoma patients is more. So microwaves can be used for diagnosis (imaging and detection) as well as for therapy (hyperthermia treatment) of oral squamous cell carcinoma. Also salivary dielectric parameters can act as useful non-invasive diagnostic tools for cancer detection and determination of histopathological grades of malignancy. Further, salivary relaxation time can be useful as an indicator of the possible occurrence of oral squamous cell carcinoma in subjects having tobacco habit.

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