BIOELECTRICAL IMPEDANCE ANALYSIS OF ORAL CANCER - A Brief Review

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Abstract – World Health Organization has considered the cancer as the 6th most potential reason for mortality all over the world. Even with all the advancement and development of technology in the field of medicine the cancer remains one of the most fatal diseases all over the world. Among these malignancies Oral Cancers are the most common worldwide. In malignant tissue there is a significant change in the bioimpedance, this change is as a result of increased water and salt content in the cells, change in membrane permeability, altered packing density and orientation of cells. Bioimpedance is the ability of organic tissue to oppose an external electric current. This review provides a brief knowledge about the bioelectrical impedance in oral cancers.

Key words: Bioimpedance, Bioelectrical impedance, Oral Cancer, Electric Current, Oral Squamous Cell Carcinoma.

INTRODUCTION –

World Health Organization in 2016 has considered the cancer as the 6th most potential reason for mortality all over the world and oral cancer is one of the 11 most commonly occurring malignancy worldwide and has a significantly greater proportion of mortality per number of cases. Even with all the advancement and development of technology in the field of medicine the cancer remains one of the most fatal diseases all over the world.[1]

Bioelectrical impedance or bioimpedance can be described as response of organic tissue to oppose an external electric current. It is the quantification of the impedance signal, which is exhibited by inserting electrical currents and measuring the voltage produced by the tissue impedance via electrodes. the frequency response of bioimpedance is highly influenced by the physiological and chemical status of the biological cells and/ or tissues greatly which is different for different individuals.[2]
In malignant tissue there is a significant change in the bioimpedance, this change is as a result of increased water and salt content in the cells, change in membrane permeability, altered packing density and orientation of cells.[3]

The study of bioelectrical properties of cells and tissues is an interesting area of research where it has proved its ability to derive the data about the morphology and physiology of the cells. This method identifies and measures the non-biological parameters of the cells, which may bear the disease signature and information can be used for detection of disease via noninvasive technique. [3]

Furthermore, in other aspects, most of the reported works using electrical impedance helps to detect breast cancer in which it attempts to reconstruct anatomical images of the mammary tissues from bioimpedance measurements to establish the location of a possible cancerous tumor in the preclinical state (diameter less than or equal to 1 cm) [4-6].

**Electrical Properties of biological tissues**

In the early 1900s, researchers discovered a groundbreaking method for assessing the health and viability of cells by examining their electrical properties. These properties are crucial indicators and are influenced by various factors such as the cell’s physiological condition, its structural characteristics, any existing pathological issues, and notably, the frequency of the electric signal used in the measurement.

At lower frequencies, when an electric field is applied, the electrical current primarily flows through the extracellular fluid, effectively traveling between the individual cells within the tissue. This phenomenon can be likened to how a stream flows around rocks. It provides insight into the interactions between neighboring cells.

In contrast, at higher frequencies of the applied electric field, the current can penetrate the cell membranes, traversing both the intracellular and extracellular fluid. This is analogous to the stream flowing through the rocks. This high-frequency behavior gives researchers a more intricate view of the internal structure and composition of the cells.

For the field of tissue engineering, this discovery has profound implications. To study the behavior and activity of cells within a tissue engineered cell construct, scientists can apply an alternating current (AC)
electric field to the cell culture. By measuring the passive electrical response of the cells, which means observing how they react naturally to the electric field without any external manipulation, researchers can gain valuable insights. Importantly, this method is non-invasive, meaning it does not harm the cells, and it does not require labeling or tagging of the cells, which is a significant advantage for tissue engineering applications.

Additionally, the electrical properties of tissues exhibit interesting variations depending on the frequency of the applied electric field. These variations manifest as α-, β-, and γ-dispersions. The α-dispersion, occurring at lower frequencies (ranging from 10 Hz to 10 kHz), is closely associated with the ionic environment that surrounds the cells. Understanding this dispersion is particularly important for medical applications because many of the critical differences between pathological and normal tissue can be observed in this frequency range. [7][8]

Moreover, variability of bioimpedance values between patients was seen because of number of reasons which include different electrode and tissue contact impedances related to fluid content of the saliva, slight variations in pressure applied between the probe and tissue and inherent patient to-patient tissue variation.

**Bioimpedance and Oral Squamous Cell Carcinoma**

Oral squamous cell carcinoma (OSCC) is one of the most aggressive epithelial malignancies with more than 200,000 new cases occurring per year in which the Indian subcontinent occupies one-third of the total cases in the world. Inspite of various newer advancements and researches the oral squamous cell carcinoma has the least survival rates. Diagnostic delay is considered as the major factor that is responsible for the disease progression. [3]

The value of bioelectric impedance is less in cancerous tissue when compared with the normal tissue. This is because in comparison to normal tissue, cancerous tissue has more cellular water and salt content, packing density, transformed membrane permeability, and cell orientation, and therefore, there is increased conductivity as it is inversely related to impedance.[7] Conductivity is a measure of the mobility of ions in the extracellular fluid in the presence of an electric field. Electrical conductivity is tissue specific and therefore the tissue composition determines travel of
Factors like increased cellular water and salt content, altered membrane permeability, changed packing density and different orientation of cells is found in OSCC which further leads to high conductivity and therefore OSCC tissue shows lower values of bioimpedance in comparison with normal tissues.[7] Ching et al conducted a study related to the use of bioimpedance in the screening of squamous tongue cancer based where the findings in study revealed that bioimpedance potentially provides a promising technique for screening of squamous cell carcinoma of tongue. Tongue cancer is usually associated with the squamous cell carcinoma (SCC) which is a malignant neoplasm of mucosal origin and often causes abnormality of the covering mucosa of the oral cavity.[9]

It avails benefits such patients who are at high risk (smokers, alcoholics, and people chewing betel nuts) and may suffer from tongue cancer to have regular tongue cancer screenings at home. Relative low-cost, instant results, requires little training The advantage of this method, as a potential screening test over the current screening methods, is that: it has a; and therefore, could be easily used in primary care or in developing countries where the organizational structure and economic factors limit national screening programs. The potential advantages of real-time screening tests include: a reduction in patient anxiety; improved patient compliance; and the ability to repeat inadequate tests immediately.[10]

Over time, bioimpedance has emerged as a more effective screening method compared to existing techniques. It offers immediate results, is cost-efficient, and requires minimal guidance. This makes it suitable for use at the grassroots level in countries facing barriers to nationwide screening programs. The advantages of immediate screening include reduced patient anxiety, improved patient cooperation, and the ability to quickly repeat inaccurate tests.[11]

Conclusion

Over the years, bioelectrical impedance has come up as a superior screening device over the screening techniques that exists. Bioelectrical impedance has a upper hand due to immediate results, cost-effectiveness, and involving little guidance. Therefore, it can be comfortably used at a very basic level in
countries, where multiple number of problems limit countrywide screening programs. The probable advantages of immediate screening tests are decreased patient anxiety, enhanced patient compliance, and the ability to repeat erroneous tests instantly.

REFERENCES


