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Role of Biomarkers and Biosensors with Artificial Intelligence in Early Diagnosis of Oral Cancer: A Review

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Abstract:- Oral cancers rank 6th most common malignancy in the world with delayed clinical detection and poor prognosis. Sometimes clinicians fail to suspect the malignant nature of the lesion and treat it by empirical procedure. Since oral cancer has a poor prognosis early detection and appropriate treatment are essential to improve the life expectancy of the patients. Before the advent of artificial intelligence, cancer diagnosis and treatment relied on histological grading of biopsy and TNM staging. Immediate biopsy of ill-defined or innocuous appearing lesions is impractical in early screening and is not advocated. With the advancement of information technology, artificial intelligence holds great promise in terms of assessing diagnosis by predicting outcomes based on the datasets provided using algorithms. Artificial intelligence can be used to analyze the biomarkers accurately which helps in understanding the pathogenesis and prognosis of oral cancer. Detection of oral cancer ranges from traditional methods of visual inspection and biopsy to current methods of detection using artificial intelligence combined with smartphone-based probes.

Keywords:- *Artificial Intelligence, Oral Cancer, Machine learning, Deep Neural Network.*

I. INTRODUCTION

Oral cancer has a poor prognosis and is an important public health problem globally [11]. In the head and neck region, oral squamous cell carcinoma accounts for 90% of all cases of cancer. [14]. To overcome this early cancer control interventions and therapies are essential to improve the quality of life and also to increase the life expectancy of these patients. Various challenges oral health care workers face during screening the population include difficulty in approaching a dentist for an opinion and lack of dissemination of information regarding symptoms of oral cancer for the population. Because of knowledge limitations sometimes dentists fail to diagnose oral cancer at the early stage and treat it empirically [17]. Biopsy is the only method of definitively diagnosing a cancer but it has certain limitations such as being an invasive procedure, requiring more time for analysis, repetitive invasive biopsies are cumbersome, and detection of oral cancer is not possible in the initial stage.

The applications of artificial intelligence algorithms for early oral cancer detection have recently been proposed [1]. Artificial intelligence is a machine's ability to solve problems based on input data that can mimic or exceed human capabilities of reasoning, imagination, understanding, perception, recognition, etc. [18]. It is revolutionizing the traditional aspects of dentistry [19].

II. ARTIFICIAL INTELLIGENCE

Various studies concluded that Artificial Intelligence can analyze enormous datasets precisely to diagnose oral cancer in contrast to conventional methods by assessing risk factors and predicting oral cancer biomarkers [11] [Figure 1]. In order to increase the accuracy of diagnosis, artificial intelligence systems integrate new patient information with their dynamic datasets [18].

A study conducted by Uthoff et al described the design and implementation of a low-cost oral screening device for detecting Oral Cancer by using smartphone-based images and artificial intelligence for high-risk populations residing in remote locations with limited access to healthcare facilities [20].

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In a study by Das et al, Deep Conventional Neural Network [CNN] was utilized for the assessment of segmented keratin regions for detecting keratin pearls using texture-based features. Accuracy for keratin pearls detection was 96.8% [3]. Another study conducted by Das et al described Oral Cancer screening by detecting the nuclear changes from histopathological images using computer-aided tools. [4].

Rahman et al described a system that exemplified a high level of precision in identifying unknown cases using texture, color, and shape features. This system has 100%, 99.4%, and 100% accuracy with color, shape, and texture features respectively [5].

Deep learning network called Fabnet was proposed by Fraz et al. This system made it possible to segment and accurately delineate microvessels and nerves in H and E-stained histology images even in challenging cases [6].

In a study by Yang et al., a deep-learning neural network performed better at correctly identifying oral squamous cell carcinoma in medical images than pathologists [2]. Deep neural networks have the highest accuracy rate of 96% compared to other systems because they consist of multiple layers of interconnected neural networks, each layer building upon the previous layer to enhance and optimize the prediction. Various datasets integration for Deep learning is required for the most effective method of diagnosis which includes case history, risk factors, fluoroscopy, cytology, endoscopy, radiography, clinical examination, histopathological images, and biopsy [21].

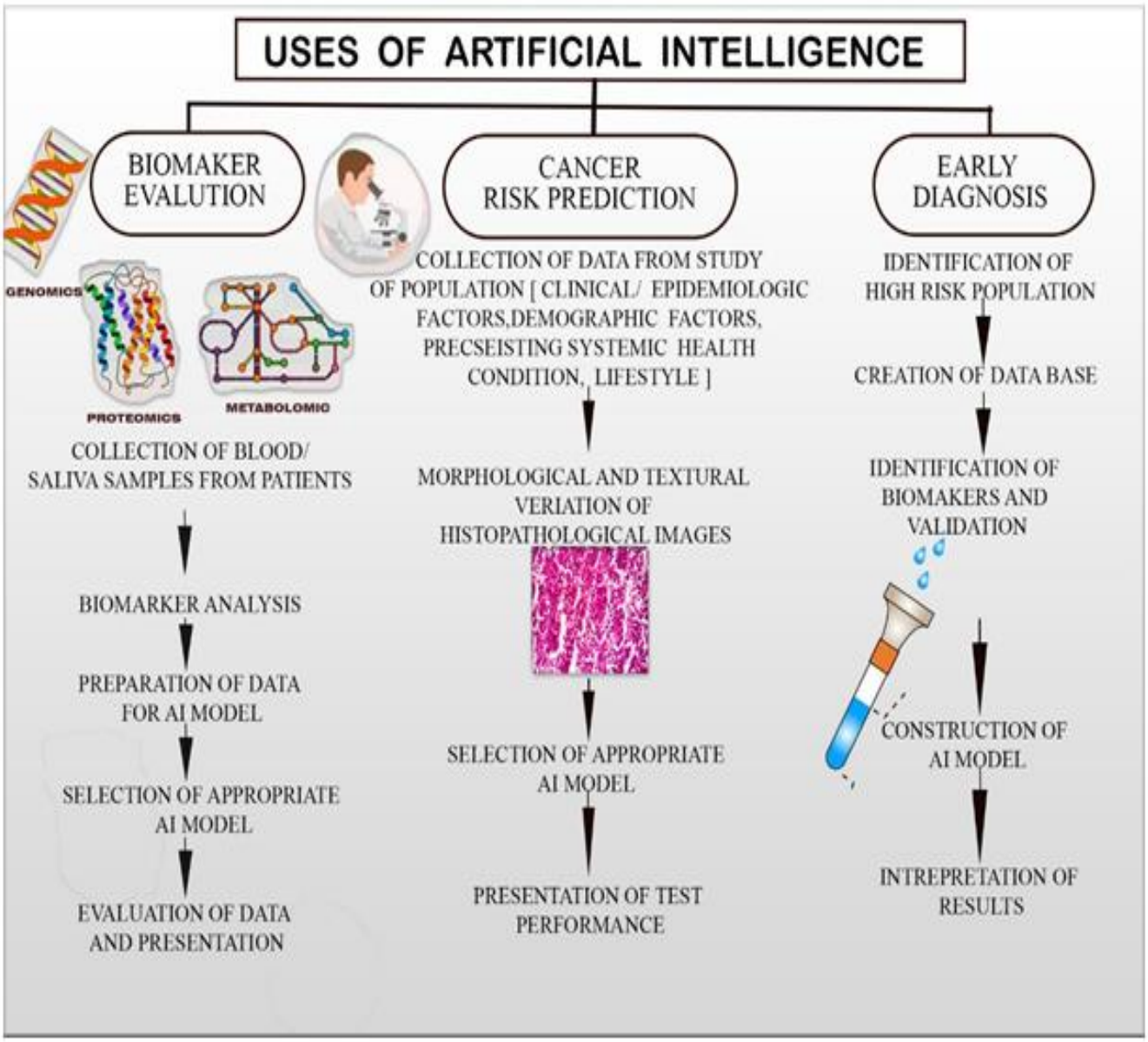

Fig 1 : Flow diagram showing uses of Artificial Intelligence

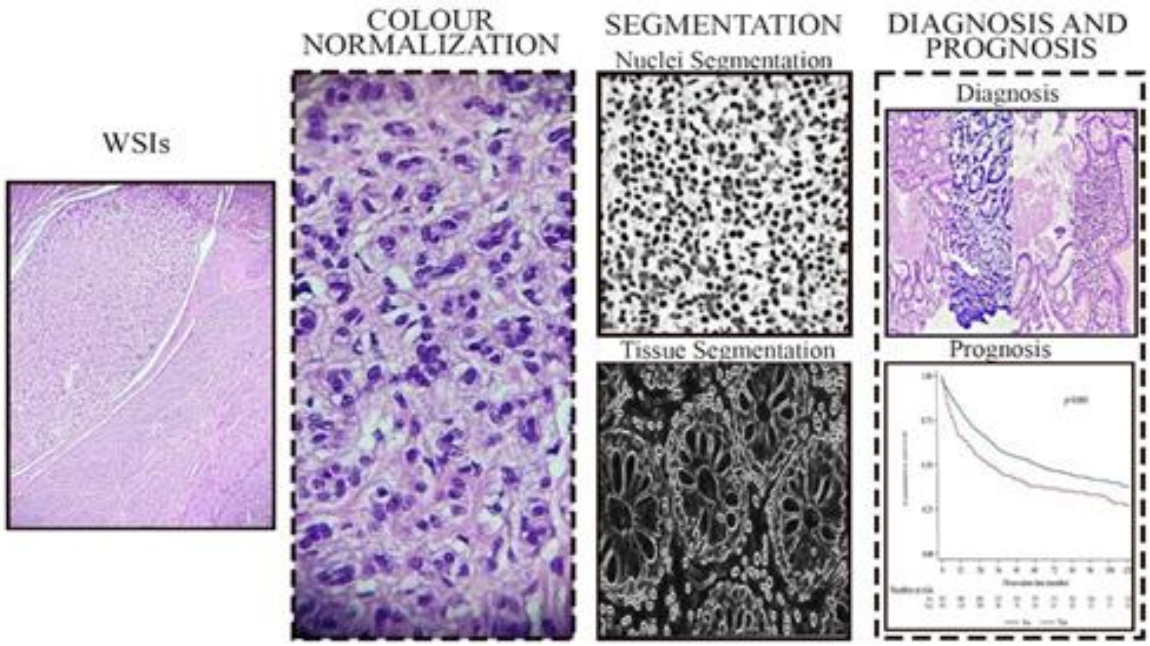

Fig 2 Showing use of Deep Neural Network in nuclei and tissue segmentation for detection of oral cancer at the early stage.

➢ *Uses of Artificial intelligence*

- Artificial Intelligence systems can abet clinicians in the process of accurate and efficient diagnosis of the case.
- Requires less time in diagnosing the case.
- Professionals can use Artificial Intelligence as a supplementary tool for increasing the precision of diagnosis, treatment planning, and predicting treatment outcomes.
- These systems can be used whenever secondary opinion is required to improve the accuracy of diagnosis.

➢ *Advantages of Artificial Intelligence in Detecting Oral Cancer*

- Screening high-risk populations.
- Detection of oral cancer biomarkers.
- Prediction of lymph node metastasis.
- Abet clinicians in accurate and efficient diagnosing the case, treatment planning, and predicting prognosis.[1]
- Extrapolation of malignant transformation of oral premalignant disorders.
- Helps in diagnosing of Oral Cancer in population residing in remote areas with limited access to healthcare facilities using smartphone-based probes at the early stage.
- Combination of various datasets such as history, risk factors, clinical features, histopathological images, and radiographic images aids in the risk assessment of oral cancer.
- Assist pathologists in decision-making with greater precision and can obtain information that may be missed with manual visualization of slides.[1]

➢ *Limitations of Artificial Intelligence*

- Data available to train the machines is limited.
- Good quality images with high contrast are required for identifying subtle changes.
- Risk of missing the data.
- Requires a huge amount for building Infrastructure for storage and training AI models.

➢ *Biomarkers*

Biomarkers are cellular indicators of physiological state that are helpful in the detection of cancer at the incipient stage as these indicators change during the disease process [16]. Biomarkers help in early detection of oral cancer in asymptomatic patients which increases the chances of survival and decreases the complications or morbidities. Artificial intelligence can be used to analyze large amounts of data on oral cancer biomarkers such as genome, epigenome, proteome, metabolome, microbiome, and transcriptome datasets [13].

During past decades salivaomics has served as a valuable diagnostic tool that has received increasing attention in early oral cancer diagnosis compared to blood as it is noninvasive, simple, repeatable, accurate, economical, and does not require special storage conditions or a skilled clinician [12].

➢ *Clinical applications of Biomarkers*

- Oral Cancer risk assessment
- Screening high-risk population
- Accurate diagnosis
- Early detection of Oral Cancer
- Prediction of prognosis
- Prediction of response to therapy
- Cancer surveillance and monitoring

➢ *Biosensors*

The flourishing field of biosensing and point-of-care smartphone-based diagnostics using artificial intelligence play a significant role in the detection of Oral Cancer. Biosensors and artificial intelligence are two innovative

technologies that revolutionize the way of diagnosing and treating illness [9]. Biosensors enable risk assessment and monitoring of patient's health [Figure 3]. Artificial intelligence can analyze vast datasets to identify patterns and predict outcomes. These two systems will continue to play a crucial role in early diagnosis and transforming healthcare for the better.

The use of Machine learning algorithms has vast advantages that program the cumbersome and complex process of retrieving information, data processing, and analyzing it by using biosensors [8].

The beneficial qualities of Biosensors include high sensitivity, high specificity, rapid performance, low cost, and accuracy [8].

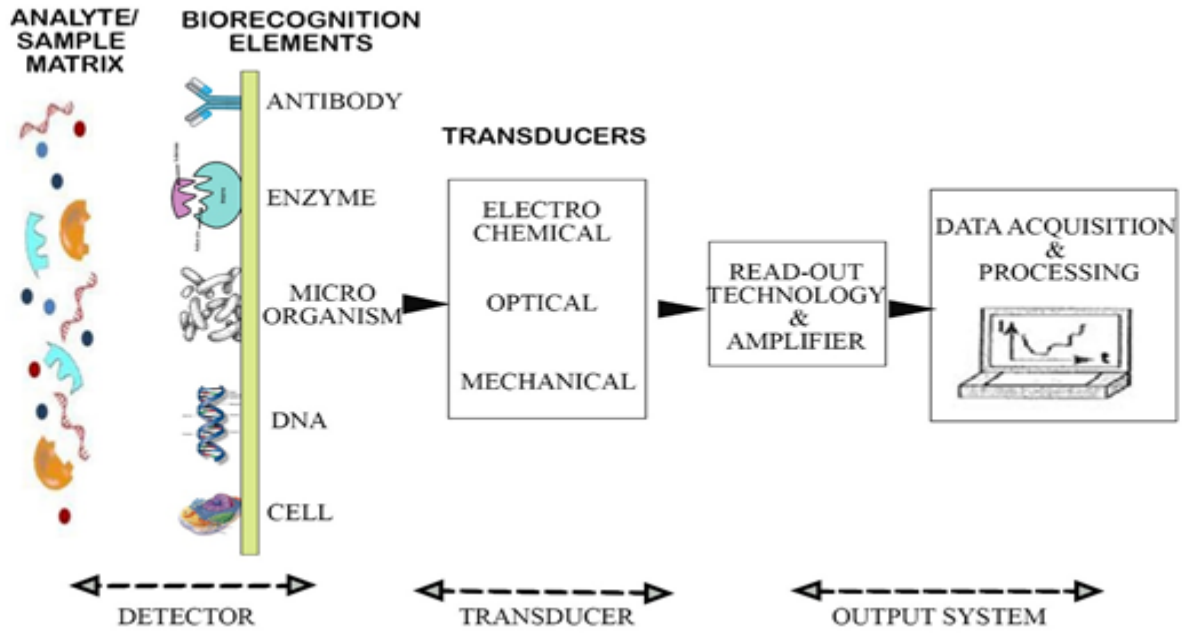

Fig 3 Showing analysis of sample matrix using Biosensors.

III. DISCUSSION

In the early stages, Oral Cancer has a high cure rate of around 80%; in the advanced stage, the cure rate is only 20% [22]. The early stages of oral cancer can appear as subtle, asymptomatic, areas with superficial surface color and textural changes, areas of induration and ulceration, and sometimes can be hidden in folds of mucosa at the base of the tongue that are most difficult to detect[15]. Traditional methods of oral cancer diagnosis before the dawn of artificial intelligence include physical examination by professionals, past medical history, imaging tests, histopathological examination, biopsies, and vital staining techniques. Traditional methods along with the integration of artificial intelligence help in early Oral Cancer diagnosis by identifying subtle changes in the lesion.

➢ *Symptoms suggestive of possible Oral Cancer*

- Early lesions may present superficial surface color changes of red, white, or mixed red-white.
- Patients complaining of discomfort with speech and or swallowing
- Patients complaining of pain especially associated with the tongue region.
- Mobile teeth/ nonvital teeth/displacement without any periodontal problems.
- If ulcers persist for more than 3 weeks.
- Anesthesia and earache without any disease.

First-line method of identifying oral lesions by visual oral examination [10]. This approach has some drawbacks because oral cancers are diagnosed when the function is compromised and are indistinguishable from benign lesions and precancerous lesions. The patient usually visits the dentist complaining of symptoms when the lesion measures over 2cm or more. A visual oral examination depends on the level of expertise of the examiner and requires experience to predict changes at an early stage [10]. Tissue Biopsy followed by histopathological assessment is the most reliable for differentiating and diagnosing stages of oral cancer but it has certain limitations such as this procedure is invasive and detection of early lesion is not possible. Biomarker detection using Artificial intelligence helps in the early indication or progression of the disease. Feature extraction from medical images by CNN improved the ability for automated cancer detection at an early stage using artificial intelligence [7].

IV. CONCLUSION

AI techniques guide professionals in a wide variety of ways, from reducing the chairside time for diagnosis to achieving excellent infection control, classifying suspicious mucosal changes of lesions, gene expression analysis, and microbiome profiling. However, AI is still under development because it requires a large amount of high-quality data to train algorithms. To assess the clinical effectiveness of Artificial Intelligence techniques in the early cancer detection of high-risk populations, further

investigation is needed. Detection of rare types of Oral Cancers can be time-consuming, expensive, and sometimes can produce false positive or false negative results so a huge number of datasets is required for training the machine before diagnosing any case.

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