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Image Based Methods Available For Early Detection of Oral Cancer: A Review

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ABSTRACT: Now-a-days Oral cancer has become a very common disease. However, it can be diagnosed early and treated promptly. Our aim is to review the automated diagnostic techniques available for early detection of oral cancer. Several research studies have been done on different feature indicative of oral cancer. The following review study reveals that features like energy, contrast, entropy, texture, color, etc. have been studied with different levels of accuracy.These studies indicate that further studies are necessary where attempt may be made to study as many features as possible indicative of oral cancer and also to consider all symptoms that may be considered as confounding factors, so as to achieve maximum accuracy.

KEYWORDS: Oral cancer,H&E,OSF, SCC,AgNOR,brush biopsy.

I. INTRODUCTION

Oral Cancer (OC) is the sixth most common cancer in the world[1]. In India (specially in North-East) it is the most common malignant neoplasm[2].India continues to report the highest prevalence of oral cancers globally with 75,000 to 80,000 new cases of such cancers reported every year[3]. In North-east India, incidence of tobacco related oral cancers is about 33%[4]. It is known that early detection of cancer is vital for successful diagnosis and prognosis of the disease. The Indian picture is very dismal with 80% of cancer diagnosed only in the advanced stage. The WHO states that low-income and disadvantaged groups are generally more exposed to avoidable cancer risk factors, such as environmental carcinogens, tobacco use, alcohol abuse and infectious agents. These groups have less political influence and less access to health services. Moreover, due to the lack of education that can empower them to make decisions to protect and improve their own health, they remain at risk of contacting the disease. Histopathological images have widely been used in the differential diagnosis of normal, oral precancerous (oral sub-mucous fibrosis (OSF)) and cancer lesions. In this article we try to give a picture about the methods/tools available for early diagnosis of oral cancer.

II. METHOD OF DIAGNOSIS OF ORAL CANCER

An oncologist or an ENT specialist may carry out several examinations for detection of oral cancer. These may include Biopsy, Endoscopy and Imaging tests. Screening for oral cancer may be done during a routine check-up by a dentist or medical doctor. The examination will include looking for lesions, including areas of leukoplakia (an abnormal white patch of cells) and erythroplakia (an abnormal red patch of cells). Leukoplakia and erythroplakia lesions on the mucous membranes may become cancerous.

If lesions are seen in the mouth, the following procedures may be used to find abnormal tissue that might develop into oral cancer:

- Toluidine blue stain: A procedure in which lesions in the mouth are coated with a blue dye. Areas that stain darker are more likely to be cancer or become cancer.

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- Fluorescence staining: A procedure in which lesions in the mouth are viewed using a special light. After the patient uses a fluorescent mouth rinse, normal tissue looks different from abnormal tissue when seen under the light.
- Exfoliative cytology: A procedure to collect cells from the lip or oral cavity. A piece of cotton, a brush, or a small wooden stick is used to gently scrape cells from the lips, tongue, mouth, or throat. The cells are viewed under a microscope to find out if they are abnormal.
- Brush cytology: The removal of cells using a brush that is designed to collect cells from all layers of a lesion. The cells are viewed under a microscope to find out if they are abnormal.
- Biopsy: Small bits of tissue are collected from suspicious areas or growths by a surgeon or endoscopist and the tissue is processed for histopathological examination.

III. PRE-MALIGNANT CONDITIONS OF ORAL CANCER

Leukoplakia
The term describes a white plaque that does not rub off and cannot be clinically identified as another entity. Most cases of leukoplakia are a hyperkeratotic response to an irritant and are asymptomatic, but about 20% of leukoplakia lesions show evidence of dysplasia or carcinoma at first clinical recognition.

Erythroplakia
An erythroplakia is a red lesion that cannot be classified as another entity. Far less common than leukoplakia, erythroplakia has a much greater probability (91%) of showing signs of dysplasia or malignancy at the time of diagnosis. Such lesions have a flat, macular, velvety appearance and may be speckled with white spots representing foci of keratosis.

Lichen planus
The premalignant or malignant potential of lichen planus is in dispute. Some believe that the occasional epithelial dysplasia or carcinoma found in patients with this relatively common lesion may be either coincidental or evidence that the initial diagnosis of lichen planus was erroneous.

Other Lesions
Premalignant changes arising in other oral lesions are uncommon. White lesions such as linea alba, leukoedema, and frictional keratosis are common in the oral cavity but have no propensity for malignant transformation. The health professional can usually identify them by patient history and clinical examination.

IV. RISK FACTORS

Tobacco/Alcohol Use

Most cases of oral cancer are linked to cigarette smoking, heavy alcohol use, or the use of both tobacco and alcohol together. Using tobacco plus alcohol poses a much greater risk than using either substance alone.

HPV

Infection with the sexually transmitted human papillomavirus (specifically the HPV 16 type) has been linked to a subset of oral cancers.

Age

Risk increases with age. Oral cancer most often occurs in people over the age of 40.

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Sun Exposure

Cancer of the lip can be caused by sun exposure.

Diet

A diet low in fruits and vegetables may play a role in oral cancer development.

V. RELATED WORK

A detailed review of researchstudies in early detection of oral cancer (as shown in **Table 1**) are discussed below:

The approach introduced by Rama Krishnan et al. [5] help the oral onco-pathologists to screen the histopathological section into normal, OSF (oral submucous fibrosis) without Dysplasia and OSF with Dysplasia. They stained the biopsy sections with H&E. Here the optical density of pixels are represented as matrix quantized as integers from 0 to 255 for each fundamental color (Red, Green, Blue), resulting in an $M \times N \times 3$ matrix of integers. They have extracted textural changes using Higher Order Spectra (HOS), Local Binary Pattern (LBP), and Laws Texture Energy (LTE) from the histopathological images (normal, OSFWD and OSFD). They have used five different classifiers: Decision Tree (DT), Sugeno Fuzzy, Gaussian Mixture Model (GMM), K-Nearest Neighbor (K-NN), Radial Basis Probabilistic Neural Network (RBPNN) to find out the best one. Finally, they have proposed a novel integrated index called Oral Malignancy Index (OMI) using the HOS, LBP, LTE features, to diagnose benign or malignant tissues using just one number. Their main objective is to help the clinicians in making a faster and more objective detection of benign/malignant oral lesions. Here, the studied feature was textural change of oral sub mucous fibrosis. The performance analysis of the results they obtained is:Accuracy 95.7%, sensitivity 94.5% and specificity 98.8%.

The study done byAnuradha. K et al. [6]can be used to segment and classify oral cancer at an earlier stage. Here they have used Marker Controlled Watershed segmentation for detection of the tumor. The features extracted here are energy, contrast, entropy, correlation and homogeneity. For this extraction, they have used Gray Level Co occurrence Matrix (GLCM). Support Vector Machine makes final classification i.e. benign or malignant. They studied the features Energy, Contrast, entropy, correlation and homogeneity. They obtained accuracy for the proposed system is 92.5%.

The approach studied by Rama Krishnanet al. [7] can be used for the characterization of normal oral mucosa (NOM) in respect to thickness and textural properties of its entire epithelial layer. According to them histological images of oral mucosa depict that both thickness and tissue architecture at cellular and tissue level undergo change, as mucosa converts from normal to precancerous or cancerous state. Here the thickness and fractal dimension of the mucosal epithelium of NOM and oral sub-mucous fibrosis (OSF) condition have been computed using 83 normal and 29 OSF images of oral mucosa. Their result shows significant delineation between NOM and OSF in respect of both the epithelial thickness (in mm) and fractal dimensions.

In another approach by Rama Krishnan et al. [8], incisional biopsy was done on OSF (Oral submucous fibrosis) patients. Biopsy tissues were processed with paraffin. From these, five (5) micrometer thick tissue sections were stained by haematoxylin and eosin (H&E). Various cells in sub-epithelial connective tissue (SECT) of OSF cases were analyzed. They have used a cell filtering technique to segment out target features for normal oral mucosa (NOM) and OSF sample images. Compactness and eccentricity feature were studied here. They obtained results with an accuracy of 88.69%, sensitivity of 90.469% and specificity of 87.54%.

In study of Rajput et al. [9], brush biopsies were collected from suspicious patients. Then silver staining of smears (Ploton's one-step method) was done and the numbers of AgNORs were counted in 100 squamous epithelial cell nuclei per slide. Their method gives the following results:

i) Sensitivity 91.176% and specificity 100% (for PAP analysis). The positive and negative prediction values were 100% and 76.92%, respectively.

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ii) Sensitivity 100% and specificity 100%. (for AgNOR analysis). The positive and negative prediction values were 100% each.

In 2003, Brockenbroughet et al. [10] made a scan software. Here scans were done with axial orientation of the mandibular occlusal plane. Scans were performed on 1 of 3 CT scanners (Highlight, LightSpeed, or CTI Systems; General Electric Medical Systems, Milwaukee, Wis). For obtaining the images they have used bone algorithm. Using the DentaScan software package, computer tomographic examination was post processed. From an axial image at the roots of the teeth, a curve was designed. DentaScan gives tumor histologic type, presence or absence of bone invasion, and final pathologic staging. According to them it is an accurate method of preoperative evaluation for mandibular invasion in patients with squamous cell carcinoma (SCC) of oral cavity. The feature studied here is cortical destruction or erosion.

Roblyer et al.'s [11] approach presents a new method to objectively delineate neoplastic oral mucosa using autofluorescence imaging. Here, autofluorescence images were obtained from the patients with oral lesions and from these images, 276 measurements from 159 unique regions of interest (ROI) sites corresponding to normal and confirmed neoplastic areas were identified. They have developed a simple classification algorithm based on the ratio of red-to-green fluorescence. Autofluorescence images were obtained from the oral cavity of 56 patients with clinically abnormal lesions and 11 normal volunteers. They divided the data into a training set and a validation set. Data acquired from the first 39 patients and 7 normal volunteers imaged between June 2006 and January 2008 were allocated to the training set, and were used to develop an algorithm for the detection of neoplasia. Data acquired from the subsequent 17 patients and 4 normal volunteers imaged between March and June 2008 formed a validation set and were used to test the performance of this algorithm relative to histopathology. With the help of a Multispectral Digital Microscope, white light and autofluorescence images were obtained at 365, 380, 405, and 450 nm excitation. Patients were imaged either in an outpatient clinic or in the operating room under general anesthesia prior to surgery. A physician positioned the patient and microscope so that the suspicious lesion or area of interest was clearly in the field of view of the device. Clinically normal areas distant from or contralateral to the lesion were also imaged. They considered autofluorescence imaging is a noninvasive tool for the detection of oral neoplasia.

Table 1: Some methods/tools used for early detection of oral cancer

Sl. No.	Author/ Year	Topic	Features Studied	Accuracy obtained
1	Rama Krishnan et al., February 2012[5]	**Automated oral cancer identification using histopathological images: A hybrid feature extraction paradigm**	Texture	Accuracy 95.7%, Sensitivity 94.5%, Specificity 98.8%
2	Anuradha. Ket al., 2013[6]	**Statistical feature extraction to classify oral cancer**	Energy, Contrast, Entropy, Correlation, Homogeneity	Accuracy 92.5%.
3	Rama Krishnan et al., 2010[7]	**Structural markers for normal oral mucosa and oral sub-mucous fibrosis**	Shape feature like thickness, Texture of epithelial layer	-
4	Rama Krishnan et al., 2009[8]	**Automated classification of cells in sub-epithelial connective tissue of oral sub-mucous fibrosis—An Support vector machine (SVM) based approach**	Compactness Eccentricity	Accuracy 88.69% Sensitivity 90.469% Specificity 87.54%
5	Rajput et al., 2010[9]	**Early detection of oral cancer: PAP**	Texture	-

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		and AgNOR staining in brush biopsies	Color Shape	
6	Brockenbroughet et al., 2003[10]	**Denta Scan as an Accurate Method of Predicting Mandibular Invasion in Patients With Squamous Cell Carcinoma of the Oral Cavity**	Shape feature like cortical destruction, erosion	Sensitivity 95% Specificity 79% Positive predictive value 87% Negative predictive value 92%
7	Roblyer et al., 2009[11]	**Objective Detection and Delineation of Oral Neoplasia Using Autofluorescence Imaging**	-	Sensitivity 95.9% Specificity 96.2% (in the training set) Sensitivity 100% Specificity 91.4% (in the validation set)

VI. CONCLUSION AND FUTURE WORK

It is known that early detection of cancer is vital for successful diagnosis and prognosis of the disease.If any method can be developed for screening of oral cancer then it is going to be a big step towards controlling the disease. For a screening method to be efficient it is also important that the method of diagnosis is as accurate as possible. Automating the method of diagnosis will contribute in enabling quick and accurate diagnosis and also handle a large number of cases. All the above researchers have made a good effort to detect the disease at an early stage. The aim of the study was to make a review so as to continue the study in this line. Our attempt will be to study as many features as possible indicative of oral cancer and also to consider all symptoms that may be considered as confounding factors.

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BIOGRAPHY

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