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Review

Analysis of images for detection of oral epithelial dysplasia: A review

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ABSTRACT

This paper provides a review of various image analysis approaches that have been previously used for recognition of dysplasia in images of the epithelium of the oral cavity. This domain has become especially admissible with the uncovering of the importance of image analysis which can probably be an aid to subjective diagnosis by histopathologists. Oral malignancy is a rampant form of cancer found among people of the Indian subcontinent due to various deleterious habits like consumption of tobacco, areca nut, betel leaf etc. Oral Submucous Fibrosis, a precancer, whose pathological category falls between normal epithelium and epithelial dysplasia, is caused because of these habits and can ultimately lead to oral cancer. Hence early detection of this condition is necessary. Image analysis methods for this purpose have an enormous potential which can also reduce the heavy workload of pathologists and to refine the criterion of interpretation. This paper starts with a critique of statistics of oral carcinoma in India and distribution of cancer in intra-oral sites and moves on to its causes and diagnostic approaches including causative agents, problems in curative approach and importance of image analysis in cancer detection. The various image analysis methods to appraise the cytological and architectural changes accompanied by Oral Epithelial Dysplasia in the images of the oral epithelial region have been described in relation to 2005 WHO Classification System and it was found that in future, analysis of images based on the mentioned methods has the potential in better interpretation and diagnosis of oral carcinoma.

Introduction

Statistics of oral cancer in India

Cancer of the oral region is single most dominant and lethal health issue faced by humans at present. 575,500 new cases are diagnosed, and 335,000 deaths occur worldwide each year, but the frequency is particularly high in East Asian countries mainly in South and Central domain (India, Indonesia, Thailand, Sri Lanka, Bangladesh, and Pakistan) [1]. Oral cancer accounts for only 2–4% in western nations but around 30–40% of all malignant neoplasms in the Indian subcontinent [2]. The recurrence of oral benign neoplastic ailment is elevated in India because of addictive oral habits, geographic and ethnic elements. A detailed study from Allahabad (Northern India) gave evidence those benign oral sores, which had the potentiality to turn into cancer, was widely distributed in patients visiting tertiary grade infirmaries in their relevant areas [3]. A standardized study which was conducted in Manipur state in India showed that yearly incidence of oral carcinoma was 21.4 for each 100,000 subjects [4]. Several deliberations have reflected that incidence of oral carcinoma has been increasing in females of the Indian subcontinent and its rank is first in men and third in women. Data collected from Tata Memorial Cancer Hospital, situated in Mumbai, showed that ratio of male to female incidence rate in South India due to oral cancer was 0.6:1 [5]. The age-standardized prevalence rates (ASR) differ from 15.9 in each 100,000 in Trivandrum to 6.5 in every 100,000 in Bangalore among males and from 10.6 per 100,000 in Chennai to 7.2 in Bombay among females [6]. In a study conducted by Sanghvi et al., it was shown that incidence of oral neoplastic impairment is in greater extent in people aged more than 50 years [7]. The 5-year survival rate for this cancer is lowest amongst all cancers and one main reason for this can be that it is not investigated in its former stages. If noticed early, the likelihood of survival quota is strikingly satisfactory in equivalence to other cancers [8].

Distribution of cancer in intra-oral sites

The benign lesions which can turn malignant are mostly present in the gingivobuccal cavity especially in the lower alveolus, buccal mucosa and retromolar trigone. These lesions are collectively is also termed as the “Indian Oral Cancer” since they amount to 60% of almost entire cancers in India. The “Indian Oral Cancer” originated mostly from “Oral Submucous Fibrosis”(OSF) which is a precancerous condition. In the western countries, the scenario is different as the majority of

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oral cancers are established in the level of mouth and tongue [9]. The oral cancer of Lip and Palate was observed in male cases who smoked tobacco. Another study described that buccal covering layer (50%) is the frequent site considered for oral carcinoma in India succeeded by a front two-thirds portion of the tongue (24%) [10,11].

Causes and diagnostic approaches

Causative agents

The agents which can cause oral cancer are tobacco and related products, alcohol, genetic liability and hormonal aspects. Varying lifestyles, low socio-economic status, cultural, ethnic and geographical factors have contributed to the increased intake of tobacco and alcohol. All the subjects considered in various studies had the habit of consuming tobacco [13]. Tobacco can be consumed either by smoking or chewing. Tobacco can be chewed in plain form, in commercially accessible packets with supplements like gutkha and also in addition to pan, lime and betel nut. Tobacco is consumed by male as well as female subjects. Alcohol consumption in addition to tobacco consumption is noticed majorly in male subjects. [13] The association of oral cavity cancer or precancers like OSF with the usage of tobacco is critical. If in addition to tobacco, alcohol is consumed, then the risks of developing mouth cancer are very high. The relevance of cancer of the mouth in the study ensemble was found to be 0.3% if associated with only tobacco consumption. However, the prevalence was found to increase to 1.12% when associated with both tobacco and liquor consumption [13]. It was perceived that smoking in addition to alcohol consumption was repeatedly correlated with cancer of palate while that of chewing tobacco was intermittently linked with carcinoma of the alveolus and buccal region mucosa [13]. In the study, it was concluded that tobacco escalates the likelihood of advancing oral cancer. The possibility ratio for carcinoma of the oral region was roughly calculated as 2-fold in smokers, 4-fold in chewers and 4-fold in chewer-smokers in contrast to non-chewer and non-smokers [7]. It has been specified that liquor consumption may not lead to malignancy, but there is increasing proof that an extensive section of the tumor, might be decided through its early, harmful and destructive metabolite acetaldehyde, after consumption of alcohol [14]. Acetaldehyde originates from ethanol in the mucosal epithelial region acted upon by alcohol dehydrogenases, but much greater levels are formed from microbial oxidation of ethanol subsequently by the oral microbial flora. Hence subjects who consume alcohol are in increasing danger of getting carcinoma because of this synergistic process [14]. In some cases, where contemporary surgical methods are still followed, after the excision of the primary cancerous tissue, an increase in the range of occurrence of secondary tumours have been reported. This is also experienced in multiple cancers or field cancerization. Aforementioned has lead to the increased mortality estimate of oral carcinoma [12].

Problems in curative approaches

Most of the oral cancer instances reported are fully developed and at a progressive stage [17]. This indicates that an authoritative figure of the rural population will not pursue the medical responsibility until the abrasions become indicative and show up a satisfactory large size [18]. The reason for this may be low education rate and disregard on account of the patients. Though emerging lifestyles and food habits can be deemed as contributing factors for this, low dentist to community ratio can also be considered for the problem of bad oral health [19]. As per World Health Organization (WHO) recommendation, the ideal dentist to population ratio should be 1: 7500 but in India, the ratio is 1: 22,500 which is appalling [15]. In 2004, Indian subcontinent had only 1 dentist for 2.5 lakh people in rural areas whereas around 10,000 mass in urban areas [16]. The problem is that three-fourths of the entire statistic of dentists is present in urban regions whereas urban areas constitute about one-fourth of the country's population [16]. Hence it is quite complicated to deal with oral problems in rural areas because of the above-stated difficulties.

Importance of image analysis in cancer detection

The standard histopathological analysis is entirely dependent on human expertise. Through its development, the classical diagnosis has also improved in the late 20th century. Computer based image analysis have been incorporated as medical diagnostic procedures in place of conservative surgical procedures [20–28]. Numerous histological features which differentiate neoplastic from normal tissues have been exhaustively described in various textbooks and publications [27]. In the routine of diagnosis, this detailed description is studied by pathologists and they use it in combination with their personal experience. This is considered as a huge responsibility undertaken by pathologists [29–31]. Since this process involves training, skills and experience, therefore various personal traits, fatigue and, the competence of the pathologist may be tested, and he may arrive at an incorrect decision. The preliminary attempts to implement image analysis systems for histopathological analysis has been described [30]. Using active contour methods, a perception arrangement for nucleus compendium was made [26,27]. A cell segmentation algorithm was proposed based on mean shift for clustering in colour space for image-guided conclusion support system in clinical pathology [28]. Another neural network methodology was proposed which used image pre-processing and feature extraction [29]. In another example, a system was proposed which was developed exclusively for images acquired from fine syringe aspiration which was in turn taken directly from the cancer lump. Features like area, symmetry, perimeter, radius, number, size, fractal dimensions, smoothness, and texture were measured and the feature vectors which were used for classification were mean value and standard deviation [30]. A cancer biopsy system was developed which involved image attainment and prosecution algorithms which were based on neural networks [31]. Machine vision techniques were utilized in developing analysis systems for cancer detection [32–34]. Since the operation of a cancer diagnosis is grounded in retaining and handling a huge volume of information, it is necessary to use computer technology to help the cultivation of expertise database [34]. Though in recent years, image analysis techniques have developed enormously, histopathological analysis of cancer has not been completely investigated [29,35–45]. The sub-standard inter-and intra-diagnostic correlation between individual pathologists provided further support to the claim, that computerized quantitative systems could supply support, not yet substitution, to the pathologist, and would be of uttermost value.

Features of oral epithelial dysplasia and their importance

Oral epithelial dysplasia is defined as a lesion in the oral epithelial region where cells exhibiting atypia substitute part of the thickness of the epithelium [46,47]. The alterations which accompany dysplastic changes are of significance in diagnosis and prognosis and are also termed as precancerous changes (for example OSF) [48]. The combination of architectural and cytological changes present in dysplasia defines the criteria of grading oral epithelial dysplasia and the grading system which is most widely followed is the WHO Classification system (Table 1) as it designates both architectural and cytological features of dysplasia in a conventional manner [49]. By analysing the architectural and cytological changes by image analysis, early detection is possible which may prevent the progression of oral precancer to oral cancer (Oral Squamous Cell Carcinoma). The various grades of dysplasia, by analysing the levels of architectural and cytological changes in Haematoxylin and Eosin stained images, are shown in Fig. 1 (see Table 2).