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Article

# Prevention of Oral Cavity Tumors: Precancerous Conditions and Diagnostics

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**Abstract:** This article is devoted to the relevance, etiological factors, pathogenesis, clinical course, and issues of early diagnosis of oral cavity cancer. Oral cavity cancer is one of the most widespread malignant diseases worldwide and is characterized by high mortality rates, largely due to its frequent detection at late stages. The main risk factors contributing to the development of the disease include tobacco consumption, alcohol use, chronic mechanical trauma, poor hygiene, and viral infections (particularly HPV). The article provides a scientifically grounded analysis of the stages of tumor development — the transition from normal epithelium through dysplasia and precancerous conditions to a malignant process. Special attention is given to precancerous conditions, including leukoplakia and erythroplakia, emphasizing their high risk of malignant transformation. Particular emphasis is also placed on the early clinical signs of the disease, such as non-healing ulcers, changes in mucosal color, infiltration, and bleeding. The article also covers modern diagnostic methods, in particular clinical examination, biopsy, and additional diagnostic technologies.

**Keywords:** Dysplasia, Carcinoma in situ, Invasive carcinoma, Metastasis, Betel (areca nut), Human papillomavirus (HPV), Leukoplakia, Homogeneous leukoplakia, Non-homogeneous leukoplakia, Verrucous leukoplakia, Erythroplakia, OSMF, Visual examination, Biopsy, Incisional biopsy, Excisional biopsy, Punch biopsy, FNAB, Brush biopsy.

## Introduction

Oral cavity cancer is one of the most pressing oncological diseases encountered in dentistry and maxillofacial surgery. It is a malignant tumor that develops from the mucous membrane of the oral cavity and, in most cases, presents as squamous cell carcinoma [1,2]. The disease may develop in the tongue, gums, buccal mucosa, palate, and lips, and is considered particularly dangerous because of its late clinical detection. Tumor progression proceeds through four stages [3,4]. The first stage is dysplasia, in which cellular atypia appears, nuclei enlarge, and mitotic activity increases. The second stage is carcinoma in situ, in which changes are confined to the epithelium and the basement membrane remains intact. The third stage is invasive carcinoma, in which the basement membrane is disrupted and the tumor invades deeper tissues. The fourth stage is metastasis, in which tumor cells spread to other regions, most commonly to the cervical lymph nodes [5].

Given the high mortality associated with late-stage detection, this article aims to provide a scientifically grounded synthesis of the etiological factors, precancerous conditions, and modern diagnostic methods relevant to the prevention and early identification of oral cavity cancer, with a view to informing clinical practice in dentistry and maxillofacial surgery.

**Methods**

This article was prepared as a narrative literature review on the prevention, precancerous conditions, and diagnosis of oral cavity tumors. Sources were drawn from standard textbooks of oral and maxillofacial pathology and oral medicine, together with epidemiological studies, systematic reviews, and clinical trials addressing global oral cancer incidence and mortality, precancerous lesions, risk factors, and diagnostic methods. Case definitions and disease classification followed the World Health Organization's classification of head and neck tumours, including the corresponding International Classification of Diseases (ICD-10) codes for cancers of the lip mucosa, tongue, gums, floor of the mouth, palate, and oral cavity [6]. Findings were organized into four thematic areas: global epidemiology, risk factors, precancerous conditions, and diagnostic approaches, including screening methods and biopsy techniques.

**Results**

***Global Epidemiology of Oral Cavity Cancer***

Oral cavity cancer ranks 11th among the most common cancers worldwide, and is most often diagnosed at stages III–IV, which reduces treatment efficacy and increases mortality [7]. In 2012, approximately 300,000 new cases and 145,000 deaths were recorded [7]. Two-thirds of the global incidence of oral cancer occurs in low- and middle-income countries, with half of these cases in South Asia. India alone accounts for one-fifth of oral cancer cases and one-quarter of deaths worldwide [8]. Morbidity and mortality from oral cancer are highest in India, Papua New Guinea, and Taiwan (China), where chewing betel (areca nut), with or without tobacco, is widespread [9]. Elevated rates are also observed in parts of Eastern Europe, France, and South America, associated with heavy tobacco smoking and alcohol consumption [10]. The age-adjusted incidence rate is, on average, twice as high in men as in women. When countries are grouped by income level, oral cancer incidence shows no clear pattern. Among countries with reliable cancer registries, India records the highest rate and Belarus the lowest, with the male-to-female incidence ratio differing more than fivefold. In South and Southeast Asia, oral cancer most often affects the buccal mucosa, whereas in all other regions the tongue is the most common site. Regional differences in incidence and tumor location are linked to distinct causes: alcohol consumption and smoking in Western countries, and betel and tobacco chewing in South and Southeast Asia. Mortality from oral cancer across regions ranges from 1 to 15 per 100,000 population, exceeding 10 per 100,000 in Eastern European countries such as the Czech Republic, Hungary, and Slovakia. Mortality is related to incidence, access to treatment, and tumor location. Over the past twenty years, incidence and mortality from oral cancer have steadily declined in most European countries. However, until recently these rates had been rising in some Central European countries, including Hungary and Slovakia, in association with changes in alcohol and tobacco consumption. In France, mortality peaked in the early 1990s and has since steadily declined, a trend linked to reduced per capita alcohol consumption. In the Scandinavian countries, the Russian Federation, and the United Kingdom, incidence and mortality have remained stable. In Australia and the Hong Kong Special Administrative Region of China, mortality is declining, whereas in Japan and the Republic of Korea it is, conversely, increasing [10].

***Risk Factors***

The main causes of oral cancer worldwide include various forms of tobacco use, heavy alcohol consumption, and, increasingly, infection with certain types of human papillomavirus (HPV). Although the influence of risk factors varies across population groups, oral cancer remains predominantly a disease of disadvantaged populations. Prevention can be achieved by improving socioeconomic conditions, as well as by reducing demand for tobacco and alcohol and restricting their

production and distribution. Healthy nutrition, good oral and sexual hygiene, and awareness of disease symptoms are of great importance. Success depends on political will, cross-sectoral collaboration, culturally appropriate educational campaigns, and public health messaging disseminated through the media. Smokeless tobacco products — betel (areca nut) mixtures, oral tobacco, and betel substitutes (locally known as guktha, nass, nasvar, khaini, mawa, mishri, and gudakhu) — increase the risk of oral precancerous conditions and oral cancer by 2 to 15 times. In many regions, the betel mixture contains tobacco, areca nut, slaked lime, catechu, and various additives wrapped in a betel leaf. In recent years, small, inexpensive, flavored, and sweetened packets of areca nut, catechu, and slaked lime, with or without tobacco, have become widespread. These are often marketed as a "safer" product and are increasingly used among young people, particularly in India. Such products are strongly associated with oral submucous fibrosis (OSMF), a fibrotic disease of the oral mucosa that significantly increases the risk of malignant transformation. Risk increases substantially with the duration and frequency of tobacco use; the risk among former smokers is always lower than among current smokers and decreases with the number of years since cessation. Combining smokeless tobacco and alcohol with smoking further increases the risk of oral cancer. This is biologically explained by a number of carcinogenic substances present in tobacco, the most potent and abundant of which are tobacco-specific N-nitrosamines, such as N-nitrosonornicotine and 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone, formed through N-nitrosation of nicotine, the principal addictive alkaloid in tobacco. Chemoprevention studies have confirmed the efficacy of dietary supplements such as retinoids and carotenoids in preventing oral cancer.

Other risk factors also play a role. Genetic factors are important, since most carcinogens are metabolized in the liver via the cytochrome P450 system; when this system is impaired due to genetic polymorphisms, the risk of developing many types of cancer increases. This is particularly relevant for oral and head and neck cancers, although the relative risk is usually modest. Genetic variations in enzymes that metabolize alcohol also affect risk: individuals with a fast-acting form of alcohol dehydrogenase are more prone to oral cancer when consuming alcohol, which further confirms the carcinogenic role of acetaldehyde. In parts of South America, mate, a beverage typically consumed frequently and very hot, may also slightly increase the risk of oral cancer. Viruses are another important factor. A case-control study found that human papillomavirus (HPV) infection is an independent risk factor for cancers of the tongue base, tonsils, and oropharyngeal region [11]. In some cases, HPV may enhance carcinogenesis in cancers already associated with tobacco and alcohol exposure, or act as the primary cause even in non-smokers. There is also growing evidence that such oropharyngeal infections may be sexually transmitted. Chronic trauma is a further risk factor: prolonged injury from sharp teeth, poorly fitted dentures, or other mechanical factors contributes to the development of oral cancer, although this effect is usually more pronounced when other risk factors are also present.

***Precancerous Conditions***

Oral cancer has a long natural preclinical course, during which well-studied precancerous conditions can be observed. These include homogeneous leukoplakia, non-homogeneous leukoplakia, verrucous leukoplakia, erythroplakia, oral submucous fibrosis (OSMF), lichen planus, and chronic traumatic ulcers [12]. Very early invasive cancers usually present as small, painless ulcers, nodules, or growths, which can be readily detected through careful visual inspection and palpation of the oral mucosa. Early-stage oral cancers smaller than four centimeters, without spread to regional lymph nodes, can be effectively treated with surgery or radiotherapy, achieving complete cure without functional or cosmetic defects, with a five-year survival rate exceeding 80% [13].

Leukoplakia is a white plaque that is clinically classified as homogeneous or non-homogeneous. Homogeneous leukoplakias are thin, flat, uniform, smooth, and white, while non-homogeneous leukoplakias may present as a mixed white-red appearance, small white nodules on a red background, or a proliferative, rough (verrucous) surface [12]. Erythroplakia is a red patch with a smooth or granular surface that cannot be clinically or pathologically attributed to any other identifiable condition; compared with leukoplakia, it carries a higher likelihood of harboring occult invasive cancer and undergoing malignant transformation [8]. Oral lichen planus may present as white

striations with erythematous borders, or as a mixture of erythematous and ulcerated areas. Oral submucous fibrosis (OSMF) occurs mainly among populations of the Indian subcontinent and certain groups in Pacific regions such as the Mariana Islands, presenting with a burning sensation in the mouth, blanching of the oral mucosa, and intolerance to spicy food [8]. As the disease progresses, the oral and pharyngeal mucosa becomes stiff and atrophic, resulting in restricted mouth opening and difficulty swallowing and speaking.

***Diagnostic Approaches***

Visual examination of the oral cavity has been extensively studied for its practicality, safety, acceptability, accuracy in detecting precancerous conditions and cancer, effectiveness in reducing oral cancer mortality, and cost-effectiveness. Visual screening involves systematic inspection of the oral mucosa under strong illumination and palpation to identify potentially malignant disorders and early-stage cancer signs, followed by careful inspection and palpation of the neck to detect enlarged lymph nodes. This method depends on the examiner and is subjective, so detection effectiveness may vary among specialists. Effective screening requires thorough knowledge of oral anatomy, the natural history of oral cancer, and the clinicopathological characteristics of precancerous and early cancerous conditions. Various trained healthcare providers — dentists, general practitioners, oncologists, surgeons, nurses, and allied health workers — can perform visual screening of the oral cavity. In detecting precancerous lesions and early-stage asymptomatic oral cancer, sensitivity ranges from 40% to 93%, and specificity from 50% to 99%. In a cluster-randomised controlled trial conducted in Kerala, India, three rounds of oral visual screening among high-risk individuals who used tobacco or alcohol reduced oral cancer mortality by 34% [14]. Despite the high risk of oral cancer on the Indian subcontinent, no national or regional screening programs currently exist there. Currently, the only large-scale national oral cancer screening programs operate in Cuba and in Taiwan, China. Cuba's program has been in operation since 1984; according to a 1994 evaluation, 12–26% of the target population underwent screening annually, but fewer than 30% of those with positive results complied with follow-up examinations. In 1996 the program was reorganized: the screening age threshold was raised from 15 to 35 years, the screening interval was extended from one to three years, and the referral system was improved. Primary care dentists and general practitioners play an important role in referring patients to cancer centers for early diagnosis and treatment; improving the competence of these physicians is particularly important for increasing early-detection opportunities among patients who use tobacco or alcohol.

Regular biopsy in patients with clinical signs resembling precancerous lesions helps in the early detection of occult invasive oral cancer. In addition to history-taking, physical examination, and biopsy, simultaneous examination of the upper respiratory and digestive tracts is necessary, since patients with oral cancer are at increased risk of developing cancer in other regions of the head and neck, as well as in the lungs.

Biopsy is a method involving the removal of a small piece of pathologically altered tissue from a living organism for microscopic examination. Its purpose is to determine the presence of a tumor, differentiate between benign and malignant lesions, and establish the type and grade of the tumor [1,2,3,4]. The significance of biopsy in dentistry lies in detecting early-stage cancer, confirming the clinical diagnosis, planning treatment, and assessing prognosis. Ulcers that fail to heal for more than two weeks should be biopsied.

There are several types of biopsy, selected according to the clinical situation, tumor size, and location. Incisional biopsy involves removing only a portion of the tumor and is mainly used for large lesions or those suspected of malignancy; tissue is typically taken from the border between the pathological and healthy zones, since this area is diagnostically most significant, while sampling from a necrotic center is not recommended. Incisional biopsy is minimally invasive, quick to perform, and often provides sufficient material for accurate diagnosis, although its disadvantage is that the tumor is not completely removed.

Excisional biopsy involves complete removal of the tumor and is typically used for small, well-demarcated lesions. This method serves both diagnostic and therapeutic purposes, as the pathological

focus is entirely removed; however, its use may be limited for large tumors or in functionally and aesthetically important areas.

Punch biopsy is performed using a special circular cutting instrument and is mainly used to examine mucosal or superficial lesions, yielding a tissue sample of small diameter but sufficient depth. Although punch biopsy is quick, technically simple, and minimally traumatic, it may not provide sufficient information for evaluating deeper-seated tumors.

Fine-needle aspiration biopsy (FNAB) is based on obtaining cells in liquid form and is mainly used to examine changes in lymph nodes, salivary glands, and soft tissues. Its main advantage is minimal invasiveness and rapid execution; however, only cells are obtained and tissue architecture is not preserved, which can complicate diagnosis in some cases.

Brush biopsy is performed by collecting superficial epithelial cells with a special brush and is used mostly as a screening method. It is painless and easy to perform but does not allow for a definitive diagnosis; therefore, in cases of a positive result, a conventional biopsy must additionally be performed. Exfoliative cytology is also based on studying superficial cells and is mainly used for monitoring precancerous conditions or in dynamic follow-up; however, due to its low accuracy, it is insufficient as an independent diagnostic method.

Frozen section biopsy allows for rapid diagnosis during surgery: the tissue obtained is immediately frozen, sectioned, and examined under a microscope. Results are obtained within a short time and play an important role in determining surgical strategy, although its accuracy may be somewhat lower than that of standard histological examination. Core (tru-cut) biopsy is based on obtaining a cylindrical tissue sample using a special thick needle; it provides more information than FNAB, as tissue architecture is preserved. It is used more often for deeper-seated tumors and provides material suitable for histological analysis.

**Discussion**

The findings synthesized above indicate that oral cavity cancer is not a disease that arises without warning: it typically develops through a well-documented sequence of epithelial change, from dysplasia through carcinoma in situ to invasive carcinoma and metastasis, and it is frequently preceded by clinically identifiable precancerous conditions such as leukoplakia, erythroplakia, and oral submucous fibrosis. The persistence of late-stage diagnosis despite this well-characterized natural history suggests that the principal barrier to improved outcomes is not a lack of biological understanding, but a gap between available knowledge and its systematic application in routine clinical and public health practice.

The epidemiological pattern described here — concentration of incidence and mortality in South Asia, association with betel and tobacco chewing in that region versus alcohol and smoking in Western countries, and a roughly twofold male predominance — has direct implications for prevention strategy. Because the dominant risk factors differ by region, generic public health messaging is unlikely to be as effective as context-specific interventions that target the locally dominant behavioral risk factor, whether that is smokeless tobacco and areca nut use in South and Southeast Asia or alcohol and cigarette smoking in Europe. The declining mortality trends observed in France and several other European countries, linked to reduced per capita alcohol consumption, provide indirect but suggestive evidence that population-level behavioral change can translate into measurable reductions in disease burden over time.

The comparison of diagnostic approaches reviewed here also has practical implications. Visual screening is inexpensive, widely deployable, and has been shown in a cluster-randomised controlled trial to reduce oral cancer mortality by approximately a third among high-risk individuals, yet its accuracy is examiner-dependent and no national or regional screening program currently exists in the very region — the Indian subcontinent — where the evidence for its effectiveness is strongest. This gap between trial evidence and program implementation illustrates that demonstrating efficacy in a controlled setting is not sufficient on its own to ensure population-level adoption; sustained political commitment, adequate referral infrastructure, and patient compliance are equally necessary, as

illustrated by Cuba's experience, where fewer than a third of screen-positive individuals initially complied with follow-up examinations.

Among adjunctive diagnostic technologies, tissue autofluorescence imaging has been proposed as a means of improving the visualization of oral mucosal lesions beyond what is achievable with white-light examination alone, and has shown reasonable sensitivity for detecting mucosal abnormalities [15]. However, such optical adjuncts do not replace histological confirmation: the choice among the various biopsy techniques reviewed here — incisional, excisional, punch, fine-needle aspiration, brush, and frozen section — remains governed by lesion size, location, and clinical suspicion, and biopsy continues to be the diagnostic reference standard against which newer optical and cytological methods are evaluated.

Taken together, these findings support a layered model of prevention and early diagnosis: primary prevention through reduction of tobacco, alcohol, and areca nut use; secondary prevention through opportunistic visual screening at every dental examination, supplemented where available by adjunctive optical technologies; and tertiary prevention through prompt biopsy of any lesion consistent with a precancerous or malignant process. From a health-systems perspective, the findings suggest that training primary care dentists and general practitioners to recognize precancerous lesions may offer a more cost-effective route to earlier diagnosis than investment in specialized screening technology alone, particularly in resource-limited settings where the burden of oral cancer is highest.

This review has limitations inherent to its narrative design: sources were not systematically searched or appraised using a standardized protocol, quantitative findings are drawn from heterogeneous populations and time periods and should not be directly compared as though derived from a single dataset, and no new primary data were collected. Future research should prioritize the evaluation of context-specific screening and referral models in regions with a high burden of oral cancer but no existing national program, and should assess the comparative cost-effectiveness of adjunctive optical technologies relative to conventional visual examination and biopsy in routine dental practice.

**Conclusion**

Prevention and early diagnosis of oral cavity tumors is one of the highest priorities of modern dentistry, since oral cavity cancer often develops against a background of neglected precancerous conditions; the timely detection and systematic treatment of leukoplakia, erythroplakia, oral submucous fibrosis, lichen planus, and other chronic inflammatory processes is therefore a decisive factor in preventing tumor disease, and the broad application of modern diagnostic methods, including cytological and histological examination and autofluorescence or luminescence diagnostics, alongside clinical examination, significantly increases diagnostic accuracy. In summary, reducing the incidence of oral cavity tumors requires raising preventive awareness by educating the population to abandon harmful habits such as tobacco and betel (nasvay) use; maintaining dispensary follow-up through continuous monitoring and rehabilitation of patients with precancerous conditions; and ensuring the vigilance of specialists, who should pay close attention to the condition of the oral mucosa at every dental examination and promptly refer suspicious changes for oncological evaluation. The combination of these measures not only reduces late-stage detection of the disease but also directly serves to preserve patients' quality of life and prevent premature death.

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