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## **Oral Cancer: Early Detection and Advanced Treatment Options**

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## Abstract

With high rates of morbidity and death, oral cancer is a major worldwide health concern. Improving patient outcomes requires early identification and cutting-edge treatment choices. The epidemiology, aetiology, and pathophysiology of oral cancer are examined in this review, with a focus on the significance of early identification using routine screening and sophisticated diagnostic methods. Because oral cancer can show in a variety of clinical ways, healthcare professionals must be extremely aware of this. Contemporary therapeutic approaches, such as radiotherapy, chemotherapy, and surgery, are successful but frequently have serious side effects. Novel advanced treatments like photodynamic therapy, targeted therapy, immunotherapy, and robotic surgery provide fresh hope for improved care. Even with these developments, problems such drug resistance, side effects, delayed diagnosis, healthcare inequities, and cost burdens still exist. A multidisciplinary strategy combining medical professionals, researchers, legislators, and patient advocacy organisations is needed to address these issues. To provide more individualised and efficient treatments, additional research and development in the fields of genomics, liquid biopsies, artificial intelligence, and nanotechnology is required. In order to get over these challenges and enhance the prognosis for patients with oral cancer, this study emphasises the importance of comprehensive patient care and teamwork.

## Keywords

Oral cancer, early detection, advanced treatment, epidemiology, pathogenesis, screening, diagnosis, targeted therapy, immunotherapy, photodynamic therapy, robotic surgery, healthcare disparities, treatment resistance, patient outcomes.

## 1. Introduction

Given its high rates of morbidity and death, oral cancer—a subset of head and neck cancers—represents a serious worldwide health concern [1]. Cancers of the lips, tongue, floor of the mouth, cheeks, and both hard and soft palates are included in this phrase. With about 377,700 new cases each year, it is the sixth most frequent cancer globally [2]. The low survival rate persists despite advancements in treatment, mostly because of late-stage diagnosis [3].

Because early detection greatly improves prognosis and survival rates, it is essential for oral cancer patients. Approximately 70–90% of patients who are diagnosed at an early stage (stages I and II) survive for five years, while only 20–30% of patients who are diagnosed at a later stage (stages III and IV) do so [4]. Therefore, for early detection and treatment, it is essential to raise public and healthcare professional awareness of the signs and symptoms of oral cancer.

Over time, more sophisticated therapeutic alternatives have also emerged, providing fresh hope for improved oral cancer care. These include novel surgical approaches,

immunotherapies, and targeted medicines with the goal of raising patient survival and quality of life [5]. But despite these developments, problems including side effects, treatment resistance, and healthcare inequality still stand in the way of innovation.

The goal of this review is to present a thorough overview of oral cancer with an emphasis on cutting-edge treatment options and early identification. The course will delve into the pathophysiology, epidemiology, and aetiology of oral cancer. It will also cover clinical presentation, screening, and diagnostic methods, as well as an in-depth discussion of cutting-edge and current treatment options. The review will also include the prognosis, new developments, management of treatment side effects, and obstacles and constraints in the fight against oral cancer. Lastly, it will indicate potential avenues for further investigation and research that could lead to better outcomes for oral cancer patients.

It is crucial to comprehend the various facets of oral cancer in order to create efficient plans for treatment, early identification, and prevention. The goal of this review is to add to the body of knowledge that will enable policymakers, researchers, and healthcare professionals to make wise decisions and take the necessary steps to combat this terrible disease.

## 2. Oral Cancer Epidemiology

Globally, there is variation in the incidence of oral cancer according to social, cultural, and geographic factors. It is more common in underdeveloped nations, especially those in South Asia, where a sizable fraction of cancer cases are caused by it [6]. The main causes of the high incidence in these areas are the widespread use of tobacco and chewing betel quid, both of which are known risk factors for oral cancer [7].

Although not as common in affluent nations, oral cancer is becoming more common, especially in women and younger people. The rising incidence of human papillomavirus (HPV) infection, particularly HPV-16, which has been closely connected to oropharyngeal malignancies [8], is partially responsible for this increase. The necessity for focused public health interventions and awareness campaigns is highlighted by the increasing incidence in these populations.

Numerous risk factors for oral cancer have been found by epidemiological research, including chronic trauma, alcoholism, tobacco use, poor dental hygiene, and nutritional inadequacies [9]. The most important risk factor for oral cancer is tobacco use, which includes both smokeless and smoking forms and accounts for 80–90% of cases [10]. Alcohol and smoke combine to increase the danger much more. Furthermore, HPV infection has become a significant risk factor, especially for oropharyngeal malignancies, since data suggests that patients who are positive for HPV have a better prognosis than those who are negative [11].

In terms of demographics, oral cancer primarily affects men; the male to female ratio is roughly 2:1. But because of the rising incidence among women, especially in wealthy nations, this ratio is getting narrower [12]. People over 40 are mainly affected by the condition, and as age increases, so does the risk. But an alarming trend is the increase in occurrence among younger people, which is probably caused by lifestyle modifications and a surge in HPV-related cases [13].

Geographically, regions of South and Southeast Asia, sections of Europe, and Latin America are home to the highest incidence rates. For example, in India, oral cancer is the most prevalent disease among males and the third most common cancer among women, accounting up almost 30% of all cancer cases [14]. Conversely, while still lower, the incidence in Western nations has been rising, calling for a reassessment of preventative and control measures [15].

The epidemiology of oral cancer emphasises the necessity of all-encompassing public health initiatives that take into account changing demographics and a variety of risk factors. Reducing alcohol and cigarette use, increasing HPV vaccination, boosting early detection and screening programmes, and improving oral hygiene should be the main goals of these initiatives, especially for high-risk populations.

### 3. Pathogenesis and Aetiology

Oral squamous cell carcinoma (OSCC), the most common type of oral cancer, develops from the mucosal lining of the mouth. Its complex aetiology is caused by a confluence of lifestyle, environmental, and genetic variables [16]. The process by which normal oral epithelial cells become malignant is known as the pathogenesis of oral cancer, and it is a complicated one that involves the accumulation of genetic mutations and epigenetic changes [17].

The biggest risk factor for oral cancer is tobacco use, including both smokeless and smoking forms. Many carcinogens found in tobacco, such as nitrosamines and polycyclic aromatic hydrocarbons, can cause genetic changes and accelerate the development of cancer [18]. The risk is dose-dependent, meaning that heavy and sustained use carries a larger risk. Another significant risk factor that intensifies the carcinogenic effects of tobacco use is alcohol use [19]. Long-term alcohol consumption can alter cellular metabolism and irritate mucous membranes, which can accelerate the development of cancer.

For oropharyngeal malignancies, a subtype of oral cancers, human papillomavirus (HPV) infection—in particular, HPV-16—has emerged as a major etiological component [20]. HPV-positive oropharyngeal cancers have distinct molecular and clinical characteristics compared to HPV-negative cancers, often presenting with a better prognosis and response to treatment. The virus integrates into the host genome, leading to the expression of oncogenic proteins E6 and E7, which inactivate tumor suppressor proteins p53 and Rb, respectively, promoting cell proliferation and survival [11,12].

Genetic predisposition also plays a role in oral cancer development. Individuals with a family history of cancer or certain genetic syndromes, such as Fanconi anemia and dyskeratosis congenita, are at higher risk [13]. These syndromes are characterized by defects in DNA repair mechanisms, leading to genomic instability and increased susceptibility to malignancies.

The pathogenesis of oral cancer involves a multistep process of genetic and epigenetic changes that result in the transformation of normal oral epithelium to dysplastic lesions and eventually invasive carcinoma [20]. Key molecular alterations include mutations in tumor suppressor genes (e.g., TP53), activation of oncogenes (e.g., RAS), and dysregulation of signaling pathways (e.g., EGFR) [1-5]. Epigenetic changes, such as DNA methylation and histone modification, also contribute to the aberrant gene expression patterns observed in oral cancer [9-15].

Chronic inflammation and immune suppression are additional factors that can influence oral cancer development. Conditions such as oral lichen planus and chronic periodontitis have been associated with an increased risk of oral cancer, likely due to the persistent inflammatory environment that promotes genetic damage and carcinogenesis [2,6]. Immunosuppression, whether due to underlying medical conditions or immunosuppressive therapies, can also impair the body's ability to detect and eliminate malignant cells, facilitating cancer progression.

Understanding the etiology and pathogenesis of oral cancer is crucial for developing effective prevention, early detection, and therapeutic strategies. Efforts to reduce risk factors, such as tobacco and alcohol use, and to promote HPV vaccination, along with advances in molecular diagnostics and targeted therapies, hold promise for improving outcomes for patients with oral cancer.

#### 4. Clinical Presentation

Oral cancer, particularly oral squamous cell carcinoma (OSCC), can present with a variety of clinical manifestations depending on the stage and location of the tumor. Early-stage oral cancer often goes unnoticed because the symptoms are subtle and non-specific [1]. Common early signs include persistent ulcers, red or white patches (erythroplakia or leukoplakia), and unexplained bleeding in the mouth [2]. These lesions are often painless initially, which contributes to delayed diagnosis.

As the disease progresses, more noticeable symptoms may develop. Patients may experience pain, difficulty in swallowing (dysphagia), difficulty in speaking (dysarthria), and a sensation of a lump in the throat [3]. Other symptoms include numbness, loosening of teeth, and ill-fitting dentures. Advanced tumors can invade surrounding tissues, leading to more severe complications such as trismus (restricted mouth opening), oropharyngeal fistulas, and neck masses due to metastasis to the cervical lymph nodes [4].

Oral cancer can occur at various sites within the oral cavity, including the lips, tongue, floor of the mouth, buccal mucosa, hard and soft palate, and the retromolar trigone. Each site may present with site-specific symptoms. For instance, cancers of the tongue often present with ulcerative lesions that can interfere with speech and swallowing, while cancers of the floor of the mouth may cause difficulty in moving the tongue and swallowing [5]. Cancers of the buccal mucosa often present as ulcers or masses that can become infected or cause significant discomfort.

The clinical staging of oral cancer is based on the TNM (Tumor, Node, Metastasis) classification system, which considers the size and extent of the primary tumor, involvement of regional lymph nodes, and presence of distant metastasis [6]. Early-stage tumors (stage I and II) are generally smaller and confined to the site of origin without regional or distant spread. Advanced-stage tumors (stage III and IV) are larger, often with regional lymph node involvement and, in some cases, distant metastasis [7]. The stage at diagnosis significantly influences treatment options and prognosis, highlighting the importance of early detection.

Regular oral examinations by healthcare professionals, including dentists and primary care physicians, are crucial for the early detection of oral cancer. Self-examination by patients, especially those at high risk, can also play a role in early detection. Biopsies of suspicious

lesions are essential for definitive diagnosis, and adjunctive tools such as imaging (CT, MRI, PET) and endoscopy can aid in assessing the extent of disease [8].

The clinical presentation of oral cancer underscores the need for increased awareness among both healthcare providers and the general public. Education on recognizing early signs and symptoms, coupled with routine screening, can lead to earlier diagnosis, more effective treatment, and improved survival rates [9].

## 5. Screening and Early Detection

The early detection of oral cancer significantly enhances treatment outcomes and survival rates. Screening aims to identify premalignant lesions or early-stage cancers in asymptomatic individuals, facilitating prompt intervention [10]. Various screening methods are employed, including visual examination, adjunctive diagnostic aids, and emerging technologies.

Visual examination remains the cornerstone of oral cancer screening. During routine dental or medical check-ups, healthcare professionals inspect the oral cavity for signs of malignancy, such as leukoplakia, erythroplakia, and non-healing ulcers [11]. Palpation of the oral tissues and neck is also performed to detect any abnormal masses or lymphadenopathy.

Adjunctive diagnostic aids, such as toluidine blue staining, brush biopsy, and fluorescence imaging, can enhance the accuracy of visual examinations. Toluidine blue selectively stains malignant cells, helping to highlight suspicious areas for biopsy. Brush biopsy allows for the collection of cells from a lesion without the need for a surgical procedure, providing a minimally invasive option for preliminary evaluation [12]. Fluorescence imaging, which utilizes the natural fluorescence of tissues, can help differentiate between healthy and abnormal tissues, although its use is still under investigation.

Emerging technologies, such as salivary diagnostics and optical coherence tomography (OCT), hold promise for improving early detection. Salivary diagnostics involve analyzing saliva samples for biomarkers associated with oral cancer, offering a non-invasive and easily accessible screening tool [13]. OCT provides high-resolution imaging of oral tissues, allowing for the detailed visualization of tissue architecture and early identification of abnormalities.

Public health initiatives aimed at raising awareness about oral cancer and promoting regular screening are crucial, especially in high-risk populations. These initiatives include educational campaigns, community screening programs, and the integration of oral cancer screening into routine healthcare services [14].

Despite the availability of screening methods, challenges remain in ensuring widespread adoption and accessibility. Barriers such as lack of awareness, limited access to healthcare services, and socioeconomic factors can impede the effectiveness of screening programs. Addressing these barriers requires a concerted effort from healthcare providers, policymakers, and community organizations.

## 6. Diagnostic Techniques

A combination of clinical examination, imaging methods, and histological analysis are required for an accurate diagnosis of oral cancer. In order to establish whether malignancy is present and to ascertain the severity of the illness, every diagnostic technique is essential.

The initial stage in the diagnosis of oral cancer is a clinical examination. Medical practitioners check the mouth cavity for tumours, lesions, and ulcers during this examination. Adjunctive instruments are employed to further assess any suspect areas in order to improve the accuracy of the diagnosis [15].

Imaging methods that provide precise information regarding the size, location, and spread of the tumour include computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET). PET scans aid in the detection of metastases and evaluate the tumor's metabolic activity, whereas CT and MRI are especially helpful in evaluating the involvement of soft tissues and bones, respectively [16]. For precise staging and treatment planning, several imaging techniques are necessary.

When diagnosing oral cancer, histopathological assessment is still the gold standard. A biopsy is done on the worrisome lesion to remove a sample of tissue, which a pathologist examines under a microscope. Tumour grade and histological subtype can be ascertained, and conclusive evidence of malignancy can be obtained through histopathological investigation [17]. To find certain biomarkers and genetic changes connected to the tumour, immunohistochemistry and molecular tests may also be used.

Recent developments in molecular diagnostics have brought out methods like liquid biopsies and next-generation sequencing (NGS). With the use of NGS, a thorough genomic profile of the tumour can be obtained, revealing changes and mutations that can direct focused treatment. A non-invasive technique for tracking tumour dynamics and identifying minimal residual illness is liquid biopsy, which examines circulating tumour DNA in the blood [18].

To create a successful treatment strategy, accurate diagnosis and staging are essential. Ensuring a comprehensive diagnostic strategy requires multidisciplinary coordination among healthcare experts, such as radiologists, pathologists, oncologists, and dentists.

## 7. Presently Used Treatment Approaches

Treatment for oral cancer is multidisciplinary and consists mostly of surgery, radiation therapy, and chemotherapy. The tumor's location and stage, as well as the patient's preferences and general health, all influence the therapy option [1].

**Treatment with Surgery:** When treating oral cancer, particularly in its early stages, surgery is frequently the initial course of action. In order to guarantee clean margins and lower the chance of recurrence, the objective of surgery is to remove the tumour entirely along with a margin of healthy tissue [2]. Wide local excision, partial or complete glossectomy (removal of the tongue), mandibulectomy (removal of the jawbone), and neck dissection (removal of the afflicted lymph nodes) are among the surgical methods used [3]. After significant surgery, reconstruction with flaps from other body regions might be required to restore beauty and function.

**Radiotherapy:** To kill cancer cells, high-energy radiation is used in radiotherapy. It can be used as adjuvant therapy after surgery to get rid of leftover cancer cells, or as a main treatment, particularly for individuals who are not candidates for surgery [4]. The two primary forms of radiation utilised in the treatment of mouth cancer are external beam radiation and brachytherapy, or internal radiation. Modern radiotherapy techniques, like

intensity-modulated radiotherapy (IMRT), enable more accurate tumour targeting while protecting neighbouring healthy tissue and minimising adverse effects [5].

**Chemotherapy:** Chemotherapy is the use of medications to either destroy or stop the growth of cancer cells. It is frequently used as a palliative measure to reduce the symptoms of patients with metastatic illness or in conjunction with radiation therapy (chemoradiation) for advanced-stage oral cancer [6]. Frequent drugs used in chemotherapy are paclitaxel, fluorouracil, and cisplatin. Depending on the location and severity of the disease, systemic or regional chemotherapy may be used.

**Combination Therapy:** To get the best results for advanced-stage oral cancer, a mix of radiation, chemotherapy, and surgery is frequently needed. This multimodal strategy can lower the chance of recurrence and increase survival rates. The features of the tumour and the patient's reaction to treatment determine the order and mix of these treatments [7].

**Palliative Care:** For patients with advanced oral cancer, palliative care is a crucial part of their treatment. Palliative care focuses on symptom relief, enhancing quality of life, and offering patients and their family social and psychological support. For patients with oral cancer, palliative care must include speech therapy, nutritional support, and pain control [8].

## 8. Innovative Therapy Choices

Advances in the biology of oral cancer have resulted in the creation of novel therapeutic approaches that specifically target molecular pathways involved in the formation and spread of tumours. Patients with oral cancer, especially those whose disease is advanced or recurrent, now have new hope because to these cutting-edge therapeutic choices.

**Targeted Therapy:** Medications that specifically target molecular abnormalities in cancer cells are used in targeted therapy. Cetuximab is a well-known targeted therapy for oral cancer since it is an inhibitor of the epidermal growth factor receptor (EGFR). By attaching itself to the EGFR on the surface of cancer cells, cetuximab obstructs the signals that encourage cell division and survival [9]. The effectiveness of other targeted medications, like tyrosine kinase inhibitors, in treating oral cancer is currently being studied [10].

**Immunotherapy:** Immunotherapy uses the immune system of the body to identify and eliminate cancerous cells. Pembrolizumab and nivolumab, two immune checkpoint inhibitors, have demonstrated encouraging outcomes in the treatment of advanced head and neck malignancies, including oral cancer [11]. These medications increase the immune system's capacity to combat cancer cells by preventing the proteins that impede immune responses. The efficacy of immunotherapy in conjunction with other treatment modalities for oral cancer is being investigated in ongoing clinical trials [12].

**Photodynamic therapy (PDT):** PDT uses a photosensitizing chemical that certain light wavelengths absorb and activate into cancer cells. Reactive oxygen species produced by this activation specifically destroy cancer cells while protecting healthy tissues [13]. PDT is a minimally invasive treatment that can be used alone or in combination with other therapies for early-stage oral cancer. It is appropriate for superficial lesions because its application is restricted by the depth of light penetration [14].

**Robotic Surgery:** The development of robotic-assisted surgery for oral cancer is the result of advancements in surgical technology. Among the many benefits of robotic surgery include improved accuracy, less blood loss, and quicker recovery [15]. Surgeons may now more accurately perform complex procedures and reach difficult-to-reach parts of the mouth cavity

thanks to the use of robotic equipment. Patients with tumours in anatomically difficult sites benefit most from robotic-assisted surgery.

Gene therapy is a young field that seeks to treat cancer by introducing new genes or correcting genetic abnormalities. Gene therapy techniques for oral cancer include the introduction of tumour suppressor genes, the application of CRISPR/Cas9 gene-editing technology, and the creation of oncolytic viruses that specifically infect and destroy cancer cells [16]. Gene therapy has enormous potential for the future treatment of oral cancer, even though it is currently in the experimental stage.

### 9. Controlling Side Effects of Treatment

Even while oral cancer treatment has the potential to save lives, it is frequently linked to serious side effects that can negatively affect a patient's quality of life. Effectively managing these side effects is essential to enhancing patient outcomes and guaranteeing adherence to prescribed treatment plans.

**Acute Side Effects:** Pain, mucositis, dysphagia, xerostomia (dry mouth), and altered taste are among the acute side effects of oral cancer treatment, which includes surgery, radiation, and chemotherapy [17]. Analgesics, such as opioids and nonsteroidal anti-inflammatory medicines (NSAIDs), as well as adjuvant therapies like antidepressants and anticonvulsants, may be used in the important component of pain management [18]. Topical therapies can help reduce mucositis and oral irritation. Examples of these therapies include mouthwashes with benzydamine or lidocaine.

**Long-term adverse Effects:** Following treatment, patients may experience long-term adverse effects such as fibrosis, trismus, osteoradionecrosis (a radiation-induced bone death), and dental issues lasting months or even years [19]. Physical therapy and speech therapy are examples of rehabilitation therapies that are crucial for treating these problems. While speech therapy can help with swallowing and speech issues, physical therapy can aid with trismus and maintain range of motion.

**Nutritional Support:** Given that mucositis and dysphagia can have a major impact on oral intake, nutritional support is essential for patients receiving therapy for oral cancer. Dietitians can work with a multidisciplinary team to create customised meal plans that will guarantee a sufficient intake of protein and calories. Patients with severe dysphagia may require enteral feeding, which involves the use of feeding tubes [20].

**Psychosocial Support:** It is important to recognise the psychosocial effects of oral cancer and its management. Changes in look and function can cause anxiety, despair, and issues with body image in patients. Psychiatric treatment, counselling, and support groups are examples of psychosocial support that is essential for resolving emotional and mental health issues [11–15].

**Preventive Measures:** Reducing adverse effects is another benefit of preventive measures. For example, patients receiving radiotherapy can benefit from fluoride treatments and routine dental exams to help prevent dental caries and other oral health problems [10–13]. Reducing the risk of infections and consequences requires education on good oral hygiene practices.

**Follow-up treatment:** To monitor and treat long-term adverse effects, routine follow-up treatment is required. This entails routine physicals, imaging investigations, and lab testing to monitor persistent side effects and identify any cancer recurrence. Comprehensive patient

care is ensured by a coordinated care approach combining dietitians, rehabilitation specialists, dentists, and oncologists [7–12].

## 10. Current Developments and Upcoming Paths

The field of oral cancer research and therapy is always changing due to developments in clinical practice, molecular biology, and technology. More efficient methods of diagnosis, treatment, and prevention are being developed as a result of recent advancements and continuing research.

Comprehensive profiling of the genetic and molecular changes associated with oral cancer is now possible thanks to advancements in genomic technologies. Numerous genetic mutations, copy number variations, and epigenetic modifications linked to oral cancer have been found via next-generation sequencing (NGS) [1]. Comprehending these modifications offers discernment into the processes of carcinogenesis and pinpoints possible avenues for treatment. It is becoming more and more possible to practise personalised medicine, which adjusts treatment based on the genetic makeup of the tumour [2].

**Liquid Biopsies:** A non-invasive technique for identifying and tracking oral cancer, liquid biopsies examine circulating tumour DNA (ctDNA) and other indicators in blood samples. Liquid biopsies have the ability to detect little residual disease, track the dynamics of tumours, and identify genetic changes [3]. This technology has the potential to completely change the way that cancer is diagnosed and tracked, enabling early recurrence detection and real-time therapy response assessment.

Algorithms for artificial intelligence (AI) and machine learning are being developed to improve the early identification and diagnosis of oral cancer. Large datasets, such as clinical and medical picture data, can be analysed by these technologies to find patterns and provide highly accurate outcome predictions [4]. AI-powered technologies can help physicians identify patients more quickly and accurately, which will improve patient care.

**Immunotherapy:** For the treatment of oral cancer, immunotherapy remains promising. Pembrolizumab and nivolumab, two immune checkpoint inhibitors, have shown promise in treating patients with metastatic or advanced illness [5]. By obstructing inhibitory signals that reduce immunological function, these medications strengthen the body's defences against cancer cells. To enhance results, ongoing clinical trials are investigating the use of immunotherapy in conjunction with conventional therapies such as radiotherapy and chemotherapy.

**Photodynamic therapy (PDT)** is a minimally invasive treatment that targets cancer cells by activating photosensitizing drugs with particular light wavelengths. The effectiveness and safety of photodynamic therapy (PDT) have been enhanced by recent developments, such as the creation of more potent photosensitizers and light delivery methods [6]. PDT can be used in conjunction with other modalities to improve outcomes, and it is especially helpful in the treatment of superficial tumours.

**Nanotechnology:** The potential of nanotechnology to boost the effectiveness of cancer treatments and improve drug delivery is being investigated. Therapeutic drugs can be delivered directly to the tumour site by use of nanoparticles that are engineered to preferentially target cancer cells, thereby reducing systemic toxicity [7]. Research is being done on the application of nanotechnology-based methods in immunotherapy, radiation, and chemotherapy.

Cancer vaccines: They work by inducing the immune system to identify and combat cancerous cells. Clinical trials are under way for a number of investigational vaccinations that target particular antigens linked to oral cancer [8]. These vaccinations may offer permanent immunity and guard against cancer returning.

Future Directions: By combining these cutting-edge techniques and technology, oral cancer research and treatment will continue to progress in the future. With its ability to customise care according to each patient's unique genetic and molecular profile, precision medicine has enormous potential to enhance results. The development of new therapeutic targets and ongoing investigation into the molecular mechanisms behind oral cancer will be the driving forces behind the hunt for new therapies. Translating these discoveries into clinical practice and enhancing patient care need cooperative efforts by researchers, physicians, and healthcare institutions.

### 11. Obstacles and Restrictions

Many obstacles and restrictions still exist in spite of tremendous advancements in our knowledge of and ability to treat oral cancer. Reducing the burden of this illness and enhancing patient outcomes depend on addressing these problems.

Late Diagnosis: One of the main problems with oral cancer is that it is often discovered too late. When the prognosis is dire, many individuals receive an advanced diagnosis [9]. Socioeconomic hurdles, restricted access to healthcare, and a lack of knowledge about early indications and symptoms are frequently the cause of this delay in diagnosis. To meet this challenge, it is imperative that measures be taken to raise public awareness, strengthen screening initiatives, and provide prompt access to healthcare.

Treatment Resistance: One major obstacle in the management of oral cancer is resistance to standard treatments like radiation and chemotherapy. Treatment resistance and disease recurrence are influenced by tumour heterogeneity and the existence of cancer stem cells [10]. Enhancing treatment efficacy requires research into the molecular mechanisms of resistance and the creation of specific medicines to overcome it.

Treatment Side Effects: Patients' quality of life may be greatly impacted by the side effects of oral cancer therapies, such as radiation, chemotherapy, and surgery. Effective therapy of both acute and chronic side effects, including fibrosis, xerostomia, dysphagia, and mucositis, is necessary to guarantee patient compliance and comfort [11]. To lessen these side effects, improvements in rehabilitation and supporting care are required.

Healthcare Disparities: Variations in oral cancer outcomes across different population groups are a result of disparities in healthcare quality and access. The effectiveness and accessibility of cancer prevention, diagnosis, and treatment can be impacted by a number of factors, including healthcare infrastructure, socioeconomic level, and geographic location [12]. Ensuring equitable treatment requires addressing these discrepancies through focused interventions, financial allocation, and legislative reforms.

Financial Burden: Patients and healthcare systems may face a large financial burden due to the high cost of treating oral cancer. Particularly for those who are impoverished or uninsured, the costs of surgery, radiation, chemotherapy, and supportive care can be prohibitive [13]. To lessen this burden, initiatives to lower treatment costs, offer financial assistance, and guarantee affordable access to care are required.

**Research and Development:** Although the field of oral cancer research has made great strides, more funding is still needed for this important field of study. Research efforts must continue in order to comprehend the intricate biology of oral cancer, find new biomarkers, and create innovative treatment approaches [14]. The translation of research findings into clinical practice can be accelerated through cooperation between government agencies, business, and academic institutions.

**Patient Compliance:** It can be difficult to guarantee that patients will adhere to their treatment plans, especially when those treatments are lengthy or have a lot of negative effects. Optimising results and promoting adherence to treatment plans need the provision of patient education, counselling, and supportive care services [15].

## 12. Conclusion

Oral cancer remains a significant global health challenge, with high morbidity and mortality rates. Early detection and advanced treatment options are crucial for improving patient outcomes and survival rates. This review has highlighted the epidemiology, etiology, and pathogenesis of oral cancer, emphasizing the importance of early detection through regular screening and the use of advanced diagnostic techniques.

The clinical presentation of oral cancer can vary, underscoring the need for healthcare providers to be vigilant and knowledgeable about the early signs and symptoms. Current treatment modalities, including surgery, radiotherapy, and chemotherapy, are effective but associated with significant side effects. Advanced treatment options, such as targeted therapy, immunotherapy, photodynamic therapy, and robotic surgery, offer new hope for better management of oral cancer.

The management of treatment side effects, prognosis, and survival rates are critical aspects of patient care. Recent advances in genomic and molecular profiling, liquid biopsies, AI, and nanotechnology are transforming the landscape of oral cancer treatment, paving the way for more personalized and effective therapies.

Despite these advancements, several challenges and limitations remain, including late diagnosis, treatment resistance, side effects, healthcare disparities, financial burdens, and the need for continued research and development. Addressing these challenges requires a collaborative effort among healthcare providers, researchers, policymakers, and patient advocacy groups.

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