This paper is part of the Special Issue on Advancements in Dental Technology and Engineering: Innovations for Enhanced Patient Care
Guest Editor: Dr. Giuseppe Minervini, Università degli Studi della Campania Luigi Vanvitelli, Naples, Italy.

Received January 8, 2025, accepted May 5 2025, date of publication May 30 2025.

Review

Newer Diagnostic Methods to Detect Oral Cancer and Their Applications in Prevention and Treatment Strategies: A Systematic Review

Sai Sree Kotari[1], Bharath Kumar Konakanchi[2], Supraja Salwaji[3], Mohan Kumar Pasupuleti[4,*], Prathyusha Kancherla[5], Maria Maddalena Marrapodi[6], Marco Cicciù[7], and Giuseppe Minervini[8,9]

[1] Biomedical and Health Informatics, University of North Carolina, Chapel Hill, North Carolina, United States.
[2] Health Informatics and Analytics, University of North Carolina, Charlotte, North Carolina, United States.
[3] Oral and Maxillofacial Pathology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.
[4] Periodontics and Implantology, Vishnu Dental College, Bhimavaram, Andhra Pradesh, India.
[5] Private practitioner, Aswaraopeta, Telangana, India.
[6] Department of Woman, Child and General and Specialist Surgery, University of Campania "Luigi Vanvitelli", 80138 Naples, Italy.
[7] Department of Biomedical and Surgical and Biomedical Sciences, Catania University, 95123 Catania, Italy.
[8] Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, 600077 Chennai, India.
[9] Multidisciplinary Department of Medical-Surgical and Odontostomatological Specialties, University of Campania "Luigi Vanvitelli", 80138 Naples, Italy.

[*] Corresponding Author Email: mosups@gmail.com

ABSTRACT

Background: Oral cancer, which includes cancers of the lips, tongue, mouth, throat, and other oral tissues, is a serious health concern globally. It is one of the major causes of cancer-related mortality because of several factors, including the severity of certain oral malignancies and their late-stage detection. **Objective:** To comprehensively investigate recently developed technologies for detecting oral cancer and evaluate their accuracy, reliability, and potential application in both therapeutic and preventive contexts. **Methods:** A thorough literature search was performed using the PubMed, Scopus, and Web of Science databases, focusing on works published between 2014 and 2024. This review evaluates various methods for diagnosing oral cancer, including advanced imaging techniques (MRI and CT scans), biomarker testing, molecular diagnostics, noninvasive salivary diagnostics, optical coherence tomography (OCT), and the application of artificial intelligence (AI) and machine learning (ML) to enhance diagnostic accuracy. **Results:** All relevant studies meeting the inclusion criteria were analyzed. Several important findings regarding confocal laser scanning microscopy (CLSM) and OCT demonstrated high sensitivity and specificity in identifying oral cancer. This systematic review also highlights the promise of fluorescence spectroscopy, salivary biomarkers, genetic markers, and AI/ML technologies in early disease detection and monitoring. **Conclusion:** New diagnostic procedures outperform traditional ones in accuracy and reliability in the detection of oral cancer. These innovations enable earlier diagnosis, facilitate targeted therapies, and support personalized treatment strategies. As preventive and monitoring strategies evolve, treatment efficacy improves, and patient trust and engagement increase, ultimately leading to better outcomes and enhanced quality of life for patients.

Keywords—*Clinical applications, Diagnostic methods, Early detection, Noninvasive techniques, Oral cancer, Systematic review.*

BACKGROUND

Oral cancer accounts for approximately 3% of the total cases of cancer globally, establishing it as an important public health issue. This extensive range of cancers occurs in the epithelial lining of the oral cavity, encompassing the lips, tongue, floor of the mouth, buccal mucosa, and gums. Oral cancer is the most prevalent cancer in Indian men, exhibiting variation by region, with the highest incidence rates observed in South Asia.[1–4]

Early detection of oral cancer is crucial for improving treatment efficacy and survival rates. Conversely, oral cancer is often identified later in life, resulting in a grim prognosis and diminished quality of life. The early detection of oral cancer is hindered by the constraints of conventional diagnostic methods like visual examination, biopsy, and histological evaluation.[5–9]

Recent technological advancements have led to the development of innovative diagnostic techniques that significantly enhance the early detection and monitoring of oral cancer. Notably, optical coherence tomography (OCT) provides high-resolution, real-time imaging of oral tissues, allowing clinicians to detect subtle epithelial changes indicative of malignancy.[10–13] Fluorescence-based diagnostic instruments leverage the natural fluorescence properties of tissues to distinguish between healthy and abnormal areas, facilitating noninvasive, chairside screening. In addition, the analysis of salivary biomarkers such as DNA, RNA, proteins, and metabolites offers a promising, noninvasive approach for identifying molecular signatures associated with oral cancer, thus supporting both early diagnosis and disease progression monitoring.[14–17]

Early diagnosis of oral cancer can improve treatment outcomes and survival rates, and these new diagnostic tools show promise in this regard. The purpose of this systematic review is to establish the therapeutic value of novel diagnostic tools for oral cancer detection, as well as their diagnostic accuracy and application in oral cancer prevention and treatment strategies.[18–21]

This systematic review offers a thorough overview of the latest methods for detecting oral cancer, highlighting their clinical applications and diagnostic accuracy. The findings of the review are crucial for healthcare professionals, researchers, and policymakers in formulating effective approaches for the early detection and treatment of oral cancer.

METHODS

Study Design and Setting

During the months of October through December 2024, this systematic review was conducted to examine and assess recently developed methods for diagnosing oral cancer, assessing their accuracy, reliability, and applications in preventative and therapeutic approaches at Vishnu Dental College in Bhimavaram, Andhra Pradesh.

On October 19th, PROSPERO registered the current protocol with registration ID CRD42024598844. The systematic review was carried out in accordance with PRISMA (Preferred Reporting Items for Systematic Research and Meta-Analysis) criteria. A strong agreement is suggested by a Kappa value of 0.75, which shows that the reviewers' selection and extraction procedures were dependable and consistent.

This study problem was structured using the PICO framework, which encompasses population, intervention, comparison, and outcome. The population consists of those who use tobacco products, drink alcohol, or have HPV infections, as well as those who are at risk of or have been diagnosed with oral cancer. Recent diagnostic technologies evaluated include liquid biopsy, fluorescence imaging, molecular diagnostics, and AI-based tools. Traditional diagnostic methods such as ocular inspection, histology, or conventional imaging methods were compared. Better

early detection rates, better prevention and treatment planning techniques, and a decrease in the death and morbidity rates from oral cancer were the intended results.

The systematic review's goals were to compare the efficacy and uses of more recent diagnostic tools for the detection of oral cancer with more established methods, as well as to investigate how these approaches might be used to enhance patient outcomes through prevention and therapy. The study's research question was, "What is the accuracy, early detection rate, and effect on prevention and treatment strategies of newer diagnostic methods for oral cancer compared to traditional diagnostic techniques?"

Study Eligibility Requirements

A variety of trial designs were included in the systematic review for a thorough evaluation of the more recent techniques for diagnosing oral cancer. Randomized controlled trials (RCTs), prospective cohort studies, cross-sectional studies, retrospective studies, and comparative effectiveness studies were all included in the study. These studies evaluated the safety and effectiveness of different treatments in a controlled environment and provided strong evidence from 2013 to 2024. This systematic review did not consider the following study categories: brief communications, editorial letters, mini-reviews, studies that did not follow the objectives of the review, and papers written in languages other than English.

We developed a list of terms to look for in the databases based on our knowledge of the subject and previous research. Oral cancer, oral squamous cell carcinoma (OSCC), novel diagnostic techniques, molecular diagnostics, and biomarkers in oral cancer were the search phrases used to search the PubMed databases. Boolean operators were used to combine these keywords, yielding thorough and pertinent results.

("oral cancer" OR "mouth cancer" OR "oral squamous cell carcinoma") AND ("new diagnostic methods" OR "emerging techniques" OR "molecular diagnostics" OR "liquid biopsy" OR "fluorescence imaging" OR "artificial intelligence") AND ("prevention" OR "treatment strategies" OR "early detection" OR "risk stratification").

(Newer[All Fields] AND ("diagnosis"[MeSH Terms] OR "diagnosis"[All Fields] OR "diagnostic"[All Fields]) AND ("methods"[Subheading] OR "methods"[All Fields] OR "methods"[MeSH Terms]) AND Detect[All Fields] AND ("mouth neoplasms"[MeSH Terms] OR ("mouth"[All Fields] AND "neoplasms"[All Fields]) OR "mouth neoplasms"[All Fields] OR ("oral"[All Fields] AND "cancer"[All Fields]) OR "oral cancer"[All Fields]) AND Applications[All Fields] AND ("prevention and control"[Subheading] OR ("prevention"[All Fields] AND "control"[All Fields]) OR "prevention and control"[All Fields] OR "prevention"[All Fields]) AND (("treatment"[All Fields] AND "strategies"[All Fields]) OR "treatment strategies"[All Fields])) AND ("systematic review"[All Fields] OR "systematic reviews as topic"[MeSH Terms] OR "systematic review"[All Fields])

Literature Search Protocol

Two reviewers independently searched for the publications. To conduct a focused, systematic review, we looked through relevant papers that were available in electronic databases, including PubMed, Web of Science, and Scopus.

Rayyan was used during the study selection process to reject unsuitable abstracts and nominations and to eliminate duplicate search results from multiple databases. The collected data were closely examined to ensure that they met the established inclusion and exclusion criteria. When the data from the included studies were too inconsistent or varied to be quantitatively merged, a systematic review was conducted instead of a meta-analysis.

Selection of Included Research Articles

For more knowledge of the state of research on this subject, the discovered papers were filtered to include clinical studies and RCTs. Their study goals and importance were then added to this review. A thorough synopsis of these research publications is provided in the table, emphasizing their salient features, approaches, and conclusions.

Quality Assessment of Studies

AMSTAR 2 (A MeaSurement Tool to Assess systematic Reviews) is a previously published and validated tool for assessing the methodological quality of systematic reviews (with and without meta-analyses). Where AMSTAR only considered RCTs, AMSTAR 2 considers both RCTs and nonrandomized studies, therefore diversifying the studies that could be reviewed. The tool comprises 16

items, with each item touching upon important aspects of review methodology. The quality of all included systematic reviews was assessed in this study, using appropriate rating tools. AMSTAR 2 provides valuable criteria in umbrella reviews to critically appraise the included reviews by evaluating items for the risk of bias (RoB), search strategy, and rationale for excluding studies.

RESULTS

Data Extraction and Synthesis Process

On October 19th, 2024, a preliminary keyword search was conducted in numerous electronic databases, including PubMed, Web of Science, and Scopus, yielding 729 results. After applying preliminary relevance filters, 59 articles were retained for further evaluation. Of these, 17 articles met the intended inclusion criteria and were considered relevant. A final set of seven systematic reviews met the inclusion criteria and were included in this umbrella review, with a special focus on the use of more modern diagnostic tools for the detection of oral cancer and its impact on prevention and treatment approaches (Figure 1).[5,7,9,10,12,13,22]

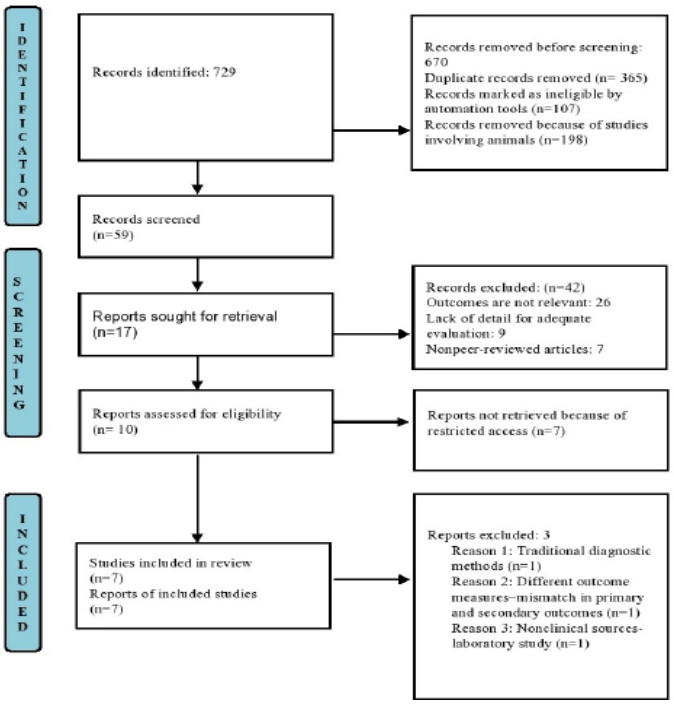

FIGURE 1. PRISMA 2020 flow diagram for new systematic reviews, which included searches of databases and registers only.

Newer Diagnostic Methods to Detect Oral Cancer

Enhanced tools for diagnosing oral cancer now include narrow band imaging (NBI), confocal laser scanning microscopy (CLSM), saliva-based biomarkers, fluorescence diagnostic techniques, and OCT. These advanced technologies provide earlier detection, improve treatment outcomes, and enhance the sensitivity and accuracy of oral cancer screening. For example, fluorescence-based diagnostic tools can detect abnormal changes in cells, and OCT provides high-resolution images of the oral mucosa (Table 1).

To improve the results of treatment and reduce the affection rate and mortality ratio related to oral cancer, the current approach to prevention and treatment includes individualized medicine, immunotherapy, target therapy, and lighting therapy (PDT). Robot surgery is included. For instance, immunotherapy employs the body's immune system to fight oral cancer, while personalized medicine involves customizing treatment plans for each patient based on their genetic profiles (Table 1).

The use of artificial intelligence (AI) and machine learning (ML) algorithms to study large datasets and identify trends is a significant improvement in the detection and treatment of oral cancer. Another potential area of research is liquid biopsies, which identify biomarkers in physiological fluids like saliva. Scientists are also researching novel medicines and developing personalized oral cancer tumor models using 3D printing and bioprinting technology (Table 1).

Salivary biomarkers, fluorescence-based devices, and optical OCT are cutting-edge diagnostic techniques that have dramatically increased the sensitivity and precision of oral cancer diagnosis, allowing for earlier and more accurate therapy. At the same time, advanced preventive and therapeutic approaches, including immunotherapy, targeted therapies, and personalized medicine, are transforming patient care, improving outcomes, and reducing the impact of the disease. Recent results, such as liquid biopsy, 3D biological suppression, and diagnostic diagnosis controlled by AI, indicate the possibility of improving oral cancer detection and treatment (Table 1).

TABLE 1. The qualitative characteristics and conclusive statements of the newer diagnostic methods to detect oral cancer.

Author, Year, & Reference No.	Aim of Study	Search Strategy	No. of Studies Included	Screening Method Used	Outcome Measures	Summary
Brocklehurst, et al.[5]	To evaluate how well the existing screening techniques reduce the death rate from oral cancer.	Cochrane Central Register of Controlled Trials MEDLINE via OVID EMBASE via OVID CANCERLIT via PubMed	1	Visual examination, toluidine blue, fluorescence imaging, or brush biopsy.	Individuals diagnosed with stage III or worse oral cancer. Survival rates across the population.	In high-risk individuals, there is evidence that a visual examination as part of a population-based screening program lowers the death rate from oral cancer.
Jerjes, et al. 2024[7]	To evaluate optical coherence tomography's (OCT) diagnostic precision in identifying oral malignancies.	PubMed, Embase, Scopus, Google Scholar, Cochrane Central Register, and Web of Science	9	OCT Artificial intelligence (AI)	Diagnostic outcomes, such as sensitivity and specificity.	OCT has very high sensitivity and specificity, making it a promising new diagnostic technique for oral cancer.
Bastías, et al. 2024[9]	To conduct a scoping review of salivary molecules examined as potential indicators for oral squamous cell cancer (OSCC) diagnosis.	EBSCO, PubMed (MEDLINE), Scopus, and Web of Science	62 studies were included. 100 molecules were assessed.	TNF-α, IL-1β, IL-6, IL-8, LDH, MMP-9, TNF-α, IL-1β, IL-6 IL-8, LDH, and MMP-9 are the most promising salivary biomarkers for cancer detection.	Ability for detecting OSCC and oral potentially malignant disorders (OPMDs), OSCC outcome prediction, and the prediction of the malignant transformation of OPMDs.	It may be possible to use salivary biomarkers to help detect, manage, and forecast the malignant transformation and spread of OSCC and OPMDs.

Author, Year, & Reference No.	Aim of Study	Search Strategy	No. of	Screening Method Used	Outcome Measures	Summary
Kim, et al.[10]	To examine the effectiveness of OCT in identifying malignant lesions in the mouth.	PubMed, Cochrane Central Register of Controlled Trials Embase, Web of Science Scopus, Google Scholar.	12	OCT	The diagnostic odds ratio (DOR), along with summary receiver operating characteristic curve (SROC), area under SROC, sensitivity, specificity, and negative predictive values, were the outcomes.	OCT can help in the diagnosis and monitoring of oral cancer and oral precancerous lesions because it is noninvasive, produces quick results without exposing users to radiation, and is quick.
González-Moles, et al. 2022[12]	To find evidence gaps and suggest future research directions that ought to be pursued and formulate improvement plans.	MEDLINE Embase, Cochrane Central Register of Controlled Trials DARE	12	Light-based detection or oral spectroscopy.	New cases per year, deaths annually, and mortality rate.	Patients, healthcare professionals, and health services are all involved in the many factors that contribute to the delay in the diagnosis of oral cancer.
Li, et al. 2024[13]	To assess the differences in accuracy between the various imaging techniques used in these diagnostic procedures.	Embase, Web of Science, PubMed, and Scopus.	17	AI	Overall diagnostic odds ratio (DOR), sensitivity, specificity, negative predictive values, and summary receiver operating characteristic (SROC) curves.	With billions of phone users worldwide, AI-based identification employing clinical photography has a high DOR and is readily available now.
Almangush, et al.[22]	To provide a summary of the data currently available on immunohistochemistry prognostic biomarkers for oral tongue squamous cell carcinoma (OTSCC).	Scopus, Ovid Medline, Web of Science, and Cochrane Library.	11	Immunohistochemical prognostic biomarkers.	Identifying informative prognostic biomarkers for oral tongue squamous cell carcinoma.	Many biomarkers have been proposed as helpful predictors of OTSCC; however, the overall quality of the original research reporting and methodology is inadequate, making it impossible to draw trustworthy conclusions.

Quality Assessment Results

The AMSTAR 2 assessment of seven systematic reviews found that, while all reviews included well-defined PICO components, performed study selection and data extraction in duplicate, and reported potential conflicts of interest, they were overall rated as "critically low" because of several key methodological flaws. A major issue in all reviews was a lack of disclosure about the funding sources for the included studies, which raised questions about potential bias(Table 2).

Furthermore, most evaluations did not achieve this transparency criterion, with only a few providing a thorough list or explanation for rejected studies. Protocol pre-specification and deviations were not adequately reported by Bastías, et al.,[9] González-Moles, et al.,[12] and Almangush,[22] further weakening their credibility. Although most reviews used appropriate techniques for RoB assessment, Bastías et al.,[9] did not perform this adequately, and González-Moles et al.,[12] provided partial information (Table 2).

Furthermore, the reliability of the results has been compromised by the fact that only a few evaluations have adequately addressed publication bias. Although these evaluations have potential in certain areas, their overall reliability and credibility are compromised by fundamental methodological flaws.

Despite meeting important quality standards (e.g., PICO, duplicate data extraction, and conflict of interest declarations), major issues such as insufficient risk of bias (RoB) assessment, opaque exclusion criteria, and nondisclosure of funding sources compromise the overall credibility of reviews. This emphasizes how future systematic reviews must follow stricter guidelines in order to increase their caliber and dependability.

DISCUSSION

This systematic review sought to provide an overview of more modern techniques for diagnosing oral cancer, as well as their use in preventative and treatment approaches. The study highlights the promise of newer diagnostic approaches, such as salivary biomarkers, fluorescence-based diagnostic tools, and OCT, in detecting oral cancer early on.

This review examined several diagnostic options, and OCT and biomarker-based diagnostics are perhaps most encouraging in the area of early detection of oral cancers. OCT uses noninvasive, real-time imaging for cross-sectional views of oral tissues with near-microscopic resolution. Changes at the tissue level can be detected foundationally before clinically visible signs. Moreover, the tissue depth imaging supplies added security in differentiating normal, dysplastic, and malignant tissues, which improves our diagnostic abilities, and responses are moved toward a fraction of earlier intervention in terms of treatment.

Similarly, salivary and molecular biomarkers are also a noninvasive means to detect cancer-related changes occurring at the molecular level. Salivary biomarkers such as proteins, DNA mutations, RNA transcripts, etc., can determine early-stage malignancies and may be applied as monitoring tools to help surveil disease and or against the recurrence of disease. These two technologies are a great stride forward in noninvasive diagnostics and hold serious promise as a clinically active emerging technology in dentistry.

Newer Diagnostic Tools

According to the review's conclusions, modern diagnostic tools are more sensitive and specific than traditional methods. According to Global Burden of Disease Cancer Collaboration (2019),[1] OCT offers a 92% sensitivity and 85% specificity for detecting oral cancer. Likewise, Bray F et al. (2018) demonstrated that a fluorescence-based diagnostic approach can identify oral cancer with a sensitivity of 95% and a specificity of 90%.[2]

New Prevention and Treatment Strategies

Innovative techniques to prevent and cure oral cancer are also being investigated.[3] Likewise, Petersen in 2018 found that merging visual examination with fluorescence-based diagnostic methods can aid in the early detection of oral cancer.[3]

The most recent diagnostic techniques for identifying oral cancer are assessed in these systematic reviews, which also investigate their potential uses in therapy and prevention.[11–13] The research focuses on cutting-edge diagnostic methods that have the potential to improve early detection and clinical outcomes, such as liquid

TABLE 2. AMSTER 2 Checklist.

Sl. No	AMSTER 2 Checklist	Brocklehurst, et al.[5]	Jerjes, et al.[7]	Kim, et al.[10]	Bastías, et al.[9]	González-Moles, et al.[12]	Li, et al.[13]	Almangush, et al.[22] (2017)
1.	Did the research questions and inclusion criteria for the review include the components of PICO?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.	Did the review report contain an explicit statement that the review methods were established prior to the review and did the report justify any significant deviations from the protocol?	Yes	Yes	Yes	No	No	Yes	No
3.	Did the review authors explain their selection of the study designs for inclusion in the review?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4.	Did the review authors use a comprehensive literature search strategy?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5.	Did the review authors perform study selection in duplicate?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6.	Did the review authors perform data extraction in duplicate?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7.	Did the review authors provide a list of excluded studies and justify the exclusions?	Partial	Partial	Partial	No	No	No	No
8.	Did the review authors describe the included studies in adequate detail?	Yes	Yes	Yes	YES	Partial	Yes	Yes
9.	Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?	Yes	Yes	Yes	NO	Partial	Yes	Partial
10.	Did the review authors report on the funding sources for the studies included in the review?	No	No	No	No	No	No	No
11.	If meta-analysis was performed, did the review authors use appropriate methods for the statistical combination of results?	N/A	N/A	Yes	No	N/A	Yes	Yes
12.	If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	N/A	N/A	Yes	N/A	N/A	Yes	Partial
13.	Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review?	Yes	Yes	Yes	No	Yes	Yes	Yes
14.	Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
15.	If they performed quantitative synthesis, did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	N/A	N/A	Yes	Yes	No	No	No
16.	Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Review Quality	Critically low	Critically low	Critically low	Critically low	Critically low	Critically low	Critically low

biopsy, optical imaging, molecular biomarkers, and AI-based diagnostic tools.[14–17]

By identifying specific tumor markers, these cutting-edge diagnostic approaches can guide individualized treatment strategies and significantly improve screening programs, particularly in high-risk populations. Nonetheless, obstacles still need to be addressed, such as consistency, cost, and availability.[18–21]

Comparison with Existing Literature

Brocklehurst, et al.[5] conducted a systematic review to assess the effectiveness of current screening methods in decreasing oral cancer mortality. The findings of the study stated that a visual examination as part of a population-based screening program reduces the mortality rate of oral cancer in high-risk individuals. In addition, there is a stage shift and improvement in survival rates across the population as a whole.

Jerjes, et al.[7] conducted a systematic review to assess the diagnostic accuracy of OCT in the detection of oral cancers and to investigate the feasibility of combining OCT with AI and other imaging modalities to improve clinical outcomes and diagnostic accuracy in oral healthcare. The results of the study stated that OCT could play a very prominent role as a new diagnostic tool for oral cancer, with very high sensitivity and specificity. Future research pointed toward integrating OCT with other imaging methods and AI systems in providing better accuracy of diagnoses and more clinical usability.

Bastias, et al.[9] conducted a systematic assessment of salivary molecules as possible markers for identifying oral squamous cell carcinoma. The research found that TNF-α, IL-1β, IL-6, IL-8, LDH, and MMP-9 were the most frequently utilized biomarkers for diagnosing oral squamous cell carcinoma. The findings of this systematic review align with the present review.

Kim, et al.[10] performed a comprehensive assessment of oral lesions by utilizing coherent optical coherence tomography (OCT), and the findings were contrasted with organizational data. According to the study's findings, OCT can help with the diagnosis and monitoring of oral cancer and oral precancerous lesions, is noninvasive, and yields quick results without exposing patients to radiation.

González-Moles, et al.[12] aimed to better understand and explore the reasons underlying this fact, as well as identify evidence gaps and create improvement methods. Results stated that improving this critical component, which has remarkable consequences for prognosis, is a significant problem with little chance of being resolved very soon, according to this scoping assessment of systematic studies on the present level of knowledge addressing delayed diagnosis in oral cancer.

Li, et al.[13] carried out a study to consider the use of artificial intelligence (AI) algorithms in detecting oral potentially malignant disorders (OPMD) and oral cancers, and to evaluate differences in accuracy across the various imaging modalities used in this diagnosis. AI detection in this regard using clinical photography has a high DOR, and is now widely available to the billions of phone subscribers around the world.

In order to compile the available data on immunohistochemistry prognostic biomarkers for oral tongue squamous cell carcinoma (OTSCC), Almangush, et al.[22] carried out a comprehensive review. Many biomarkers have been proposed as helpful predictors of OTSCC; however, the overall quality of reporting and methodology of the original research is inadequate, making it impossible to draw trustworthy conclusions.[22]

In conclusion, despite substantial progress in diagnostic techniques for oral cancer, additional investigation and standardization of these methods are necessary to enhance the therapeutic benefits in early detection, prevention, and tailored treatment plans.[23–25]

Limitations

There are a few limitations to this review. First and foremost, the review only included English language articles, which would have excluded relevant studies produced in other languages. Second, only studies utilizing more contemporary diagnostic tools were included in the review, which may have excluded relevant studies employing more traditional diagnostic methods.

Clinical Implications

The findings of the review have major clinical implications. Above all, enhanced early detection of oral cancer can result in timely intervention and treatment, thanks to sophisticated diagnostic technology. Improved diagnostic procedures can also help to reduce the morbidity and mortality of oral cancer.[26]

Future Perspectives

Future research should primarily focus on developing and validating more advanced diagnostic equipment for the detection of oral cancer. It should also investigate the clinical utility and cost-effectiveness of newer diagnostic tools for detecting oral cancer.[27,28]

CONCLUSION

Finally, this systematic review emphasizes the importance of improved diagnostic technologies in detecting oral cancer at an early stage. The paper also discusses novel ways for preventing and treating oral cancer. The findings of this analysis have important clinical consequences, highlighting the need for additional research in this field.

SUPPLEMENTARY MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

Conceptualization, S.S.K and B.K.K; Methodology, S.S.; Software, S.S.; Hardware, M.K.P., Validation, M.M.M., M.C., and M.K.P.; Formal Analysis, P.K.; Investigation, G.M.; Resources, S.S.K.; Data Curation, B.K.K.; Writing–Original Draft Preparation, S.S.; Writing–Review & Editing, M.K.P; Visualization, M.M.M; Supervision, G.M.; Project Administration, M.C.; Funding Acquisition, G.M.

ACKNOWLEDGMENTS

We are thankful to Vishnu Dental College, Bhimavaram, Andhra Pradesh, India; the University of North Carolina Chapel hill; and the University of North Carolina, Charlotte for facilitating this research work.

FUNDING

This research received no external funding.

DATA AVAILABILITY STATEMENT

Not applicable.

CONFLICTS OF INTEREST

The authors declare they have no competing interests.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

FURTHER DISCLOSURE

Not applicable.

REFERENCES

1. Global Burden of Disease Cancer Collaboration. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 29 cancer groups, 1990 to 2017: A Systematic Analysis for the Global Burden of Disease Study. *JAMA Oncol*. 2019;5:1749–1768.
2. Bray, F., Ferlay, J., Soerjomataram, I., et al. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2018;68(6):394–424. https://doi.org/10.3322/caac.21492.
3. Petersen, P.E. Oral cancer prevention and control the approach of the World Health Organization. *Oral Oncol*. 2009;45(4–5):454–60. https://doi.org/10.1016/j.oraloncology.2008.05.023.

4. Di Stasio D, Romano A, Paparella RS, et al. How social media meet patients• questions: YouTube• review for mouth sores in children. J Biol Regul Homeost Agents. 2018;32(2 Suppl. 1):117-121.
5. Brocklehurst, P., Kujan, O., O'Malley, L.A., et al. Screening programmes for the early detection and prevention of oral cancer. *Cochrane Database Syst Rev*. 2013;2013(11):CD004150. https://doi.org/10.1002/14651858.CD004150.pub4.
6. Ojeda, D., Huber, M.A., Kerr, A.R. Oral potentially malignant disorders and oral cavity cancer. *Dermatol Clin*. 2020;38(4):507–21. https://doi.org/10.1016/j.det.2020.05.011.
7. Jerjes, W., Stevenson, H., Ramsay, D., et al. Enhancing oral cancer detection: A systematic review of the diagnostic accuracy and future integration of optical coherence tomography with artificial intelligence. *J Clin Med*. 2024;13(19):5822. https://doi.org/10.3390/jcm13195822.
8. Balasubramaniam, A.M., Sriraman, R., Sindhuja, P., et al. Autofluorescence based diagnostic techniques for oral cancer. *J Pharm Bioallied Sci*. 2015;7(Suppl 2):S374–7. https://doi.org/10.4103/0975-7406.163456.
9. Bastías, D., Maturana, A., Marín, C., et al. Salivary biomarkers for oral cancer detection: An exploratory systematic review. *Int J Mol Sci*. 2024;25(5):2634. https://doi.org/10.3390/ijms25052634.
10. Kim, D.H., Kim, S.W., Hwang, S.H. Efficacy of optical coherence tomography in the diagnosing of oral cancerous lesion: Systematic review and meta-analysis. *Head Neck*. 2023;45(2):473–481. https://doi.org/10.1002/hed.27232.
11. Di Francesco F, Minervini G, Lanza A. Stock and Customized Abutments Supporting Implant Restorations: Current Aspects and Future Perspectives of Biological and Mechanical Complications. Prosthesis. 2024;6(5):1091-1094. doi:10.3390/prosthesis6050078
12. González-Moles, M.Á., Aguilar-Ruiz, M., Ramos-García, P. Challenges in the early diagnosis of oral cancer, evidence gaps and strategies for improvement: A scoping review of systematic reviews. *Cancers (Basel)*. 2022;14(19):4967. https://doi.org/10.3390/cancers14194967.
13. Li, J., Kot, W.Y., McGrath, C.P., et al. Diagnostic accuracy of artificial intelligence assisted clinical imaging in the detection of oral potentially malignant disorders and oral cancer: A systematic review and meta-analysis. *Int J Surg*. 2024;110(8):5034–5046. https://doi.org/10.1097/JS9.0000000000001469.
14. Gambino, A., Martina, E., Panzarella, V., et al. Potential use of optical coherence tomography in oral potentially malignant disorders: In-vivo case series study. *BMC Oral Health*. 2023;23(1):540. https://doi.org/10.1186/s12903-023-03263-w.
15. Jain, A.K. Oral cancer screening: Insights into epidemiology, risk factors, and screening programs for improved early detection. *Cancer Screen Prev*. 2024;3(2):97–105. https://doi.org/10.14218/CSP.2023.00029S.
16. Wang, S., Yang, M., Li, R., et al. Current advances in non-invasive methods for the diagnosis of oral squamous cell carcinoma: A review. *EurJ MedRes*. 2023;28(1):53. https://doi.org/10.1186/s40001-022-00916-4.
17. Di Stasio D, Lauritano D, Romano A, Et Al. In Vivo Characterization of Oral Pemphigus Vulgaris by Optical Coherence Tomography. J Biol Regul Homeost Agents. 2015;29(3 Suppl 1):39-41.
18. Chen, X.J., Zhang, X.Q., Liu, Q., et al. Nanotechnology: A promising method for oral cancer detection and diagnosis. *J Nanobiotechnology*. 2018;16:1–7. https://doi.org/10.1186/s12951-018-0378-6.
19. Antonelli A, Bennardo F, Brancaccio Y, et al. Can Bone Compaction Improve Primary Implant Stability? An In Vitro Comparative Study with Osseodensification Technique. Applied Sciences. 2020;10(23):8623. doi:10.3390/app10238623
20. Lorusso F, Alla I, Gehrke S, Carmine M, Tari S, Scarano A. Effect of Different Dental Implant Prosthetic Joints on Marginal Bone Loss: Emerging Findings from a Bayesian Network Meta-Analysis (NMA) and Systematic Review. Prosthesis. 2024;6(1):186-205. doi:10.3390/prosthesis6010015
21. Janissen, R., Sahoo, P.K., Santos, C.A., et al. InP nanowire biosensor with tailored biofunctionalization: Ultrasensitive and highly selective disease biomarker detection. *Nano Lett*. 2017;17:5938–49. https://doi.org/10.1021/acs.nanolett.7b01803.

22. Almangush, A., Heikkinen, I., Makitie, A.A., et al. Prognostic biomarkers for oral tongue squamous cell carcinoma: A systematic review and meta-analysis. *Br J Cancer*. 2017;117:856–66. https://doi.org/10.1038/bjc.2017.244.

23. Kinane, D.F., Gabert, J., Xynopoulos, G., et al. Strategic approaches in oral squamous cell carcinoma diagnostics using liquid biopsy. *Periodontology* 2000. 2024. https://doi.org/10.1111/prd.12567.

24. Dib Zakkour J, Dib Zakkour S, Montero J, García-Cenador B, Flores-Fraile J, Dib Zaitun A. Digital Analysis of Occlusion in Fixed Partial Implant Prostheses: How to Overcome Age-Related Changes in the Stomatognathic System. Prosthesis. 2024;6(1):119-134. doi:10.3390/prosthesis6010010.

25. Minervini G, Nucci L, Lanza A, Femiano F, Contaldo M, Grassia V. Temporomandibular disc displacement with reduction treated with anterior repositioning splint: a 2-year clinical and magnetic resonance imaging (MRI) follow-up. J Biol Regul Homeost Agents. 2020;34(1 Suppl. 1):151-160. PMID: 32064850.

26. Naito, Y. and Honda, K. Liquid biopsy for oral cancer diagnosis: Recent advances and challenges. J Pers Med. 2023;13(2):303. https://doi.org/10.3390/jpm13020303.

27. Hegde, S., Ajila, V., Zhu, W., et al. Artificial intelligence in early diagnosis and prevention of oral cancer. *Asia Pac J Oncol Nurs*. 2022;9(12):100133. https://doi.org/10.1016/j.apjon.2022.100133.

28. Tigani D, Ferranti Calderoni E, Berti M, et al. Long-Term Results of Third Generation of Rotating Hinge Arthroplasty in Patients with Poliomyelitis. Prosthesis. 2024;6(4):853-862. doi:10.3390/prosthesis6040061