REVIEW ARTICLE

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A novel approach of tongue cancer diagnostic imaging: a literature review

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ABSTRACT

Objectives: This review article is aimed to provide a scientific information about novel approach of tongue cancer diagnostic imaging based on evidence-based reputed published studies.

Review: The databases used in this literature review are Google Scholar, PubMed and Elsevier. The research results were selected by title and abstract according to their relevance to the review topic, then the results were selected again based on the inclusion and exclusion criteria. A total of 13 literatures were reviewed. This review shows the diagnostic imaging is a useful tool for staging and management planning in tongue cancers. In this era of technological development, a novel diagnostic imaging technologies that can be used for the diagnosis of tongue cancers such us Ultra High-Frequency Ultrasound (UHFUS), Diffusion-Weighted Imaging MRI (DWI-MRI), Dynamic Contrast-Enhanced MRI (DCE-MRI), Optical Coherence Tomography (OCT), Positron Emission Tomography (PET), Endoscopic images, and the other noninvasive imaging methods like vital staining, autofluorescence, Narrow-Band Imaging (NBI), and in vivo confocal microscopy. Besides that, imaging of tongue cancer requires a multimodality imaging approach to obtain accurate information about pathological condition such as PET/MRI, FDG PET/CT, and SPECT-CT.

Conclusion: Each diagnostic imaging has limitations in imaging the patient's condition, so it can be used alone or in combination with one another to obtain accurate information about pathological conditions. FGD PET-CT and UHFUS reportedly provide a high level of sensitivity and specificity to diagnose and staging of tongue cancer.

Keywords: *Tongue cancer, diagnostic imaging, advanced modality*

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INTRODUCTION

According to the Global Cancer Observatory (GLOBOCAN), Oral Cavity Cancer (OCC) is the most prevalent form of malignancy in the head and neck area. It is anticipated that the global occurrence of new OCC will surpass 29 per 100,000 individuals by the year 2030, affecting both genders and all age groups.[1] Oral cavity cancers (OCC) rank sixth in global cancer incidence, with squamous cell carcinomas (SCC) accounting for approximately 90% of all oral cancer cases. Squamous cell carcinoma (SCC) affecting the oral tongue is a frequently encountered subsite of SCC in the oral cavity. In males, SCC of the oral tongue is recognized as the 12th most prevalent cause of cancer-related mortality. According to estimates for the year 2018, there will be a total of 17,110 fresh incidences of oral tongue cancer, with 12,490 cases occurring in men and 4,620 cases developing in women (constituting one-third of the total cases). According to estimates, the mortality rate attributed to oral tongue cancer in the year 2018 was 2,510 fatalities, with 1,750 occurring in males and 760 in females.[2]

The early diagnosis of oral cancer is a crucial matter of interest in public health, as it leads to reduced morbidity post-treatment and a more favorable prognosis for patients. Patients who receive an early diagnosis of oral cancer tend to exhibit a more favorable long-term survival rate, ranging from 60% to 90%. In contrast, patients diagnosed with advanced stage oral cancer have a significantly lower survival rate, ranging from 20% to 50%. For patients receiving palliative care, the survival rate is less than 5%. The initial stage in the examination and diagnosis of oral cancer and precancer involves traditional oral exploration and palpation, as the majority of such tumors are discernible without the aid of magnification. Then, the definitive diagnosis is established by histological study of the biopsy specimen. Accurate disease diagnosis and staging, crucial for effective treatment planning, necessitates the utilization of complementary imaging modalities that provide supplementary information, spanning from conventional X-rays to highly advanced technologies.[3,4]

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Currently, diagnostic imaging of radiology technology in dentistry is no longer superior in visualizing hard tissue changes, but also its developed various imaging modalities that can visualize soft tissue pathological conditions such as soft tissue malignancy including tongue. In the early -stage detection of tongue cancer and in making informed decisions regarding oral tongue cancer management, diagnostic imaging analysis has the potential to assist pathologists and clinicians. The gold standard for the diagnosis of tongue cancer is established based on the results of histopathological examination of the biopsy specimens, while the clinical staging of oral cancer is determined based on the results of clinical examination and diagnostic imaging. The utilization of diagnostic imaging is crucial in instances of tongue cancer as it aids in the determination of the clinical stage by assessing the primary tumor's extent, metastases to regional lymph nodes, and the degree of metastases. Additionally, it assists in identifying the most suitable treatment approach for the patient. The utilization of imaging techniques is imperative in facilitating the accurate and effective management of these cancers. Awareness of specific issues related to spread of oral cancers at various subsites and the principles of management would help the radiologist choose a deal imaging approach and provide the clinician with a relevant report.[5]

The early detection of tongue cancer combined with appropriate imaging methods for proper staging is highly required and crucial. In this era of technological development, a novel diagnostics imaging technology has also been exploited in this field. In this article, a novel approach, combined with appropriate imaging methods used for the diagnosis of tongue cancer is discussed. This review article is aimed to provide scientific information about a novel approach of tongue cancer diagnostic imaging based on evidence-based reputed published studies. This research is expected to provide information regarding a novel diagnostic imaging of tongue cancer based on published studies and assist in establishing the diagnosis of tongue cancer.

REVIEW

A literature review using 3 databases, Google Scholar, PubMed, and Elsevier was conducted to explore the existing literature on the diagnostic imaging of tongue cancer. The research result was selected by title and abstract according to their relevance to the review topic, the result was selected again based on the inclusion and exclusion criteria. The inclusion criteria in this study were articles that discuss the diagnostic imaging of tongue cancer and literatures published between 2020-2023. Exclusion criteria in this study were duplicated literatures, unavailable full-text and written in other languages than English or Indonesian. Based on the selection criteria 13 literatures were collected and reviewed.

TONGUE CANCER

Tongue cancer is a form of malignancy affecting the tongue, with Squamous Cell Carcinoma (SCC) accounting for approximately 95% of all diagnoses. Tongue carcinomas predominantly arise on the anterior two-thirds of the tongue, with a prevalence of 40-75%, typically affecting the lateral and the lower edges of the organ. This particular malignancy accounts for a prevalence of 1% among all carcinomas throughout the body, and represents the most prevalent form of oral malignancy, with an incidence rate ranging from 25% to 45%. The delayed diagnosis of over 50% of cases results in a decrease in the patient's survival rate. [6] Oral tongue squamous cell carcinoma is a type of cancer that is anatomically characterized by its occurrence in the anterior two-thirds of the tongue. This area is situated within the oral cavity and spans from the apex of the tongue in the anterior direction to the circumvallate papillae in the posterior direction. In contrast to oral tongue cancer, which is situated at the anterior two-thirds of the tongue and is found in the oral cavity, base of tongue cancer is localized at the posterior one-third of the tongue and is situated within the oropharynx. The secondary spread of oral tongue squamous cell carcinoma may occur to the base of tongue or other contiguous oral cavity subsites, including the floor of mouth, gingiva, mandible, and beyond. However, the carcinoma is characterized by its origin from the oral tongue. [7]

The etiology of tongue carcinoma is considered to be multifactorial, with a known correlation to tobacco consumption, such as in the form of cigarettes. Tobacco use is considered a significant risk factor in the etiology of squamous cell carcinoma (SCC) of the tongue. The consumption of tobacco products, such as cigarettes, cigars, pipes, chewing tobacco, and snuff, represents the most significant risk factors for the development of head and neck cancer, including the tongue. Tobacco use has been found to be associated with 85% of head and neck cancers. Alcohol, constitutes a risk factor for the onset of oral cavity and tongue cancer, albeit being a less potent carcinogenic agent than tobacco. Individuals who engage in the consumption of tobacco and alcohol concurrently exhibit a synergistic effect, leading to a significant increase in risk. The magnitude of this risk is estimated to be between 30 to 36 times higher for individuals who engage in heavy smoking and drinking.[2,6]

DIAGNOSTIC IMAGING METHODS IN TONGUE CANCER

The use of radiographic imaging has entirely revolutionized diagnosis and treatment planning in medical sciences. The role of imaging in oral malignancies can be broadly grouped in those used to evaluate primary disease and those to evaluate metastatic disease. It is a useful tool for staging and management planning in oral tongue cancers.[8] The identification and detection of early-stage oral tongue cancer through imaging pose a significant challenge. Numerous imaging modalities are available for the detection of tongue cancers within the oral cavity. Hence, a meticulous examination of the literature derived from diverse studies is imperative to ascertain and synthesize a novel diagnostic imaging approach for tongue cancer. Table 1 presents a comprehensive overview of the latest research conducted on the diagnostic imaging modalities utilized in the detection of tongue cancer, as described below.

This review shows the diagnostic imaging is a useful tool for staging and management planning in oral tongue cancers. In this era of technological development, a novel diagnostic imaging technology that can be used for the diagnosis of tongue cancers such us Ultra High-Frequency Ultrasound (US), Diffusion-weighted imaging MRI (DWI-MRI), Dynamic contrast-enhanced MRI (DCE-MRI), Optical coherence tomography (OCT), Single-photon emission computed tomography (SPECT), Positron emission tomography (PET), Endoscopic images, and the other noninvasive imaging methods like vital staining, autofluorescence, narrow-band imaging (NBI), and and in vivo confocal microscopy. Besides that, imaging of tongue cancer requires a multimodality imaging approach to obtain accurate information about the pathological condition such as PET/MRI, PET/CT, and SPECT-CT.

Table 1. Summary of the recent studies on the diagnostic imaging methods in tongue cancer

Author (Year)	Title	Conclusion	Identified Diagnostic Imaging Methods	Design of Study
Yang et.al [9] (2023)	Deep-Learning Based Automated Identification and Visualization of Oral Cancer in Optical Coherence Tomography Images	It is proved that automatic identification methods combining the powerful learning capabilities of deep learning with the advantages of OCT imaging are feasible, which is expected to provide decision support for effective screening and diagnosis of oral cancer and precancerous tissues.	OCT	Deep learning Model
Tang et.al [10] (2022)	Assessment of tumor depth in oral tongue squamous cell carcinoma with multiparametric MRI: correlation with pathology.	E-THRIVE was the optimal MR sequence to measure the MR-derived DOI, and DOI derived from e-THRIVE could serve as a potential cut-off value as a clinical T staging indicator of OTSCC.	DWI-MRI DCE-MRI	Retrospective analysis
Heo et.al [11] (2022)	Deep learning model for tongue cancer diagnosis using endoscopic images	The deep learning model developed based on the verified endoscopic image dataset showed acceptable performance in tongue cancer diagnosis.	Endoscopic image	Deep learning Model
Aydos and Cebeci [12] (2023)	Prognostic role of primary tumor metabolic-volumetric parameters of 18F-fluorodeoxyglucose positron emission tomography in tongue squamous cell carcinoma	Primary tumor MTV is an independent prognostic factor in resectable TSCC. PET volumetric features can be used as a prognostic biomarker to predict patients with poor prognosis.	PET	Retrospective study
Novikov et.al [13] (2021)	Single photon emission computed tomography-computed tomography visualization of sentinel lymph nodes for lymph flow guided nodal irradiation in oral tongue cancer	Localization of sentinel LNs determined by SPECT-CT corresponds to the localization of metastatic LNs in terms of side and levels.	SPECT-CT	Retrospective study
Linz et.al [14] (2021)	Accuracy of 18-F Fluorodeoxyglucose Positron Emission Tomographic/Computed Tomographic Imaging in Primary Staging of Squamous Cell Carcinoma of the Oral Cavity	The results of this study suggest that combined FDG PET/CT is a valuable diagnostic tool in the preoperative staging of SCC of the oral cavity. The use of FDG PET/CT was associated with a high NPV and was superior to stand-alone morphologic imaging.	FDG PET/CT	Prospective diagnostic study

(Cont.) Table 1. Summary of the recent studies on the diagnostic imaging methods in tongue cancer

Author (Year)	Title	Conclusion	Identified Diagnostic Imaging Methods	Design of Study
Izzetti et.al [15] (2021)	Evaluation of Depth of Invasion in Oral Squamous Cell Carcinoma with Ultra-High Frequency Ultrasound: A Preliminary Study	UHFUS has the potential to become a valuable technique for the evaluation of OSCC lesions, and give insight into its application in OSCC diagnostic work-up and surgical management.	UHFUS	Retrospective study
Iandelli et.al [16] (2023)	The Role of Peritumoral Depapillation and Its Impact on Narrow-Band Imaging in Oral Tongue Squamous Cell Carcinoma	In our study, clinical peritumoral depapillation is associated with PNI on the pathology report. Its presence does not affect the NBI's ability to detect perilesional neoangiogenesis and delineate resection margins.	NBI	Retrospective study
Ikeda et.al [17] (2020)	Usefulness of fluorescence visualization-guided surgery for early-stage tongue squamous cell carcinoma compared to iodine vital staining	We strongly suggest that FV-guided surgery is a useful method for accurate resection in early-stage tongue squamous cell carcinoma.	Vital staining Autofluorescence	Prospective study
Kanno et.al [18] (2020)	Comparison of diagnostic accuracy between [^{18}F]FDG PET/MRI and contrast-enhanced MRI in T staging for oral tongue cancer	Although shallow DOIs are often overestimated, regional [^{18}F] FDG PET/MRI without fat suppression and gadolinium enhancement is comparable to and may be substituted for ceMRI in preoperative T staging for OTC patients, reducing metal artifacts and avoiding the adverse effects of GBCAs.	FDG PET/MRI	Retrospective study
Guo et.al [19] (2020)	Quantitative dynamic contrast-enhanced MR imaging can be used to predict the pathologic stages of oral tongue squamous cell carcinoma.	The quantitative DCE-MRI parameter Kep can be used as a biomarker for predicting the pathologic stages of OTSCC.	DCE-MRI	Prospective study
Jeng et.al [20] (2021)	Multiclass classification of autofluorescence images of oral cavity lesions based on quantitative analysis.	The QDA algorithm outperforms the LDA classifier in the analysis of autofluorescence images with respect to all of the standard evaluation parameters.	Autofluorescence	Retrospective study
Contaldo et.al [21] (2020)	Intraoral confocal microscopy of suspicious oral lesions: a prospective case series	In vivo reflectance confocal microscopy (RCM) can reveal dysplastic/ neoplastic signs occurring in oral lesions, thus supporting their diagnostic pathway.	In vivo confocal microscopy	Prospective study

DISCUSSION

An accurate analysis of the stage of tongue cancer is vital in deciding the therapy offered to the patient. Even though tongue is an organ, which is visible, clinical examination is difficult as most of the patients with carcinoma of tongue cannot open their mouth wide and many cannot tolerate palpation. Furthermore, these tumors are infiltrative, and if they cross the barrier of lingual aponeurosis, they will grow beneath it extensively involving the musculature while the mucosal surface shows a small or even no abnormality. Hence diagnostic imaging and staging of tongue cancer are indispensable.[22]

OPTICAL COHERENCE TOMOGRAPHY (OCT)

The utilization of optical coherence tomography (OCT) as an optical modality has the potential to furnish an optical manifestation of tissue and discern structural modifications transpiring in both benign and malignant lesions (Figure 1). Optical Coherence Tomography (OCT) is a non-invasive imaging modality that facilitates the quantification of epithelial thickness and structural alterations by analyzing data scans. The utilization of optical coherence tomography resulted in a sensitivity of 85% and a specificity of 78% when evaluating oral disorders that have the potential to become malignant or are already malignant. The accuracy of the assessment based solely on architectural changes was dec be 82%. Achieving resolutions of

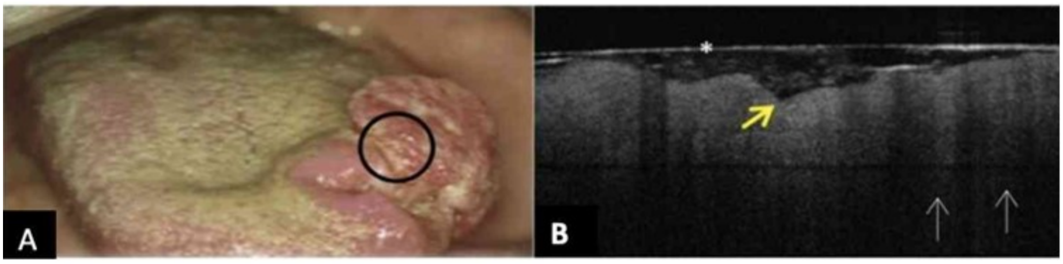

Figure 1. Representative image of tongue cancer on (A) Clinical, (B) Optical Coherence Tomography (OCT)[24]

up to 1-2µm is possible, which is approximately 100 -250 times greater than high-resolution ultrasound and comparable to that of microscopy. OCT imaging has demonstrated a significant correlation with histology in epithelial tissues, thereby establishing its potential in facilitating the diagnosis of pathological lesions and detecting cancer-free or positive margins following resection.[23]

DIFFUSION-WEIGHTED IMAGING MRI (DWI-MRI)

The utilization of Diffusion-weighted Imaging (DWI) is employed to examine the cellularity of tissues and the integrity of cell membranes through the measurement of the stochastic movement of water molecules in biological tissues (Figure 2A). DWI magnetic resonance imaging (DWI-MRI) is a technique that quantifies variations in tissue microarchitecture by analyzing the stochastic motion of water molecules. The quantification of discrepancies in water mobility is accomplished through the utilization of the apparent diffusion coefficient (ADC), which exhibits an inverse correlation with tissue cellularity. Therefore, the aforementioned technique has the capability to distinguish between tumorous tissue and normal or necrotic tissue. The metastasis of lymph node in patients diagnosed with oral squamous cell carcinoma (OSCC) is a negative prognostic indicator, necessitating precise identification to facilitate optimal treatment. The current investigation revealed that DWI-MRI exhibited a sensitivity of 75%, a specificity of 88.24%, and an accuracy of 96.69%. [25] Diffusion-weighted imaging (DWI) has the capability to accurately identify cancer-involved structures and distinguish reactive lymph nodes from metastatic ones. Consequently, it is recommended to evaluate lymph nodes prior to surgical intervention. Furthermore, DWI-MRI has the potential to aid in the evaluation of the initial response of the neoplasm to chemotherapy, with possible detection as early as one to two cycles of chemotherapy. The drawbacks associated with the utilization of this imaging modality include the existence of ferromagnetic substances, patients experiencing claustrophobia, and patients who have implanted pacemakers.[4]

DYNAMIC CONTRAST-ENHANCED MRI (DCE-MRI)

Dynamic contrast-enhanced magnetic resonance imaging, also known as DCE-MRI, is a method that collects a sequence of sequential pictures during contrast enhancement (Figure 2B). The utilization of DCE-MRI in clinical settings has been growing steadily over the past several years. Quantitative and semi-quantitative analyses are the two primary classifications that may be used in the DCE-MRI techniques of data analysis. Opportunities to investigate the properties of the tissue may be found via the use of quantitative and semi-quantitative methodologies. The prospective application of DCE-MRI in the management of patients afflicted with cancers includes assessing factors such as the treatment response, tumor differentiation, and tumor stage. DCE-MRI has the potential to give complete information about tumor features and has the ability to evaluate the stages of tongue cancer in a clinical environment without the use of invasive procedures.[26] The utility of DCE-MRI has been established in the diagnosis and differential diagnosis of both benign and malignant tumors in the head and neck region. Additionally, it is effective in characterizing metastatic cervical lymph nodes, assessing tumor cell proliferation and microvessel attenuation, predicting treatment

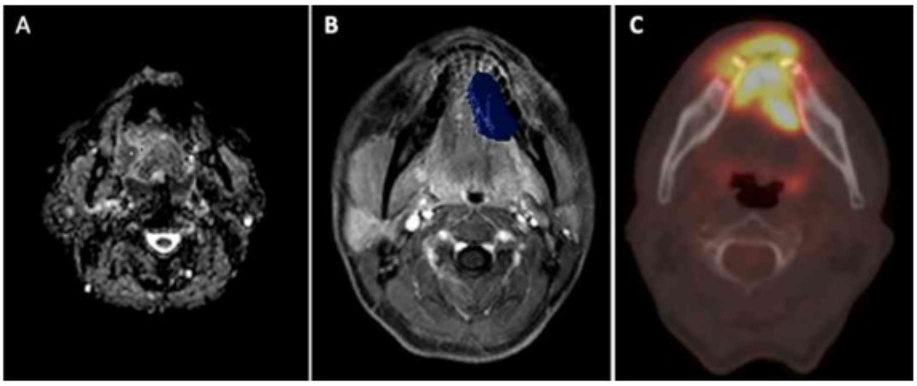

Figure 2. Representative image of tongue cancer on (A) DWI-MRI[10], (B) DCE-MRI[19], (C) PET[28]

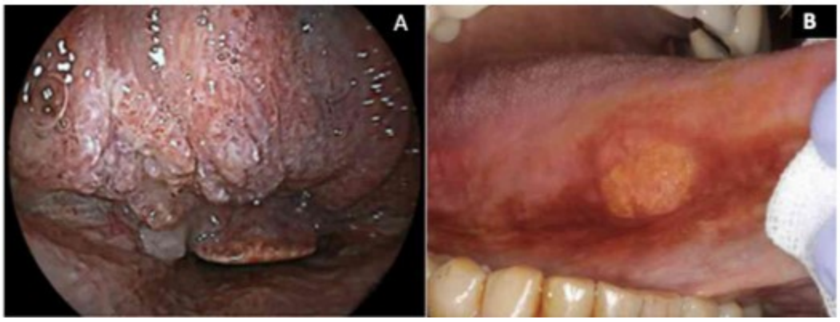

Figure 3. Representative image of tongue cancer on (A) Endoscopic[31], (B) Iodine Vital staining[17]

response, and evaluating treatment outcomes and prognosis in head and neck cancers. The utilization of DWI-MRI yielded a sensitivity of 89.2% and a specificity of 82.6% in the evaluation of oral lesions with potential malignancy or malignancy.[19]

POSITRON EMISSION TOMOGRAPHY (PET)

The utilization of radioisotopes that undergo positron emission decay is a fundamental aspect of Positron Emission Tomography (PET). The patient is encompassed by a detector that identifies the paired gamma photons that are emitted due to decay and record the occurrence as an image (as illustrated in Figure 2C). The preferred radionuclide utilized in positron emission tomography (PET) is [18F]-fluoro-2-deoxy-d-glucose (FDG).[27] Positron emission tomography (PET) utilizing 18F-fluorodeoxyglucose, a radioactive compound, can be administered either orally or intravenously to assess tissue metabolic activity. This technique has been employed to ascertain the metastatic potential of tumor cells. PET scans have additional applications such as facilitating the preparation of adjuvant therapy, approximating the likelihood of recurrence, and detecting the primary tumor location in instances of early metastasis, specifically in carcinoma of unknown primary.[4] Positron emission tomography (PET) utilizing 18F-fluorodeoxyglucose is a modality for assessing tissue metabolic activity. This is utilized in the context of devising supplementary therapeutic interventions and forecasting the likelihood of relapse-free survival. The application of this method enables the identification of metastatic lymph nodes with a sensitivity of 83% and a specificity of 88%. It allows for an estimation of the risk of recurrence.[28]

ENDOSCOPIC IMAGES

Endoscopy is a minimally invasive, simple and efficacious technique utilized for the diagnosis of tongue cancer. Nevertheless, the interpretation of endoscopic findings (as shown in Figure 3A) is a skill possessed by only a limited number of experts. If a dubious lesion is detected at a nearby clinic, it is recommended that the patient be directed to a specialist to verify the disease status and implement additional measures for its management. Inexperienced general practitioners may erroneously identify visual patterns as indications of ulceration or oral mucosa disease when diagnosing patients with tongue cancer. The employment of artificial intelligence (AI) analysis of oral endoscopic images has emerged as a promising approach to enhance the prospects of early detection of tongue cancer, thereby serving as a primary diagnosis method. Prior research on oral cancer has utilized images captured in non-clinical settings through the use of smartphones or digital cameras, rather than in a medically validated environment employing an endoscope. Additionally, the sample size of images was limited, consisting of less than 300 images. The endoscopic method yielded an accuracy rate of 84.7%, with a sensitivity of 81.1% and a specificity of 86.8%, in the detection of tongue cancer.[11]

VITAL STAINING

Vital staining is commonly employed as an adjunctive aid in vivo to visualize potentially malignant lesions within the oral cavity and/or to better define their margins and extent. The aforementioned dyes are non-toxic agents that possess the ability to infiltrate viable cells and adhere to particular biological structures. Toluidine blue (TB) and Lugol's iodine (LI) are the most frequently utilized agents in clinical practice. TB, a metachromatic dye, exhibits selectivity towards tissues that are abundant in nucleic acids due to its acidophilic properties. Therefore, neoplastic or highly dysplastic lesions, characterized by cells with a high concentration of DNA and RNA, exhibit a clinical presentation of royal blue staining (TB-positive), whereas healthy and non-dysplastic/non-neoplastic tissues display a pale blue color or do not exhibit any dye uptake (TB-negative). The diagnostic accuracy of tuberculosis (TB) in identifying tumors ranges from 93.5% to 97.8% with a specificity of 73.3% to 92.9%. The iodine staining principle involves the reaction between iodine and cytoplasmic glycogen of cells, resulting in iodine-starch reactions that can be clinically observed through a distinct color change, typically brown-orange in appearance (as depicted in Figure 3B). Hence, in the course of mucosal inspection under Lugol's staining, the mucosa that is considered normal exhibits a brown or orange hue owing to its elevated glycogen concentration. Conversely, dysplastic or neoplastic tissues do not undergo staining and manifest as pale yellow in contrast to the adjacent tissue.The diagnostic accuracy of LI in the detection of tumors is reported to range from

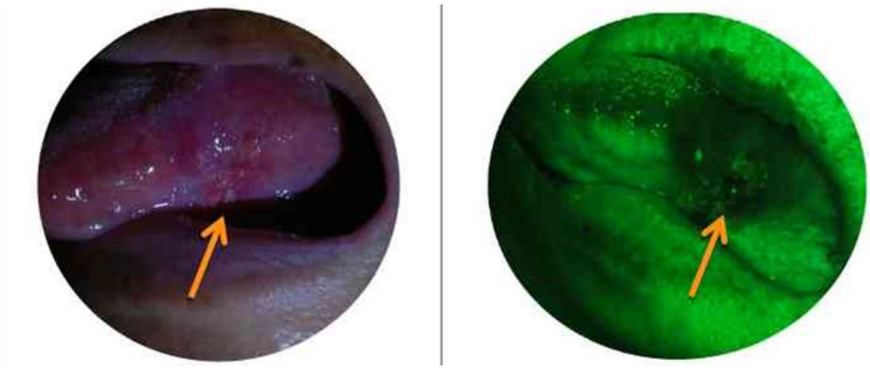

Figure 4. Representative image of tongue cancer on Autofluorescence[33]

87.5% to 97.2% with a corresponding specificity of 60% to 84.2%. The combined utilization of LI and TB can enhance the substantiation for distinguishing the dysplastic/neoplastic region from the healthy area in and around a mass.[29, 30]

AUTOFLUORESCENCE

Tissue autofluorescence (AF) is based on the detection of the inherent fluorescence emitted by tissues upon exposure to a specific light wavelength (Figure 4). Autofluorescence imaging utilizes blue light within the range of 400-460 nm to prompt the discharge of green fluorescence, which occurs at the wavelength of 500-520 nm, from endogenous fluorophores. These fluorophores include keratin, collagen, elastin, and NADH, and their interaction with tissues leads to the aforementioned emission. On the other hand, it has been observed that hemoglobin, porphyrins, and melanin possess a tendency to absorb incident blue light, leading to a reduction in the autofluorescence of tissues. A negative correlation has been observed between the progression of dysplasia and the fluorescence intensity. As dysplasia progresses from a mild stage to carcinoma, there is a gradual decrease in fluorescence intensity. Eventually, neoplastic lesions become undetectable due to this decrease in fluorescence intensity. In addition to TB, AF has significant utility in discriminating malignant tumors, identifying early-stage neoplasms, in situ carcinomas, and tumor recurrences, prior to the manifestation of typical clinical symptoms.[29] Autofluorescence has been found to exhibit a notable degree of specificity and sensitivity in detecting both oral cancer and precancerous lesions, with rates of 72.4% and 63.79%, respectively. The acquisition of such data can also furnish significant insights for diagnostic purposes, facilitate the formulation of strategies for margin resection in surgical excision, and enable the tracking of the therapeutic response throughout the follow-up period.[32]

ULTRA HIGH-FREQUENCY ULTRASONOGRAPHY (UHFUS)

Ultra-high frequency ultrasound (UHFUS) is a technique that can examine extremely minute structures and provide high-resolution pictures with dynamic, real-time, and comparative assessment (Figure 5). UHFUS produced pictures with exceptionally high resolution, revealing novel lymphatic vessel features. The use of UHFUS in the investigation of oral lesions is one of the most significant advances in US imaging of the head and neck region. The conventional ultrasonography (CUS) approach employs probes with frequencies ranging from 10 to 15 MHz, whereas UHFUS, with accessible frequencies of 48 and 70 MHz, may photograph the superficial layers of the mucosa as well as oral cavity diseases. In comparison to CUS, UHFUS has a higher spatial resolution, despite the constraint of a modest penetration depth of 1-3 cm. In reality, 48 MHz probes have a depth of penetration of 23.5 mm, whereas 70 MHz probes can image the first 10.0 mm below the scanning surface.[34] UHFUS has values for sensitivity, specificity, and negative predictive value that all surpass 90%. For mucosal growths and oral cancer diagnosis, sensitivity and negative predictive value were both 100%. Specificity varied from 97% to

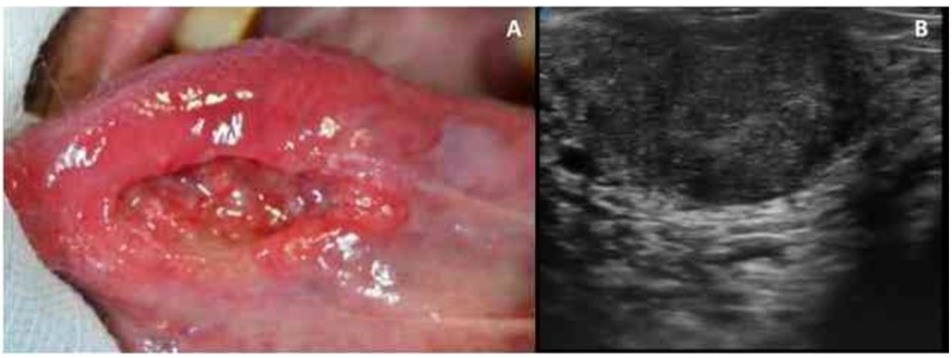

Figure 5. Representative image of tongue cancer on (A) Clinical, (B) UHFUS[15]

99%, while positive predictive value ranged from 83% to 99%.[35]

NARROW-BAND IMAGING

The technique of Narrow-band imaging (NBI), which is also referred to as virtual chromoendoscopy with magnification (VCM), is widely employed in the identification and monitoring of cancer. Its primary purpose is to differentiate tumor vascular patterns from non-neoplastic conditions (as illustrated in Figure 6A). Narrow-band imaging (NBI) is a technique that involves the integration of standard endoscopes with magnification capabilities and a conventional white-light source that is enhanced with narrow-bandwidth filters. These filters enable the sequential emission of green-blue light, which alters the spectral characteristics of the incident light. The strong adsorption of green and blue light by hemoglobin and the wavelength-dependent absorption and scattering processes in tissue structures result in good contrast for mucosa microvasculature. Specifically, blue light at 415 nm highlights the more superficial vessels of the submucosa, while green light at 540 nm can penetrate deeper into the tissue and improve visualization of deeper vessels beyond the mucosa. The utilization of NBI either independently or in conjunction with other diagnostic modalities can enhance the diagnostic procedure, particularly in instances of early cancers and high-grade dysplasia. The findings indicate that NBI has high sensitivity (92.3%) and specificity (88.2%) in early detection of oral squamous cell carcinomas (OSCC).[29, 36]

IN VIVO CONFOCAL MICROSCOPY

The technology of in-vivo microscopy (IVM) enables the visualization of living tissue in patients with high resolution and in real-time, at depths of approximately 200-300 µm, without the need for tissue removal, fixation, freezing, or staining. The oral cavity can be evaluated for both soft and hard tissues, as depicted in Figure 6B. The phenomenon under consideration involves the utilization of refracted light emission subsequent to its interaction with incident light of a particular wavelength. In vivo confocal microscopes utilize laser light of specific wavelengths to induce the emission of fluorescent or refracted light from living tissues, based on the presence of fluorophores or the refractive indices of the tissue's various compounds, respectively. This process is non-invasive and harmless. The correlation between in vivo confocal images and histological sections is robust and, therefore be considered "optical biopsie"'. The capacity to observe cells within living tissue, without the requirement of biopsies and fixation, provides novel and valuable insights into both health and disease. The detection of oral squamous cell carcinoma (OSCC) was accomplished through in vivo confocal microscopy with a sensitivity of 89.9% and a specificity of 78.6%.[29,37]

MULTIMODALITY IMAGING

Each imaging modality has limitations in imaging conditions patients, so they can be used single or in combination with each other to obtain accurate information about pathological conditions in the oral cavity. Until now there is no specific imaging modality that is ideal for tumor examination. Thus the examination of tumors and cancers involving the oral soft tissue requires a multimodality imaging approach.[5]

The integration of Positron Emission Tomography (PET) and Computed Tomography (CT) into a single device, known as PET/CT (Figure 7A),

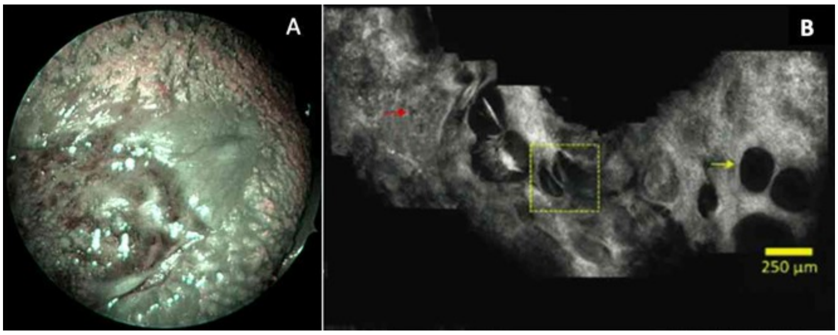

Figure 6. Representative image of tongue cancer on (A) NBI[16], (B) In Vivo Confocal Microscopy[38]

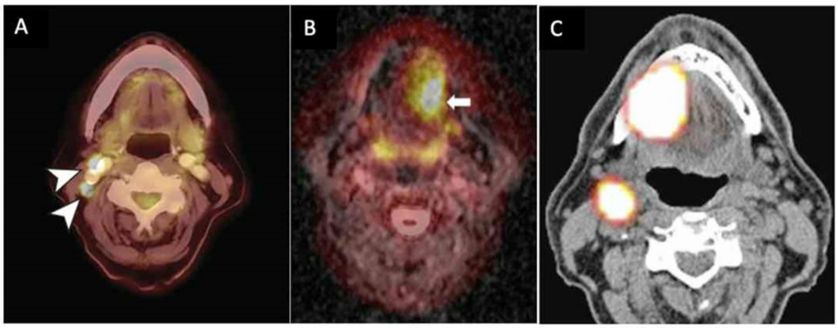

Figure 7. Representative image of tongue cancer on (A) PET-CT[14], (B) PET/MRI[39], (C) SPECT-CT[40]

represents a significant advancement in PET technology. This innovative technology enables the acquisition of highly accurate and integrated functional as well as anatomical information simultaneously. Although widely regarded as the most precise imaging modality presently available, it is not without limitations, including high expenses, limited accessibility, and the incapacity to identify micrometastases.[8] PET/CT imaging with fluorine-18 fluorodeoxyglucose (18F-FDG) is a hybrid molecular imaging method used in the main stage of head and neck tumors to identify lymph node and distant metastases. [12] FDG PET/CT is a very accurate noninvasive imaging method for pre-surgical diagnosis and staging of tongue squamous cell carcinoma and is extremely sensitive for diagnosis and highly accurate for pre-surgical staging. PET-CT detected tongue cancer with a sensitivity of 97.8% and a specificity of 100%.[14]

The technology of simultaneous positron emission tomography and magnetic resonance imaging (PET/MRI) has emerged as a promising imaging modality that offers superior diagnostic capabilities compared to either modality alone due to the complementary information of each modality. Furthermore, the employment of concurrent PET/MRI is anticipated to be more advantageous due to its reduced radiation exposure and offers better soft-tissue contrast resolution. The utilization of PET/MRI in head and neck cancer is significant owing to its exceptional soft-tissue contrast, which facilitates the detailed visualization of small anatomical structures. A prior investigation has documented that the employment of PET/MRI concurrently (as depicted in Figure 7B) could potentially result in a synergistic impact, thereby enhancing the precision of staging.[39] The integration of PET/MRI technology utilizing 2-[18F]-fluoro-2-deoxy-d-glucose ([18F]FDG) offers several benefits, including the ability to conduct PET and MR imaging concurrently. This approach also provides enhanced soft tissue contrast, multiplanar image acquisition, and functional imaging capabilities, all without the need for fat suppression or gadolinium-based contrast agents (GBCAs). Standard clinical PET/MR scans utilizing [18F]FDG for oncology purposes typically involve a regional scan to assess local tumor invasion, as well as a whole-body scan to identify lymph nodes and distant metastases. The utilization of PET-MRI yielded a sensitivity rate of 90% and a specificity rate of 91% in the detection of tongue cancer.[18]

The clinical application of combining single-photon emission CT (SPECT) with CT, known as the SPECT/CT dual-imaging modality technique (Figure 7C), has proven to be highly relevant in oncological applications. This technique has demonstrated improved sensitivity and specificity in producing registered anatomical and functional images. The amalgamation of two modalities can potentially enhance the staging and monitoring of treatment efficacy when assessing treatment outcomes. The majority of research findings suggest that SPECT-CT improves the informative value of localizing the sentinel lymph nodes (SLNs) and yields supplementary SLNs.[41] SPECT/CT achieved Sentinel node biopsy (SNB) with 76% sensitivity and 100% specificity.[40]

The availability of various imaging techniques, either alone or in conjunction with one another, has increased with the progress of technology, facilitating the assessment of oral malignancies, such as tongue cancer. The review shows that each diagnostic imaging has a different sensitivity and specificity value. FGD PET-CT and UHFUS reportedly provide a high level of sensitivity and specificity to diagnose and staging of tongue cancer. The sensitivity and specificity of FGD PET-CT were 97.8 % and 100 % while UHFUS were 100 % and 97-99%.

CONCLUSION

Diagnostic imaging is a part of the protocol for diagnosis and treatment of tongue cancer. Each diagnostic imaging has limitations in imaging the patient's condition, so it can be used alone or in combination with one another to obtain accurate information about pathological conditions. FGD PET -CT and UHFUS reportedly provide a high level of sensitivity and specificity to diagnose and staging of tongue cancer. FDG PET/CT and UHFUS are novel potential approaches diagnostic imaging for the early detection of tongue oral cancer. Further refinement of diagnostic imaging techniques is mandatory to improve their accuracy until it approaches that of the gold standard.

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FOOTNOTES

All authors have no potential conflict of interest to declare for this article.

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