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Distinct Imaging Modalities in Head and Neck Cancer: Benefits and Drawbacks

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Abstract

This review mainly focuses on the distinct imaging techniques in for head and neck cancer (HNC), its altered techniques used in diagnosis and its applications. It also depicts the upcoming imaging methods present in the field of HNC causing areas. It explains precise determination regarding the degree and extends of neoplasm. We mainly look on to the MRI(Magnetic resonance imaging), PET(Positron emission tomography), CT (computed tomography)imaging biomarkers for the management of HNC. It plays an important role in the therapy selection strategies and also enhances the therapeutic ratio in the management of HNC. The role of imaging techniques become increasingly more crucial in the management process in locally progressed head and neck squamous cell carcinoma(HNSCC). In this structure, PET allows non-invasive assessment of a range of tumour biomarkers such as metabolism, hypoxia and proliferation. MRI techniques such as can characterize different tissues by probing into their microstructure, providing a novel methodology in oncological imaging. CT, MRI, and PET/CT are widely used to determine the presence and extent of the tumours before and after treatment. This review depicts a synopsis of the most recent imaging strategies and imaging recommendations for every one of the different strides along the clinical way of patients with head and neck malignant growth.

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INTRODUCTION

HNC is considered 6^{th} utmost leading malignancy. Alcohol and Tobacco are considered to be the major risk factor causing the incidence of HNC. Apart from these other uncommon causes include Paan (betel quid) in the mouth, consumption of preserved or salted foods, poor oral hygiene, Occupational and Radiation exposure, Epstein-Barr virus infection(a risk factor for nasopharyngeal cancer) (Differding *et al.*, 2015) The clinical signs and symptoms may be nonspecific and can vary depending on the tumour site in the head and neck (oral cavities, pharynx, larynx, nasal cavity, paranasal sinuses, salivary glands, thyroid, and skin). "Head and neck cancers" is the term used to designate a number of malignant tumours that progress in or nearby the throat, larynx, nose, sinuses, and mouth. Utmost common carcinomas are squamous cell carcinomas (SCC). If cancer is only originated at the squamous layer of cells, it is termed carcinoma in situ. If the cancer has grown outside this cell layer and progressed into the deeper tissue, then it is termed invasive squa-

mous cell carcinoma. If cancer develops in salivary glands, this type tumor will generally be categorized as an adenocarcinoma, adenoid cystic carcinoma, or mucoepidermoid carcinoma (Wang *et al.*, 2001)

Visualization of HNC has technologically advanced immensely over the last few years. Innovative cross-sectional imaging techniques allow precise staging of illness and contribute significantly to management strategies and prognosis. Prior to imaging, the position and the level of metastases of a head and neck cancer had repeatedly been recognized clinically and it is not uncommon for a histological diagnosis to have been held from a representative biopsy. Therefore, the primary role of radiology is in precisely staging the complete size and distant spread of disease with the present tumor–node–metastasis (TNM) system, that will influence surgical or medical management strategies. Functional magnetic resonance imaging (MRI) of tumours of the head and neck commonly includes diffusion-weighted imaging (DWI) and intravenous (IV) contrast T1 dynamic perfusion imaging (DCE-MRI or PWI). Both techniques can specify different tissues by examining into their microstructure, providing a novel approach in oncological imaging (Beltagi *et al.*, 2019). Although PET/CT is superior to CT and MRI in detection of carcinoma of unknown primary, cervical lymph node metastasis, distant metastasis, residual tumour, recurrent disease, Contrast-enhanced computed tomography (CT), MRI, and PET/CT are widely used to determine the degree and extent of the tumours before and after treatment (Kumar *et al.*, 2016)**.**

Magnetic resonance imaging (MRI)

In MRI a powerful magnetic fields around the molecule and it develops an image of internal part of the body. It is beneficial for imaging the nervous system and the whole pathology also used to pick up the spread of tumor in lymph node and it is useful in soft tissue imaging Table 1 Fibrous dysplasia with bony lesions could identify by MRI with little signal strength in the T2 weighed systems. It is preferred for visualizing the parotid lesions on T1 weighed MRI because of hypertensive cause of the gland. MRI is chosen in case of meningeal symptoms as the leptomeninges are well explained with MRI than CT (Beltagi *et al.*, 2019; Balasubramanian *et al.*, 2012) Also it is shown as the consistent analyst about the malignancy or benignity of salivary gland.

Functional MRI in the HNC usually comprises diffusion-weighted imaging (DWI) and Perfusion weighted MRI (PWI or DCE-MRI). Both techniques can distinguish all types of tissues by penetrating into the microstructure, given that a novel tactics in oncological imaging. (Beltagi *et al.*, 2019; Wang *et al.*, 2001)

Uses of functional MRI for assessment of HNC (Beltagi *et al.*, 2019)

Determining controversial circumstances in the analysis of prime cancer.

1. More precise gross tumor volume delineation: Differentiation of primary tumor from associated inflammatory changes.
2. Staging issues: Bone/cartilage invasion, vascular and prevertebral muscle involvement (Murthy *et al.*, 2018)
3. Pretreatment prediction of response.
4. Intra-treatment response assessment.
5. Early (2 weeks) post-Rx: Response assessment for salvage management; specifically of locally advanced disease T3/4 tumor.
6. Differentiation of early post-therapy changes from Rx failure: Residual versus post-therapy non-tumorous inflammatory changes.

Computed tomography(CT)

It is also commonly used as like that of MRI. CT scan is a vital part of current scenario in all HNC patients as part of their investigative process. It gives a current and fairly economical method of recognising both local and distant metastases. The capacity of CT is to describe in details about primary tumours' and it is based on tumour spot and dimensions but can often be demanding (May *et al.*, 2019).

Multidetector CT (MDCT), is a better use of non-ionic and iodine based contrast medium which improves the image of lesion through its soft tissue and bone window programmer. As a result of its higher contrast uptake along with penetration of the muscle and fat tissue, it provides accurate image of the spread of tumor.

Middle ear examination is mainly done by spiral CT (Helical Computed axial tomography) of the petrous portion of the temporal bone. After CT scan, it implicates the thickening of the lymphatic membrane and fluid in the middle ear. CT displays lobulated, severely controlled osteolysis.

In T2-weighted systems, they occur with a high magnitude and high contrast improvement. As contrast medium is practically all the time required for oncologic symptoms, altered scientific methodologies are accessible to enhance image quality by escalate the contrast to noise ratio.

Table 1: Advantages and disadvantages on imaging techniques of head and neck cancer.

Imaging Techniques used in HNC	Advantages	Disadvantages
MRI	No radiation involved Soft tissues is better visualized by MRI than CT MRI is the best imaging practice and assessment for tumors of nasopharynx and skull base Saves time It can calculate the tumor reaction by detecting intra and prompt post therapy biological variations.	Expensive Time consuming than CT scan Images can be disrupted with movement and dental works. MRI for tumors except nasopharynx and skull base is not clear Less specificity and sensitivity while diffusion weighted methods may be superior (Wang *et al.*, 2001; Zhao and Rao, 2017)
CT	Effectively evaluate the examination of arteries and veins More reliable for showing the bone anatomy. Generally available in medical centers and very little scan time Effective and comparatively economical option for classifying not only localized but also distant metastases (Zhao and Rao, 2017; May *et al.*, 2019)	Only shows the late change connected with nerve invasion. Images can be despoiled with movement and dental mechanisms. Capacity to define predominant tumors based on tumor spot and dimensions and can be frequently demanding After therapy, more mucosal based recurrences are hard to detect without straight vision Regularly hard to distinguish post-operative or radiation changes from reoccurrence.
PET	Radioactive tracer decays quickly. While shared with a CT scan or MRI doctors can combine functional imaging with anatomic imaging to attain more accurate information. Better to separate actual cancer from deformities related to the effects of radiation. Key benefit is that it provides both anatomic and functional evidence related to CT or MRI Better sensitivity was notice in finding images taken after 10 weeks 18F-FDG PET/CT revealed high precision for Metastatic staging before salvage treatment (Zhao and Rao, 2017; Kumar *et al.*, 2016)	Scan image results are less accurate than anatomic examinations. Expensive Lights up the regions that are not certainly cancer containing affected areas. Lesser susceptibility in revealing of neck cancer Those who at less possibility of reoccurrence mainly HPV+ oropharyngeal patients probably to have trifling advantage Portions of infections too express bigger SUV rates creating variation of tumor from infection. Exposures to higher levels of radiation Lower grade malignancies cannot be detected by PET For lymph metastasis, 18F –FDG PET has no further significance beyond CT only for nodal delineation in accordance with pathological gold standard
Ultra Sound (US)	Generally accessible in medical centers, movable and inexpensive related to other imaging techniques Expose to radiation is not there The benefit of this scanning method is the union of fine needle aspiration cytology with its capacity to distinguish into benign and malignant lesions.	In HNC, sonography can affect results (Zhao and Rao, 2017)

Table 2: Imaging methods based on different organs affected

Organs affected	Type of cancer	Types of Imaging Techniques used
Oral cavity Lips to the end of hard palate. It includes teeth, the buccal and gingival mucosa, mandible and hard palate, the floor of the mouth, tongue and circumvallate papillae posteriorly (Balasubramanian *et al.*, 2014)	Most common cancer is Oral Squamous cell carcinoma (OSCC) (Balasubramanian *et al.*, 2014) Basaloid squamous cell carcinoma(BSCC) (Thankappan, 2012)	Both CT and MRI are used for measuring the principal tumor position It must be accomplished with IV contrast(CECT) to increase the visibility of the tumor DECT permits decrease of metal objects In the situation of dental amalgam artifact, utilize DECT with low metal object or MRI. CT is more better for bone invasion subtle cortical erosion and for early marrow invasion MRI is superior FDG-PET/CT used at stage of III to IV cancers.
Pharynx The cone shaped cavity situated at the back of the mouth and it starts from skull base to cricoid cartilage Structure: Nasopharynx (continues from the base of the skull to the upper surface of the soft palate) Oropharynx (continuing from the uvula to the extent of the hyoid bone. It pertaining to the mouth and pharynx) Laryngopharynx (It is the caudal part of the pharynx. It lies lower to the epiglottis and continues to where the digestive and respiratory pathways deviates) Nasopharynx Oropharynx Hypopharynx (Laryngopharynx)	Most common cancers are SCC , Adenocarcinoma begins in the glandular cells of the throat and Sarcoma is less common. BSCC Most common type of cancer is Nasopharyngeal carcinoma (NPC) (Petersson, 2015) NPC encompasses keratinizing, non- keratinizing carcinoma, and basaloid SCC SCC is the more prevalent kind of cancers. Most common hypopharyngeal malignancy is SCC	MRI with or without differentiation of skull base to clavicle is the best strategy. Consider CT for ambiguous instances of cortical erosion. Ruminate FDG-PET/CT for stage 3 to 4 malignant growths, N2-3 tumors and so on. Consider FDG-PET/CT to evaluate for metastases, predominantly for non-keratinizing histology, endemic phenotype (Petersson, 2015) Chest CT can be taken into consideration for progressive nodal cancer to image for distant metastases and for cigarette smokers to monitor for lung cancer FDG-PET/CT used at stage of 3 to 4 disease. The greatest method is CECT or MRI with or without differentiation (Adelstein *et al.*, 2017) CECT or MRI is the best method. MRI is suitable in measuring invasion of prevertebral fascia. It is ideal in the site of moving artifact Cogitate dual energy CT or MRI with contrast for cartilage invasion FDG-PET/CT used at stage of 3 to 4 disease (Kuno *et al.*, 2012)

Continued on next page

Table 2 continued

Organs affected	Type of cancer	Types of Imaging Techniques used
Larynx The organ of voice consist of supraglottic larynx, glottis, and subglottic larynx	SCC is most common at this area. BSCC is less common(elderly men) (Thankappan, 2012)	CECT for both staging and surveillance. It is faster and little prone to motion objects than MRI. CT reveals more valid indication of cartilage invasion, tumor spread and inclusion of soft tissues away from the outer cartilage margin. DECT expands the diagnostic presentation and replicability for finding of thyroid cartilage invasion over regular CT and MRI FDG-PET/CT used at stage of 3 to 4 cancers (Kuno *et al.*, 2012)
Nasal cavity & Paranasal Sinuses	Most common malignancies are SCC, adenocarcinoma, salivary gland tumors, Olfactory Neuroblastoma, melanoma, lymphoma, and undifferentiated carcinomas, sinonasal neuroendocrine carcinoma	CT and MRI are principal imaging techniques used for nasal cavity and paranasal sinuses MRI with or without contrast is the preference in evaluating the staging of primary Sino - nasal cavity malignancies and extent of disease FDG-PET/CT used at stage of 3 to 4 cancers
Salivary Gland	Salivary gland tumors	CECT is the primary imaging techniques in patients with palpable salivary gland masses MRI is presently suggested method for evaluating tumour progression, staging, spread and postoperative reoccurrence. There is an important part for FDG-PET/CT in the evaluation of cancer progression (Friedman and Saindane, 2013)
Perineural spread PNS of tumor refers to extension of benign or malignant tumor along a nerve and tumor growth apart from the primary site.	Most common malignancies observed in PNS is SCC Common HNC malignancies with PNS are: SCC of skin and mucosa Adenoid cystic carcinoma at salivary gland Desmoplastic melanoma Carcinoma at nasopharynx Basal cell carcinoma	CT or MRI are best modalities for imaging PNS CT shows erosion of skull base foramina or canals and destruction of fat density inside the foramina or pterygopalatine fossa (PPF) (Badger and Aygun, 2017)
Occult primary carcinoma(unknown primary carcinoma CUPs)	Cervical lymph node metastases is more common	FDG-PET/CECT is the best method
Lymph Nodes	SCC is more prevalent	CECT or MRI are preferred FDG-PET/CT used at stage of 3 to 4 cancers (Kumar *et al.*, 2016; May *et al.*, 2017)

Dual-energy method delivers in order default images (DI) with image quality similar to prevailing single-energy examinations and also permits for numerous post-processing uses (May *et al.*, 2017; Faby *et al.*, 2015)

Single source dect(SS- DECT)

For single-source CT, several dealers offer varied technical methods to get dual-energy data: double spiral acquisitions, fast kilovolt-switching, dual-layer indicators, or split-filter system. (May *et al.*, 2017; Faby *et al.*, 2015)

Double source dect(DS- DECT)

DS-DECT has a restricted field of view (268–353 mm) because of inadequate coverage from the smaller detector. Yet, the finite field of view is not completely pertinent for imaging the head and neck area and DS- DECT delivers the maximum spectral detachment and could hence be review as a source for soft tissue iodine distinction.

CECT (Contrast Enhanced CT) is routinely the essential imaging methods in grown-ups with discernable salivary organ masses since it can commonly separate among irresistible and neoplastic changes (May *et al.*, 2017; Kaemmerer *et al.*, 2016)

Positron emission tomography(PET)

It is basically a functional test other than anatomical test, which means, it measures different activities of cells in the body. Cancer cells at principal sites along with lymph nodes which is at distinct site can also be detected. PET molecular imaging shows an analytical part, as it deals the chance to determine non-invasively numerous tumour biomarkers including metabolism, hypoxia and proliferation. The primary aim of the preliminary imaging of a patient with a HNSCC is to decide the clinical stage with the prominent attainable accuracy. In this concern, head- to-toe 18F- FDG PET/CT (Fluorodeoxyglucose) permits the TNM stage to be discovered noninvasively in an individual process (Chang *et al.*, 2013; Cistaro *et al.*, 2011) Certain article have publicised excessive sensitivity and specificity of 18F-FDG PET in association to conservative radiological standards along with the histological gold standard. (Differding *et al.*, 2015)

PET/CT

PET/CT is higher to CT and MRI in finding of carcinoma of cervical lymph node metastasis, distant metastasis, remaining tumour, persevering sickness and second essential tumors causing in change in the therapy Table 2 However, the examination of FDG PET/CT investigation in the head and neck is fascinating as of the typically compound life systems, physiologic varieties, and strange design of FDG take-up following radiation treatment and medical procedure (Beltagi *et al.*, 2019) Since FDG isn't a tumour-exact pointer, it can assemble in a range of benign progressions with benign tumours, inflammatory, post traumatic disorders. In addition, there is physiologic uptake of FDG in fat, muscles, vocal cords, and lymphatic system in the head and neck area. (Kumar *et al.*, 2016; Metser *et al.*, 2007) Lesion classification on the CT area of the PET/CT study is subsequently more significant as it rises particularity of recording.

Puffed-cheek technique

It was as of late portrayed by Weissman and Carrau. On hurling the cheeks, the oral vestibule is squeezed with air, by making a negative contrast partitions of buccal and labial mucosa from the gingival mucosa, permitting both mucosal surfaces to be evaluated independently (Cistaro *et al.*, 2011; Chang *et al.*, 2013)

Open-mouth technique

It is characterized by Henrot and colleagues. A planned head-to-toe FDG PET/CT has evaluated from supraorbital edge to mid-thigh. Patient is mentioned to open the mouth and the device (50-mL needle) is then situated associating the teeth to affirm legitimate immobilization. The method is done all throughout quiet breathing. The laser is regulated to the open mouth, and an additional 3 to 4 minute PET/CT check is accomplished from the orbitomeatal line to the clavicular fossa, with one field of vision (May *et al.*, 2019, 2017)

Modified valsalva maneuver

The amended Valsalva maneuver was characterized by Jonsson19 in 1934 as "a strategy for appraisal of the hypopharynx and upper aviation route entries". The patient ought to maintain the strain for 10 - 15 seconds and to proceed with typical breath. A re examined Valsalva move comprise of a strain of 40mmHg weight for 15 seconds with the patient in the semirecubent state, a short time later in supine position with 15 seconds of inactive leg raise at a 45 degree point. Mentioned to blow 10ml needle enough to change the pluger makes a strain of around 40mm Hg (Henrot *et al.*, 2003)

Phonation

This method is done by requesting to say "e" consistently for at least 10 seconds. Visualization of the laryngeal ventricles permits further precise confirmation at the site of a supraglottic tumour or a glottic tumour. Modified Valsalva and phonation maneuvers are primarily utilize in CT procurement (Henrot *et al.*, 2003)

Ultrasound

Ultrasound, comparable to CT, is broadly accessible all over medical centres and is used in both prognosis and treatment. Ultrasound is mostly used in the treatment of HNC for prognosis and image lead biopsies of cervical lymphadenopathy. Ultrasound is also cited as one of the first choices in imaging the salivary glands (Lewis-Jones *et al.*, 2016)

Nasopharyngolaryngoscopy

This endoscopy assessment utilizes a stretchy, illuminated optical gadget called an endoscope to check the nasal cavity, voice box and throat. With the help of topical anesthesia, the tube is brought into the mouth or nose to catch pictures and evaluate the uneven cells (Lewis-Jones *et al.*, 2016; Mehanna *et al.*, 2016)

Panoramic dental X-ray

Further known as all-encompassing radiography, this two-dimensional (2-D) dental x-beam assessment catches the entire mouth in a solitary picture, with the teeth, upper and lower jaws, neighboring structures and tissues. It benefits understanding the event of oral diseases (Hermans, 2006)

Dental cone beam CT

This CT scan rehearses especially computerization to make three dimensional (3-D) pictures of dental structures, delicate tissues, nerve paths and bone in the craniofacial zone in an individual output. Cone beam CT is generally used to test whether radiation treatment are appropriately coordinated (Hermans, 2006)

Chest imaging

The utmost typical area for HCC to extend to is the lungs. It shows images of the heart, lungs, airways, blood vessels and the bones of the spine and chest (Lewis-Jones *et al.*, 2016)

CONCLUSIONS

To conclude, innovative modalities are progressively becoming accessible, and it is predominant to select the correct investigation methods for every medical question. This article mainly emphasis on different or currently used imaging modalities for head and neck cancers and their features, advantages and disadvantages. Based on different parts of head and neck cancer, specific imaging techniques has been chosen. Finally, there are numerous impending procedures such as in CT field, dual energy CT, flash CT and in case of MRI, such as MRA, spectroscopy, and tractography. However, ample work needs to be done to study the best time points, triggers, and reactions to tumour changes that can be tested in an approaching manner. Likewise, the broadly held recommendation advocates that PET-CT imaging is the most extreme profitable of existing imaging strategies at distinguishing remaining or intermittent malignant growth after treatment. On the other hand, considering the expense and the absence of significant level confirmation, it has not been collectively suggested and is directly not actually prompted in NCCN methodologies. The ideal schedule of essential PET-CT scan after treatment is by all accounts 3-6 months to get the most out of time for infection to resolve and to be able to identify the need for salvage treatment promptly. Further evaluation is required to assess the efficacy and cost of these techniques.

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Conflict of interest

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