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Imaging Modalities for Evaluation of Loco-Regional Spread of Oral Squamous Cell Carcinoma (OSCC) - A Systematic Review

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Abstract: *Oral squamous cell carcinoma (OSCC) is one of the commonest malignancies worldwide. This systematic review is an attempt to update regarding imaging modalities available for local and regional spread of OSCC. As oral and maxillofacial region has complex anatomy the spread of OSCC does not follow specific pattern. Imaging is necessary for the evaluation of Spread of malignancy. Although there is no specific imaging modality which gives exact dimensions of the malignancy, but the combination of imaging modalities are helpful. Although there are variety of studies on various imaging modalities but there is no consensus on imaging protocol of OSCC for pretreatment evaluation, treatment planning and formulate prognosis.*
Keywords : *OSCC, CT scan , MR imaging.*

I. Background

Worldwide, head and neck cancer is the sixth most common cancer for men and women, and the third most common in developing nations[1]. The disproportionately higher prevalence of oral cancer in India as one of the fifth leading cancer in either sex are related to the use of tobacco in various forms, consumption of alcohol and low socioeconomic condition related to poor hygiene, poor diet or infections of viral origin[2]. Ninety percent of oral cavity cancers aresquamous cell carcinoma (SCC)[3].Oral malignancies are easily evident on clinical examination. But complex anatomic structure of oral and maxillofacial region makes it difficult to determine the spread of malignancy. This article attempts to elucidate updates of imaging oral squamous cell carcinoma(OSCC). Various Imaging options include panoramic radiography, CT, MRI, and positron emission. Using these tools, radiologists contribute information regarding the characteristics of the primary tumor (T stage, as defined by the American Joint Committee on Cancer Staging). Malignancies in different locations within the oral cavity vary in behavior depending on the site, so that acquaintance with the expected pathways of extension is required for accurate interpretation.

Available imaging modalities:

Imaging strategies vary from patient to patient because of technical considerations as well as the site and extent of the malignancy. Imaging choices should be guided by information of the potential benefits and drawback for each modality. Primarily after clinical examination conventional radiography or plain film radiographic examination of the patient is performed. It gives primary idea about the bone invasion. Major drawback of conventional radiography is, two dimensional imaging of three dimensional structure. To overcome the shortfall it is suggested to use advanced imaging modalities like computed tomography (CT), magnetic resonance imaging (MRI) or ultrasound imaging with color Doppler. CT of the neck should be performed from the top of the frontal sinuses through the manubrium, after the administration of intravenous iodinated contrast, to evaluate for regional lymphatic spread and to characterize the extent of local oral cavity disease. Multidetector-row scanning with faster gantry rotation speeds allows the study to be completed in less than 10 seconds, significantly reducing motion artifacts. The helically acquired volume of image data is processed to form the standard axial images, which are usually generated at a 2- to 5-mm slice thickness. Because of the helical acquisition, the data can generally be reformatted in the coronal or sagittal plane without compromising resolution. If bone invasion is suspected, additional images can be generated using a filter to improve bone detail (bone algorithm filter).

The most significant drawback to CT, when imaging the oral cavity, is beam-hardening artifact attributable to dental amalgam. Special techniques to diminish this artifact include ‘‘open-mouth’’ imaging [5], which requires an additional acquisition through the oral cavity. An alternative technique to reduce beam-hardening artifact uses a postprocessing algorithm, but this is only available on scanners from certain manufacturers at the present time. Older single-slice CT scanners possessed the capability of gantry tilting, allowing angulation of the CT gantry to perform a ‘‘butterfly’’ technique to scan though the oral cavity and oropharynx at different angles, changing the location of the metallic streak artifact on each acquisition. Newer multidetector scanners do not allow for significant angulation of the gantry; thus, this maneuver is not an option. Because of the preponderance of beam-hardening artifact in the oral cavity, MRI is generally preferred for evaluation of an oral cavity primary tumor. Although dental amalgam may cause some distortion on MRI scans, it is generally less than would be seen on CT. A standard MRI examination of the neck includes T1-weighted axial and coronal images before and after contrast. The fat signal is suppressed on postcontrast images to improve the distinction between enhancing tumor and surrounding tissue. Axial T2-weighted images are also acquired through the oral cavity and neck, ideally with a fat-suppression technique. The examination requires 20 to 45 minutes, depending on patient compliance, scanner hardware, and

level of detail required. Although MRI of the neck includes coverage of the oral cavity, dedicated higher resolution MRI through the face may provide additional details about the primary tumor that may be missed with routine neck MRI. MRI may be limited by motion artifact from patient swallowing, lip smacking, talking, and tongue motion. Faster imaging hardware (eg, 3-T magnets and parallel imaging), faster MRI sequences, and patient education may help to diminish patient motion. In patients who do not have extensive dental hardware or amalgam, the choice between CT and MRI is more nuanced. MRI is generally preferred to CT for delineating tumor margins because of its superior soft tissue contrast. Tumor thickness is most accurately assessed on T1-weighted sequences before and after contrast. T2-weighted sequences may overestimate tumor size, because peritumoral inflammation and edema can have the same bright T2 signal as the tumor [6]. This information is important for treatment planning. CT is faster, less expensive, and more user independent than MRI. CT also better demonstrates cortical bone destruction in advanced tumors and is more sensitive for lymphadenopathy than MRI. Some patients can be stratified by their clinical histories. MRI should be used for patients who cannot receive CT contrast (eg, because of renal insufficiency or contrast allergy). CT should be used in claustrophobic patients or in patients who cannot easily lie still. CT and MRI are comparable for T staging of oral cavity tumors, but MRI provides more information for surgical planning purposes.

Ultrasonography and color Doppler is lesser used for the determination of spread of OSCC but it is modality of choice for determination of lymphaphatic spread of malignancy which is majorfactor for deciding treatment modality and prognosis.

Imaging modalities and site of OSCC:

Gingivobuccal sulcus

The gingivobuccal sulcus is the most common site of OSCC. The epithelial surface of the cheek and lip is the buccal mucosa, defined superiorly and inferiorly by the gingivobuccal sulci and posteriorly by the pterygomandibular raphe region. Cancer of the buccal mucosa may extend to deeper structures to involve the buccinator muscle and buccal space, including the parotid duct and body of the buccal fat pad, as well as to the dermis and mandible. Extension posteriorly to involve the retromolar trigone (RMT) is also a concern. Small buccal tumors may not be visible by standard CT or MRI, and the ‘‘puffed cheek’’ dynamic CT maneuver may help the radiologist to visualize the lesion [5,7] The upper alveolar ridge refers to the alveolar process of the maxilla, and the lower alveolar ridge refers to the alveolar process of the mandible. The lingual extent of the lower alveolar ridge mucosa is marked by the free mucosa of the floor of mouth. In regard to SCC of the gingiva, invasion of the adjacent buccal space occurs in 42% of the lower gingival tumors and 47% of the upper gingival tumors [8].Spread into the masticator space is seen in 14% of all lower gingival tumors (via the RMT and buccal space) but rarely occurs in SCC arising from the upper alveolar ridge [8]. Floor of the mouth (sublingual space) extension may occur with lower gingival tumors [8,9] and is well depicted by MRI. Eighty-five percent of imaged lower alveolar ridge mucosal cancers invade the mandible, and 88% of imaged upper gingival cancers invade the bony maxillary alveolus [15]. PNT spread from gingival and other oral cavity tumors may occur with direct mandibular involvement, affecting the inferior alveolar nerve, or secondarily from masticator space extension directly to the third division of the trigeminal nerve (V3). With inferior alveolar nerve tumor involvement, CT may reveal asymmetry of the inferior alveolar canals within the mandible or loss of the normal fat pad located at the insertion of the inferior alveolar nerve into the mandibular foramen. The inferior alveolar nerve within the mandible displays normal mild enhancement by MRI, but asymmetric enhancement should raise the concern for PNT spread.

Evaluation of V3 involvement can be tricky, and attention should be paid to normal enhancement in V3 as well as to normal variability in the size of the foramen ovale, as appreciated on CT. False-positive results can be avoided on MRI by searching for asymmetric enhancement compared with the contralateral foramen ovale. Middle cranial fossa dural and cavernous sinus involvement may be subtle as well and is best visualized on postcontrast, coronal, fat-suppressed, T1- weighted images. As a general rule, MRI of the face and skull base is more sensitive than CT for evaluation of PNT spread, which can be clinically silent. Thus, dedicated MRI of the face and skull base may be indicated even when there is no clinical evidence for PNT spread.

Retromolar trigone

The RMT begins behind the last mandibular molar tooth and extends superior to the maxillary tuberosity. It is, basically, the mucosal surface of the posterior mandibular body superior extent and inferior ramus anterior inferior extent. Th esubmucosal pterygomandibular raphe runs along the medial aspect of the RMT, extending from the mylohyoid ridge of the mandible to the inferior aspect of the medial pterygoid process. The posterior buccinator muscle and the superior anterior extent of the superior pharyngeal constrictor muscles attach to the pterygomandibular raphe.

The RMT is a relatively small region, and carcinomas arising in this location often present with invasion of adjacent structures, which include the buccal space, the alveolar ridge, the mandible, the oropharynx (eg, soft palate, palatine tonsil), the pterygoid process of the buccal fat pad (the bulk of which is posterior to the maxillary sinus and orbit), the floor of mouth, and the muscles of mastication (eg, pterygoid, masseter muscles) (Fig. 10). Infratemporal fossa and pterygopalatine fossa (PPF) involvement, from PNT spread or direct invasion, may occur secondarily (Fig. 11). Bone erosion, PNT spread, or muscle invasion elevates the T stage of all oral cancers to T4 [10,11]. Direct tumor spread may not be visible by physical examination but is readily identified with MRI [12] and less well with CT [13]. The diagnostic accuracy of MRI to depict the T stage is 86% [12]. MRI is the preferred modality to evaluate RMT SCC because of the increased contrast between tumor and the surrounding soft tissue. [11]. Denervation inflammatory hanges from V3 PNT spread may cause diffuse enhancement of the muscles of mastication, and PET may be required to define the extent of the primary tumor

Anterior 2/3rd tongue

The oral tongue includes the anterior two thirds of the tongue, extending posterior to the circumvallate papillae. Roughly two thirds of oral tongue cancers are moderately to far advanced at the time of initial diagnosis. Common (and ominous) patterns of spread include mandibular involvement and bilateral lymphadenopathy. Tumor extension across the midline lingual septum may require a total glossectomy or relegate the patient to nonsurgical treatment. On imaging, note should be made of involvement of the ipsilateral and contralateral neurovascular bundles, which enter the tongue at the level of the tongue base and extend anteriorly at the level of the sublingual space to supply the tongue. Oral cavity lesions are upgraded to a T4 tumor stage when they invade bone (usually the mandible but also the maxillary sinus and skull base) or involve the extrinsic tongue musculature. The extent of mandibular involvement determines the type of mandibulectomy. Nodal drainage of the oral tongue is to levels I, II, and III; occasionally, metastatic disease may bypass these groups and spread directly to level IV. Cross-drainage of lymphatics in the tongue is common, increasing the likelihood of contralateral nodal involvement [14].

MRI is generally superior to CT to evaluate cancers of the oral tongue. T1-weighted pre- and postcontrast MRI scans in the axial, coronal, and sagittal planes are particularly well-suited for the purpose. Additionally, fat-suppressed T2- weighted images may be beneficial and should routinely be used to evaluate the oral cavity and neck. CT may be helpful to confirm the extent of mandible involvement. Studies have demonstrated that in the oral tongue, tumor thickness is an independent prognostic factor to predict nodal metastases, local recurrence, and patient survival. Particularly in patients with N0 disease, tumor thickness significantly influences patient care.Lam and colleagues [6] found that only 8% of patients with a tumor thickness less than or equal to 3 mm had subclinical nodal metastasis. When the thickness exceeded 9 mm, however, 53% of their patients had subclinical nodal metastases. Tumor thickness is well evaluated with coronal and sagittal planes on MRI.

Floor of mouth

The floor of mouth is the most common site of oral cavity cancer after the lips [15]. The space is divided into the sublingual and submandibular spaces by the mylohyoid muscle. The sublingual space lies above the mylohyoid muscle, and the submandibular space lies below the mylohyoid muscle. Within the sublingual space are the sublingual glands, the Wharton submandibular ducts (Fig. 5), the hypoglossal nerves, and the lingual arteries and nerves. Because of its fat content, the sublingual space should demonstrate low attenuation on CT and be T1-hyperintense on MRI. The submandibular space contains the main bodies of the submandibular glands. MRI has been shown to differentiate accurately between direct invasion of the

submandibular gland and sialectasis [16]. Tumors that arise in the floor of mouth can spread posteriorly along the mylohyoid muscle to the tongue base and superior to the oral tongue. Floor of mouth tumors that spread laterally can involve the mandible. Mandibular invasion may be limited to
cortical involvement (obvious destruction or more subtle ‘‘saucerization’’) or may extend to involve cancellous bone. The type of resection is based on the amount of erosion. Disease limited to the mandibular cortex may be treated with a marginal mandibulectomy, but tumor invasion of marrow necessitates segmental resection [10].

Mandibular involvement may be assessed with panoramic tomographic radiography, CT, MRI, and bone scans with single photon emission computed tomography (SPECT). Panoramic tomographic radiography is insensitive for the detection of marrow invasion. The superior and inferior cortices of the mandible are imaged tangentially by this technique, and subtle cortical erosion in these regions, as by alveolar ridge carcinoma, may be readily detected. This method of imaging does not visualize the lingual cortex of the mandible in tangent, and lingual (as well as buccal) cortical bone involvement may be overlooked. CT has the advantage of more accurately depicting the pattern of bone invasion than panoramic radiography, whether it is erosive, invasive, or mixed [17]. Helical CT scanning allows the imaging data to be reconstructed in any plane at identical resolution. CT scanner manufacturers offer postprocessing options to reconstruct cross-section images that are perpendicular to the mandible as well as panoramic images of the mandible with dental planning software packages. These may be useful to determine the extent of mandibular invasion with oral SCC [18,19]

Brown and Lewis-Jones [20] reviewed the published evidence to support the use of the different modalities to assess mandibular invasion in the setting of oral cancer. They found nuclear medicine bone scan imaging using SPECT to be quite sensitive (97%) but not as specific (76%) for SCC, because non carcinomatous pathologic findings within the mandible may cause abnormal uptake.

It is essential that the bone scan (with or without SPECT) be interpreted in conjunction with other imaging studies that can more accurately localize the tumor. CT is more specific (86%) than radiography and serves as a useful adjunct to bone scanning.

The meta-analysis by Brown and Lewis-Jones [20] showed that MRI provides a sensitivity of 85% and specificity of 72%. Bolzoni and coworkers [21] found more encouraging data to support the use of MRI. In a recent 2004 study, they found MRI to have a sensitivity of 93% and specificity of 93%. The older literature should be viewed cautiously, because MRI and CT technologies continue to improve rapidly and older investigations into their applicability may not be accurate. For example, CT scans are now routinely obtained at submillimeter resolution, and images of the mandible can be generated in any plane on the radiology imaging workstation. This is in contrast to older published studies that evaluated the use of 3- to 5-mm axial slices to determine bone invasion, without the ability to reconstruct and adjust the display window and level settings. If involvement of the mandibular inferior alveolar canal is identified, the extent of PNT spread should be evaluated with MRI.The extent of spread determines treatment of cancers of the floor of mouth. Tumors that extend inferiorly along the mylohyoid or hyoglossus muscle may require a combined transoral and cervical approach for complete surgical resection.Oral cavity tumors that spread via the tongue base to the pre-epiglottic space, vallecula, or tonsillar region may require a partial pharyngectomy if treated surgically. The primary lymph drainage from the floor of mouth is to level I and level II nodes; occasionally, these nodal groups are bypassed with direct spread to level III nodes [14].

Labial mucosa

Imaging is not typically indicated with early SCC of the lips, because the extent of disease is readily assessed clinically. In more advanced cases, tumor margins may not be delineated on clinical examination. CT or MRI should focus on the mental and inferior alveolar canals for bony destruction and perineural tumor spread, which upstages these tumors to T4.

Palatal mucosa

Although a rare location for primary SCC, hard palate disease deserves special mention. SCC involvement of the hard palate most commonly occurs secondarily to extension from the adjacent maxillary alveolar gingiva. The size of the primary tumor is readily assessed with a combination of clinical examination, CT, or MRI. Subtle spread of tumor along the palatine nerves can be overlooked, however. CT (displayed using a bone window setting) may show asymmetry of the palatine foramina, which is located roughly at the junction of the hard and soft palates, and MRI may show asymmetric enhancement of the palatine nerves. With advanced PNT spread, there is loss of the normal fat hypodensity (CT) and T1 hyperintense signal (MRI) within the involved PPF. Tumor may then spread posteriorly along the second division of the trigeminal nerve through the foramen rotundum to involve the cavernous sinus or superiorly into the inferior and superior orbital fissures, with further extension possible from these locations.

Perineural extension from the PPF posteriorly via the vidian nerve is also possible, and the sharp cortical margins of the vidian canal should be evaluated carefully to exclude tumor involvement on CT scans of advanced tumors. Hard palate SCC may extend superiorly to invade the maxillary sinus and inferior nasal cavity. Maxillary sinus mucosal disease may be indistinguishable from invasive tumor by CT [22]. MRI can usually distinguish tumor from retained paranasal sinus secretions with T2-weighted images, however. Secretions are typically brighter than tumor on T2-weighted images. T1-weighted images, before and after contrast, occasionally contribute information to make the distinction [23].

Lymphadenopathy

Regional nodal disease from oral cavity SCC usually involves nodal groups I (submandibular, submental) and II (superior internal jugular chain). The presence or absence of nodal metastases greatly affects survival of patients with head and neck cancer [24,25], and criteria that influence N staging include laterality of nodes and nodal dimensions. Patients rarely present with distant disease unless there is extensive tumor. CT is more sensitive than physical examination for detecting involved nodes [26,27] and should complement the clinical evaluation routinely. A study by Malard and colleagues [28] showed CT evidence of nodal involvement in 30% of patients with clinically N0 necks. On MRI and CT, lymph nodes are judged by their morphology and location. CT has been shown to perform slightly better than MRI for the detection of nodes involved by metastatic SCC [29,30], although a recent study has shown MRI to be comparable to CT when the MRI slice thickness is reduced and the interslice gap is removed [31]. Tumor necrosis within lymph nodes is the most specific marker of nodal involvement. [17], and routine neck CT is performed at a higher resolution than routine neck MRI, allowing for improved detection of this necrosis. Of note, necrosis can only be appreciated on contrast images (necrosis is missed on unenhanced studies).

''Necrotic'' nodes are always considered pathologic in the setting of oral SCC, although specificity may be diminished when a normal fatty hilum is mistaken for central necrosis because of volume averaging. Another clue for metastatic nodal involvement is irregular spiculated nodal margins on CT or MRI. This sign is highly suggestive of extracapsular tumor spread in the absence of prior surgery, radiation, and inflammation. CT has generally been more accurate than MRI in detecting extracapsular extension [29,32, although MRI may be comparable to CT when the axial MRI slice thickness is reduced [33]. Various imaging size criteria have been proposed to determine if a cervical node is involved by tumor. If a larger diameter cutoff is used (eg, 15 mm), small involved nodes are not detected and sensitivity drops. If a smaller cutoff is used (eg, 8 mm), specificity suffers. Additionally, differently sized criteria may be applied to the different nodal levels. Castelijns and van den Brekel [34] have recommended using a maximum short axis dimension,

as measured by ultrasound, of 7 mm for level II nodes and 6 mm for other cervical nodal groups, based on previous work [35]. To reduce the number of false-positive nodes that these criteria would produce, these investigators sample the nodes using ultrasound guidance.When ultrasound, combined with fine-needle aspiration cytology, confirms an N0 neck, the electiveneck dissection may be deferred [34,35,36]. This approach has gained wider acceptance in Europe than in North America, where more liberal size criteria are used and ultrasound-guided fine-needle aspiration is not utilized. Generally, a 10-mm long-axis dimension (on axial images) is used for all cervical nodal groups except for level II, where 15 mm is generally used.

Others, however, recommend using 15 mm as the maximum dimension in level I [32]. Cervical node size criteria have not been validated and serve as a general guideline for determining regional spread by imaging. Involved subcentimeter nodes are missed, and enlarged, reactive, benign nodes are described as involved by tumor. Size should be factored in with nodal shape when predicting malignancy. Most normal lymph nodes possess an ovoid shape, and a node that is more rounded should be viewed with concern. Rounded nodes may be benign, however, reflecting the sequelae of chronic infection and poor dental hygiene; thus, roundness may not correlate with malignancy [37]. Because of these drawbacks, nodal necrosis remains the most specific imaging finding on CT or MRI. Another imaging modality that can help to identify nodal disease is nuclear medicine lymphoscintigraphy. A radiotracer is injected around the tumor, and gamma camera imaging or a handheld probe is used to localize the node or nodes draining that region. Surgical treatment can then be focused on these sentinel nodes. Preliminary results show that the test is technically feasible and promising in oral cancer [38].

Summary and conclusion:

Spread of OSCC is not specific. Multiple factors are responsible for the spread of the malignancy. Malignancies of same site follows specific pattern of growth but it is not thumb rule. Familiarity with the patterns of oral cavity tumor spread is essential to appropriate interpretation of imaging studies.

A single imaging modality cannot give complete spread of malignancy, so the use of multiple imaging modalities is mandatory. Despite of various studies there is no structured protocol for the imaging modalities for the loco regional spread of OSCC. All relevant imaging studies should be viewed simultaneously, in conjunction with the appropriate clinical history provided by the clinician surgeon. CT and MRI of the oral cavity may be complementary to evaluate OSCC, although MRI is generally better suited for the purpose. There has to be attempt to formulate a structured protocol for pre treatment evaluation of OSCC.

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