MULTI DETECTOR COMPUTED TOMOGRAPHIC EVALUATION OF NECK SPACES IN LOCALLY ADVANCED ORAL CANCERS

By

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DOCTOR OF MEDICINE (MD)
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I hereby declare that this dissertation entitled **"MULTI DETECTOR COMPUTED TOMOGRAPHIC EVALUATION OF NECK SPACES IN LOCALLY ADVANCED ORAL CANCERS"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. ANIL KUMAR SAKALECHA,** M.D, Professor Department of Radiodiagnosis & under the co-guidance of Professor, **Dr. AZEEM MOHIYUDDIN. S.M.,** MS Department of ENT, Sri Devaraj Urs Medical College, Kolar, in partial fulfillment of University regulation for the award "**M.D. DEGREE IN RADIODIAGNOSIS**", the examination to be held in April, 2016 by SDUAHER. This has not been submitted by me previously for the award of any degree or diploma from the university or any other university.

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ABSTRACT

INTRODUCTION

Malignancy of the oral cavity account for about 7.6% of total cancer in India. Many Indians present at late stage of disease by the time of diagnosis. Local anatomical spread of oral cancers into the face and maxilla and further extension into neck spaces is critical for staging of cancers. Cancer staging helps in the treatment of oral cancers. CT is considered the primary modality of investigation as it helps in delineating the size and extent of primary tumor and also helps to evaluate bone involvement.

AIMS AND OBJECTIVES

1. To perform multi-detector computed tomography (MDCT) and to evaluate its usefulness in assessing the involvement of deep neck spaces in locally advanced oral cancers.
2. To assess Computed tomographic morphology specifically to know resectability or non-resectability of oral cancers.

MATERIALS AND METHODS:

Data was collected from a total of 39 cases of locally advanced oral cancer referred for contrast enhanced computed tomography of neck to the department of Radio-diagnosis, Sri R.L. Jalappa hospital and research center over a period of 18 months, from January 2014- June 2015 with SIEMENS SOMATOM EMOTION 16 equipment. MDCT findings were analyzed with regard to location, size and extent of the disease and findings were correlated with either clinical follow up or surgical findings.

RESULTS:

In our study out of 39 patients, highest number of cases were of carcinoma buccal mucosa (71.8 %) followed by carcinoma tongue (10.3%) and lower alveolus (10.3%), showing female preponderance (F:M-2:1), as the habit of betel nut chewing was observed in 59 % of patients. Most commonly involved neck space was buccal space (94.9 %), followed by masticator space/ infratemporal fossa (46.2 %) and Submandibular space (43.6 %). CT was 100% accurate in detecting the bone erosion, and was confirmed in 18 patients who underwent surgery.

It is proved that CT is useful over clinical examination for the staging of advanced oral cancers in arriving at treatment options for 19 patients who were inaccurately diagnosed clinically.

CONCLUSION:

MDCT evaluation of neck spaces in locally advanced oral cancers is a superior diagnostic tool in tumour staging and appropriate treatment planning. Surgical management of T4b oral cancers in patients with involvement of temporalis, masseter, lateral pterygoid muscles and ramus of mandible below sigmoid notch in our study subjects showed good results with > 50% of patients showing loco-regionally controlled disease after surgery, which were previously considered to be inoperable as per AJCC, 2002 staging.

LIST OF ABBREVATIONS

AJCC- American Joint Committee of Cancer

BS- Buccal Space

BPF – Buccopharyngeal fascia

CS- Carotid Space

CT – Chemotherapy

DLDCF – Deep layer of deep cervical fascia.

ITF – Infratemporal Fossa

MDCT- Multi-detector Computed Tomography

PP – Pterygoid Plates

PPS – Parapharyngeal Space

PS- Parotid Space

RPS – Retropharyngeal Space

RMT – Retromolar Trigone.

RT - Radiotherapy

MS – Masticator Space

SMS – Sub-Mandibular Space

SCC – Squamous Cell Carcinoma

SLDCF – Superficial layer of deep cervical fascia.

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INTRODUCTION

Malignancy of the oral cavity is common in clinical practice. In India, cancers of lip and oral cavity account for about 7.6% of total cancer cases and account for more than 7% of cancer-related mortality. Sex standardized distribution shows a higher predilection in males (incidence 11.3% and mortality 10.2%) compared to females (incidence of 4.3% and mortality of 4.8%). In fact, projections from current data show that the incidence of oral cancers is expected to grow over the coming years[1],[2].

In India, oral cancer is of significant public health importance due to myriad of features ranging from late diagnosis, lack of quality health care facilities to affliction predominantly in people of lower socioeconomic strata, probably due to increased exposure to risk factors[2,3].

Oral cancers have multi-factorial etiology ranging from lifestyle practices to environmental changes[2]. Smoking, chewing tobacco, betel nut and alcohol consumption, which are implicated as causative factors for oral cancers, are largely preventable [2,3,4]. Additionally, many Indians also present late for diagnosis and treatment, which adds up to burden on healthcare and on the patient. Most of the cases who present are already at a late stage and therefore have a dismal prognosis. Data shows that approximately 60 to 80% of Indians present with advanced, while it is only 40% among westerners. The need for early detection cannot be stressed enough as it not only improves cure rate but also reduces morbidity and treatment costs[2].

There are various factors that affect the overall diagnosis and management of oral cancers. One among them being the tumor extension into the local anatomical areas, which is a harbinger of poor prognosis. Local anatomical spread of oral cancers into the face and maxilla and further extension into neck spaces is critical for staging of cancers[5,6]. Cancer staging helps in the treatment of oral cancers by reducing excessive morbidity[6].

Although the evaluation of oral cavity and oropharynx is done clinically cross-sectional imaging plays an important role in staging, visualization of pathology beneath mucosa, determine size, thickness and depth of tumour and invasion to local structures. CT is considered the primary modality of investigation as it helps in delineating the size and extent of primary tumor and also helps to evaluate metastatic lymph nodes and bone involvement. It is also easily available and relatively inexpensive compared to MRI[6].

It is important to understand the anatomy of oral cavity and oropharynx to understand the associated malignancies. Squamous epithelium lining the oropharynx is endodermal in origin and has a greater tendency towards development of poorly differentiated, aggressive malignancies. On the other hand, squamous epithelium lining the oral cavity is ectodermal in origin, which tends to be more differentiated and less aggressive in nature. Additionally, it is important to identify specific subsite of origin of these tumors as routes of spread, lymphatic drainage and management options depend on sub-site of origin[7].

As per American Joint Committee on Cancer (AJCC) 2002 staging, the T4a oral cancers which involve cortical bone, intrinsic or extrinsic muscles of the tongue, maxillary sinus or skin are resectable whereas T4b involving masticator space, pterygoid plates, skull base or internal carotid artery was considered unresectable[8]. But recent studies proved that selected T4b oral cancers were found to be resectable with favorable outcomes and may benefit from radical surgery, free-flap reconstruction, and adjuvant therapy[9].

This study has been performed to determine the extent of the involvement of neck spaces in cancer of oral cavity and to evaluate resectability of T4b cases.

AIMS AND OBJECTIVES

1. To perform Multi Detector Computed Tomography (MDCT) and to evaluate its usefulness in assessing the involvement of deep neck spaces in locally advanced oral cancers.
2. To assess Computed Tomographic morphology specifically to know resectability or non-resectability of oral cancers.

REVIEW OF LITERATURE

ANATOMY

Oral Cavity

The oral cavity constitutes the most ventral part of aero-digestive tract. The oral cavity and oropharynx are separated by junction of hard and soft palate superiorly, bilateral anterior tonsillar pillars and ring of structures made of circumvallate papillae inferiorly. The anatomic sub-divisions of oral cavity are:

1. Lips
2. Floor of the mouth
3. Oral tongue (anterior $2/3^{rd}$ of tongue)
4. Buccal mucosa
5. Upper gingiva
6. Lower gingiva
7. Hard palate
8. Retromolar-trigone

Oropharynx

It is posterior to oral cavity between the nasoparhynx and hypopharynx and is a part of pharynx. The constituents of oropharynx are:

1. Base of tongue (posterior $1/3^{rd}$ of tongue)
2. Palatine tonsils
3. Soft palate
4. Vallecula
5. Posterior pharyngeal wall.
6. Oropharyngeal mucosa

The anterior border of oropharynx is a plane formed by the circumvallate papillae, anterior tonsillar pillars and soft palate. Posterior pharyngeal wall forms the posterior border. The elevated soft palate forms the superior border and the pharyngo-epiglottic fold forms the inferior border. Anterior and posterior tonsillar pillars, palatoglossus and palatopharyngeus muscles respectively form the lateral borders on each side. The anatomic sub-divisions of oropharynx are:

1. Base of the tongue
2. Tonsils.

Oral Tongue

The tongue is made up of symmetric halves separated from each other by a midline septum. The lingual septum and the hyoglossus membrane, a thin, broad sheet suspended between the two minor tubercles of the hyoid bone, form the ‘‘supporting skeleton’’ of the tongue. The fibrous lingual septum that arises from the midline of the hyoglossus membrane and the middle of the hyoid bone has been referred to as midline low-density plane as it is appears as a hypodense midline structure on CT scans through the tongue. The muscles of tongue can be divided into extrinsic and intrinsic muscles and are composed of muscular fibers arranged in various directions.

The bulk of the tongue is made up of four interdigitating intrinsic muscles – the superior and inferior longitudinal, the transverse, and the vertical or oblique muscles. The extrinsic muscles have origin external to the tongue, however, the more distal fibers have been shown to interdigitate within the substance of the tongue. The extrinsic muscles provide attachment of the tongue to hyoid bone, mandible, and styloid process of the skull base. The main extrinsic tongue muscles are the genioglossus, hyoglossus, and styloglossus muscles. Palatoglossus and superior pharyngeal constrictor muscles are included by some authors as part of extrinsic tongue muscles[10].

Intrinsic Muscles of the Tongue

The superior longitudinal muscle arise from the hyoglossus membrane and the fibrous lingual septum and consist of a thin layer of oblique and longitudinal fibers. The fibers fan out into a broad sheet, passing forward and outward to the edges of the tongue, just under the mucosa of the dorsum of the tongue[10].

The inferior longitudinal muscle has the same origin as the superior longitudinal muscle, and is divided into two halves by genioglossus muscle, which is situated in the undersurface of the tongue.

The inferior longitudinal muscle extends from the base to the tip of the tongue, lying medial to hyoglossus and lateral to genioglossus muscles[10].

The transverse muscles originate from the fibrous septum and fan outward to insert into the submucosal fibrous layer at the sides of the tongue. Fibers from the vertical (oblique) muscles extending from the upper surface to the undersurface of the tongue intersect with the transverse fibers. These vertical fibers are encountered only at the borders of the anterior portion of the tongue[10].

It is difficult to identify intrinsic muscles on CT, and fibers of the superior longitudinal muscle may be mistaken for a tumor. These muscle bundles can be appreciated on MR imaging as these low signal intensity muscle fibers are surrounded by higher signal intensity of fibro-fatty supporting tissues. In particular, sagittal MR imaging demonstrates the full extent of the longitudinal muscles. The intrinsic muscles of the tongue receive motor innervation from the hypoglossal nerve (XII) [10].

Extrinsic Muscles of the Tongue

The extrinsic muscles of the tongue include genioglossus, hyoglossus, styloglossus and palatoglossus muscles[10].

The Genioglossus Muscles

The paired genioglossus muscles originate via a short tendon from superior genial tubercle on the inner surface of the mandible, just above the origin of the geniohyoid muscles. The fibers fan out, the inferior fibers attaching via a thin aponeurosis to the body of the hyoid fascicles from one muscle cross the midline to interdigitate with those of the contralateral muscle, the middle fibers coursing posteriorly, and the superior fibers directed upward and dorsally to insert into the entire length of the undersurface of the tongue from its base to its apex. Posteriorly, the genioglossus muscles are quite distinct from each other, separated by the midline lingual septum and fatty tissue, easily identified on both axial and coronal CT and MR images. The two muscles are quite symmetric, measuring 9 to 11 mm in the transverse dimension at their intersection with the hyoglossus muscle[10].

The Hyoglossus Muscles

These muscles are thin, flat quadrilateral muscles and form the lateral borders of the tongue. They arise from the greater cornua of the hyoid bone and course vertically, lateral to the genioglossus muscles, to insert into the sides of the tongue. Postero-superiorly, fibers of the hyoglossus interdigitate with fibers of the styloglossus muscle. The hyoglossus muscles are best imaged on CT or MR imaging in the axial plane. The normal transverse diameter of each muscle, measured in the axial plane, is 5 to 7 mm[10].

The Styloglossus Muscle

It arises from the anterolateral surface of the styloid process of the temporal bone, near its apex, and from portions of the stylomandibular ligament. Passing downward and forward between the internal and external carotid arteries, it divides at the side of the tongue into two sets of fibers. The longitudinal fibers enter the side of the tongue near its dorsal surface, anterior to the hyoglossus fibers, and the more posterior oblique fibers interdigitate with fibers of the hyoglossus muscle[10].

The Palatoglossus Muscle

The palatoglossus muscle and the overlying mucosa forms the palatoglossal arch (anterior tonsillar pillar). The muscle arises from the oral surface of the palatal aponeurosis and the soft palate and extends laterally, forward, and downward to the palatine tonsil to insert on the dorsum and side of the tongue, its fibers blending with those of the styloglossus and transverse lingual muscles[10].

Motor and Sensory Innervation of the Tongue

All intrinsic and extrinsic muscles of the tongue receive motor innervation from the hypoglossal nerve (XII), which courses between the mylohyoid and hyoglossus muscles. The palatoglossus muscle is innervated by the pharyngeal plexus. Adjacent to the hypoglossal nerve is the lingual nerve, a branch of the trigeminal nerve that carries sensory fibers from the anterior portion of the tongue. Special sensory taste fibers from the anterior two thirds of the tongue course with the lingual nerve over a short distance before they coalesce to form the chorda tympani nerve, which extends to the lateral skull base, traverses the middle ear, and joins the facial nerve. Special sensory taste fibers from the posterior one third of the tongue are supplied by the glossopharyngeal nerve (IX) [10].

Floor of the Mouth

The floor of the mouth is a U-shaped structure covered by squamous mucosa. The primary muscles comprising the floor of the mouth are the mylohyoid muscles and their fibrous median raphe. Additional support is provided by the paired anterior bellies of the digastric muscles and the geniohyoid muscles. Surgically, the floor of the mouth is considered that space between the mucosa of the floor of the mouth and the mylohyoid muscle sling. Caudal to this muscle but above the hyoid bone, the space is considered the suprahyoid neck[10.]

The Mylohyoid Muscle

The mylohyoid muscle is a flat, triangular muscle that arises from the entire length of the mylohyoid ridge on the inner surface of the mandible and extends from the mandibular symphysis anteriorly to the last molar tooth posteriorly. Posterior fibers course inferiorly to insert onto the body of the hyoid bone. The remaining middle and anterior fibers insert into the fibrous median raphe that runs between the mandibular symphysis and the hyoid bone, thus joining with fibers from the opposite side to form the U-shaped muscular floor of the mouth. The mylohyoid muscle sling is best demonstrated by CT and MR imaging in the coronal plane. The mylohyoid branch of the inferior alveolar nerve (a branch of the mandibular division of the trigeminal nerve provides motor innervation to the mylohyoid muscle. Just before entering the mandibular foramen, the inferior alveolar nerve gives off the small mylohyoid nerve, which descends in a groove on the inner surface of the mandible, held in position by a fibrous membrane. There is a gap at the free posterior border of the mylohyoid muscle, between it and the hyoglossus muscle. It is via this gap that the submandibular gland wraps around the dorsal aspect of the mylohyoid muscle, with the deep lobe of the gland lying cranial to the muscle fibers and the superficial lobe lying on its external surface[10].

The Digastric Muscle

The digastric muscle consists of two bellies. The anterior belly arises from the digastric fossa on the inner surface of the mandible, just below the genial tubercles. The posterior belly arises from the digastric fossa on the inner surface of the mastoid process of the temporal bone. The two bellies terminate in a central tendon that pierces the stylohyoid muscle and runs through a fibrous loop (lined with a synovial membrane) that is attached to the body and lesser horn of the hyoid bone. The two paramedian anterior digastric muscles lie just below (caudal to) the mylohyoid muscle sling and thus contribute to the muscular floor of the mouth. They are best seen on CT and MR imaging in the coronal plane. Like the mylohyoid muscle, the anterior belly of the digastric muscle is innervated by the mylohyoid branch of the mandibular nerve (V3). The posterior belly receives its innervation from the facial nerve (VII) [10].

The Geniohyoid Muscle

Each geniohyoid muscle is a slender muscle that arises from the inferior genial tubercle on the inner surface of the mandible. It passes inferiorly to insert onto the anterior surface of the body of the hyoid bone. Closely approximated, the geniohyoid muscles lie just above the mylohyoid sling; this is best appreciated on CT scans and MR images obtained in the coronal plane. Because the geniohyoid muscles do not have interspersed fibro-fatty tissue, as do the extrinsic muscles of the tongue, they may occasionally appear denser than the genioglossus muscles on CT. Motor innervation to the geniohyoid muscles is variably described to be from the hypoglossal nerve (XII), by the few fibers from C1 that course with the hypoglossal nerve until it crosses the internal carotid artery, or by motor fibers from both C1 and C2[10].

The Sublingual Region

Superomedial to the mylohyoid muscle, lateral to the genioglossus-geniohyoid muscles, and below the mucosa of the floor of the mouth is the primarily fat-filled sublingual area known as the sublingual space or sublingual compartment of the submandibular space. Based on its CT appearance, it is also referred to by some authors as the lateral low-density plane. This region is continuous with the submandibular region at the posterior margin of the mylohyoid muscle. Contents of this sublingual ‘‘space’’ include the deep portion and hilum of the submandibular gland, Wharton’s duct, the anterior fibers of the hyoglossus muscle, and the lingual nerve, artery, and vein. On either side, the hyoglossus, styloglossus, and palatoglossus muscles form a slightly curved lateral muscular bundle in the sublingual space. Together these muscles are an important surgical landmark to the anatomy of the sublingual region, as they separate Wharton’s duct and the hypoglossal and lingual nerves, which lie laterally, from the lingual artery and vein, which course medially. Wharton’s duct arises from the deep portion of the gland and runs anteriorly, in contact with the hypoglossal and lingual nerves. Initially, it lies between the hyoglossus and mylohyoid muscles, and more anteriorly it lies between the genioglossus and mylohyoid muscles. The duct drains into the floor of the mouth, just lateral to the frenulum of the tongue[10].

Submandibular Space

Inferior to the mylohyoid muscle lies the submandibular space. It is a fascially defined space except at the posterior margin of the mylohyoid muscle, where it is in continuity with the posterior aspect of the sublingual space and the anterior aspect of the parapharyngeal space. This communication permits easy spread of pathology among these spaces. The primary contents of the submandibular space are fat and the larger superficial portion of the submandibular gland.

On either side, the anterior belly of the digastric muscle lies within the fat in a paramedian location, and the region between these two muscle bellies is referred to as the **submental space**. This is a small triangular midline area in which the submental lymph nodes (level IA) reside.

Submandibular lymph nodes (level IB) and branches of the facial artery and vein lie lateral to the anterior digastric muscle in the fat surrounding the superficial portion of the submandibular gland. The artery courses deep to the gland, while the vein runs superficially, just beneath the investing fascia. The vein is a useful landmark when evaluating submandibular region masses. Primary disease of the submandibular gland is never separated from the gland by the vein but displaces the vein laterally. However, lymphadenopathy and other soft-tissue masses that lie lateral to the gland are separated from the gland by the interposed vein. On CT, the normal submandibular gland is fairly homogeneous in appearance and may be of either a relatively fatty or soft-tissue attenuation. The density and enhancement of the two glands should be symmetric. If not, one gland is abnormal. On MR imaging, the normal submandibular gland has either a homogeneous or heterogeneous MR signal intensity, which is higher than that of surrounding muscle on both T1-weighted and T2-weighted images[10].

Lips and Gingivobuccal Region

The lips are composed primarily of the orbicularis oris muscle, which is not a sphincter muscle but rather is composed of muscle fibers derived from multiple facial muscles that insert into the lips and some additional fibers proper to the lips themselves. Muscles that contribute to the orbicularis oris include the levator labii superioris alaeque nasi, levator labii superioris, levator anguli oris, zygomaticus major, depressor anguli oris, platysma, risorius, and buccinator muscles. Motor innervation to the lips is supplied by branches of the facial (VII) nerve, and lymphatic drainage is primarily to the submental and submandibular lymph nodes (level I). The external surface of the lips is covered by keratinizing stratified squamous epithelium, and the internal surface is lined by non-keratinizing stratified squamous mucosa. The vestibule of the mouth separates the lips and cheeks, which are lined by buccal mucosa, from the teeth and gums. It is essentially a cleft into which drain the ducts of the parotid glands and the mucous glands of the lips and cheeks. The vestibule is bounded superiorly and inferiorly by reflections of the buccal mucosa onto the maxilla and mandible, respectively. The vestibule is continuous posteriorly with the oral cavity proper through an interval between the last molar tooth and the ramus of the mandible[10].

The gingiva is the mucosal covering and overlies both the medial (lingual) and lateral (buccal) aspects of the alveolar processes of the mandible and maxilla. The junction of the gingiva with the buccal mucosa is termed the gingivobuccal sulcus and is a common location for squamous cell carcinoma of the oral cavity. At times it may be difficult to determine if a lesion originates from the gingival or buccal mucosa. On imaging, instructing patients to ‘‘puff’’ their cheeks, thereby dilating the vestibule with air and separating these mucosal surfaces, is a useful maneuver for visualizing lesions in this area. There is also a triangular area of mucosa posterior to the last mandibular molar tooth termed the retromolar trigone. This region covers the lower ascending ramus of the mandible, and it is another area in which squamous cell carcinomas commonly arise[10].

Buccomasseteric Region

The term buccomasseteric region refers to the masseter and buccinator muscles, the buccal space, and the inferior body of the mandible[10].

The masseter muscle is one of the muscles of mastication and is innervated by a branch of the mandibular division of the trigeminal nerve. Posteriorly, the muscle is largely covered by the superficial lobe of the parotid gland, and buccomasseteric pathology is often initially mistaken for parotid disease[10].

The buccinator muscle, the major muscle of the cheek, is located external to the buccal mucosa. It is a deep muscle of facial expression that is innervated by a branch of the facial nerve. Its main function is to compress the cheeks (i.e., during mastication, playing the trumpet, etc.). The origin of this muscle is from the alveolar processes of both the maxilla and the mandible, opposite the sockets of the molar teeth, and the anterior border of the pterygomandibular raphe. The fibers of the buccinator muscle converge toward the angle of the mouth, where they blend and insert into the orbicularis oris muscle. The pterygomandibular raphe is a thick fascial band that extends between the hamulus of the medial pterygoid plate and the posterior border of the mylohyoid ridge of the mandible. Forming the line of attachment for the buccinators and superior pharyngeal constrictor muscles, the pterygomandibular raphe is the junction of the oropharynx and oral cavity, lying between the anterior tonsillar pillar and the retromolar trigone. Malignancies in the retromolar trigone may extend cephalad along this raphe into the upper buccomasseteric region or the suprazygomatic portion of the masticator space, or they may extend caudally to the mylohyoid muscle and along the floor of the mouth. The pterygomandibular raphe also is the anterior boundary of the prestyloid compartment of the parapharyngeal space and the masticator space. The lingual and inferior alveolar branches of the trigeminal nerve traverse the parapharyngeal space[10].

The buccal space, limited by the superior and inferior attachments of the buccinator muscle, is located lateral to the buccinator muscle, deep to the zygomaticus major muscle, and anterior to the mandibular ramus and masseter muscle. It primarily contains the buccal fat pad, the major portion of which lies lateral to the buccinator, with prolongations that may extend between the muscles of mastication. Four projections of fat may be identified extending peripherally from the more central fat pad. Laterally the fat follows the course of the parotid duct posteriorly to lie adjacent to the anterolateral portion of the superficial lobe of the parotid gland. Medially the buccal fat pad extends between the mandible and maxillary sinus and frequently communicates with fat in the masticator space. Superiorly the temporal extensions of the buccal fat are divided into deep and superficial portions based upon their relationship to the temporalis muscle. The anterior extension of the fat pad is located superficial to the parotid duct. The main duct of the parotid gland (Stensen's duct) crosses the masseter muscle, courses transversely through the buccal fat pad, pierces the buccinator muscle opposite the second maxillary molar, and drains into the vestibule of the mouth[10].

The parotid duct separates the buccal space into fairly equal-sized anterior and posterior compartments. Fat in the posterior compartment reportedly differs from that in the anterior compartment, being composed of a special type of adipose tissue known as syssarcosis that may represent the remnants of the succatory fat pad of infants. This specialized adipose tissue aids in muscular motion such as that required for opening and closing the mouth. The CT attenuation of this specialized adipose tissue is reported to be less than that of fat in adjacent spaces, including the fat within the anterior compartment of the buccal space[10].

Within the buccal space, the angular segment of the facial artery, originating from the external carotid artery, and the buccal artery, originating from the facial artery, may be identified. The angular artery extends through the buccal space to reach the nasolabial region. The buccal artery courses to the posteromedial portion of the buccal space between the medial border of the masseter muscle and the lateral border of the buccinator muscle. The facial vein is typically identified on cross-sectional images along the lateral margin of the buccinator muscle, anterior to Stenson's duct. It courses through the buccal space from the nasolabial region to the external jugular venous system and averages 3.5 mm in the transverse dimension. Nerves within the buccal space, not routinely identified on cross-sectional images, include the buccal division of the facial nerve, which primarily innervates the buccinators muscle, and the buccal branch of the mandibular nerve, which innervates the mucosa deep to the buccinator muscle and the skin overlying the buccal space[10]. When involved by tumor or infection, the buccal space may serve as a route of spread between the mouth and the parotid gland. The lack of fascial compartmentalization superiorly, inferiorly, and posteriorly permits spread of pathology (especially infections) both to and from the buccal space. The buccomasseteric region is commonly affected by disease involving the masticator space, a fascially defined region that contains the muscles of mastication, portions of the mandible, the maxillary artery, and branches of the mandibular division of the trigeminal nerve.[10] Pathology of the masticator space most commonly results from dental infections involving the second and third mandibular molars[10].

The Masticator Space

The superficial layer of deep cervical fascia (SLDCF) splits about the lower edge of the mandible, and the outer or superficial layer encloses the masseter muscle, extends over the zygomatic arch, and attaches to the calvarium about the dorsal and cranial margins of the temporalis muscle and the lateral orbital wall. The inner or deep layer of fascia covers the medial pterygoid muscle before fusing with the interpterygoid fascia and continuing to the skull base. The split layers of the SLDCF fuse again along the ventral and dorsal borders of the ramus of the mandible and, in so doing, close this space about the muscles of mastication. The lateral pterygoid muscle lies freely within this space, while the fasciae about the masseter, temporalis, and internal pterygoid muscles con-tribute to the boundaries of this space. The portion of the masticator space that extends cranially between the calvarium and the outer layer of the SLDCF is occasionally referred to as the temporal space, but it is probably better regarded as the cranial extension of the masticator space. The internal maxillary artery and the third division of the trigeminal nerve run within the masticator space[10].

The Parapharyngeal Space

The parapharyngeal space is also known as the lateral pharyngeal, peripharyngeal, pharyngomaxillary, pterygopharyngeal, pterygomandibular, and pharyngomasticatory space.

The parapharyngeal space is a hatchet-shaped space on either side of the neck. Its ventral (prestyloid) compartment lies just lateral to the pharynx and deep to the masticator space and the ramus of the mandible. It is filled with fat and connective tissue, and the deep portion of the parotid gland protrudes into it. The dorsal (retrostyloid) compartment of the parapharyngeal space corresponds to the carotid sheath and its enclosed structures.

The parapharyngeal space extends from the skull base down to the level of the angle of the mandible, the medial wall of the parapharyngeal space is formed by the buccopharyngeal fascia (BPF) or visceral fascia as it extends from the skull base caudally. Caudally, the parapharyngeal space extends down to the hyoid bone. Styloglossus muscle, is considered to be the inferior boundary of the parapharyngeal space. The lateral boundary is formed by the superficial layer of the deep cervical fascia[10].

Cross Sectional Anatomy

Figure 1 through

Figure 12 depict the cross-sectional CT anatomy in evaluation of head and neck[11].

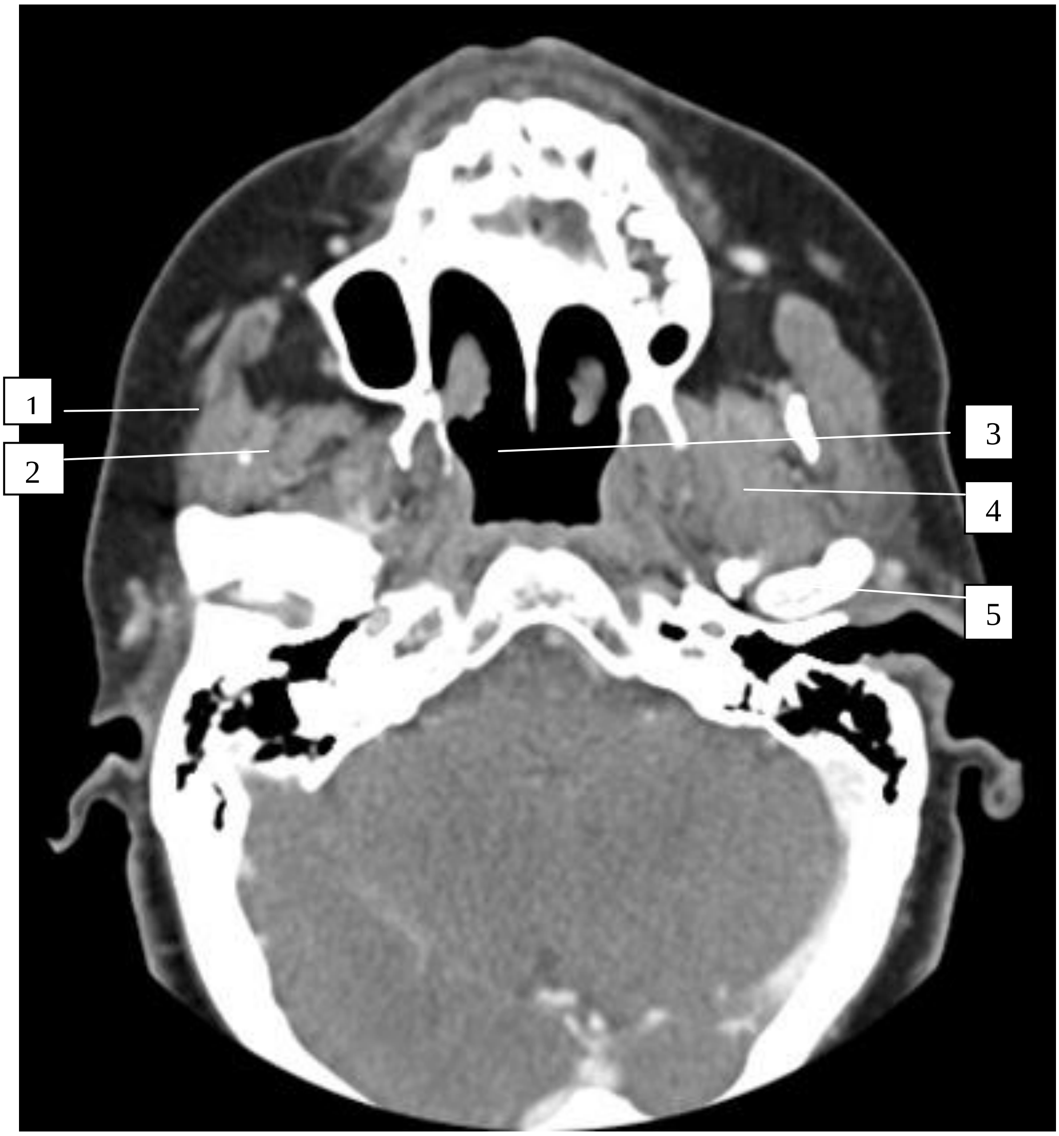

Figure 1. Cross-sectional anatomy head and neck at the base of skull -1.Masseter muscle, 2.Temporalis muscle, 3.Naso-pharynx, 4.Lateral pterygoid muscle, 5.mandibular head .

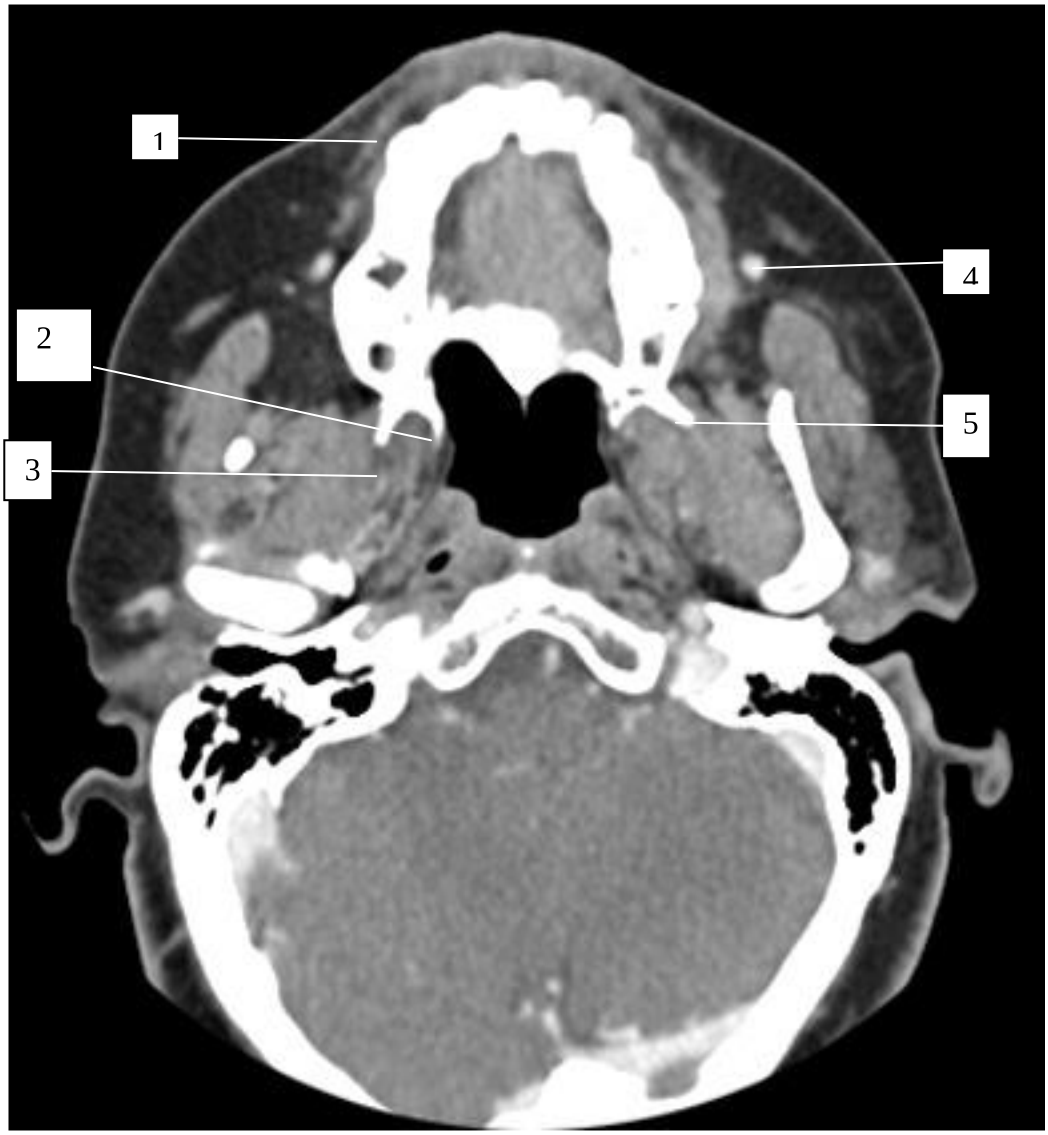

Figure 2. Cross sectional anatomy of head and neck at the level of pterygoid plates - 1.Maxillary alveolus, 2.Medial pterygoid plate, 3.Medial pterygoid muscle, 4.facial artery, 5.Lateral pterygoid plate.

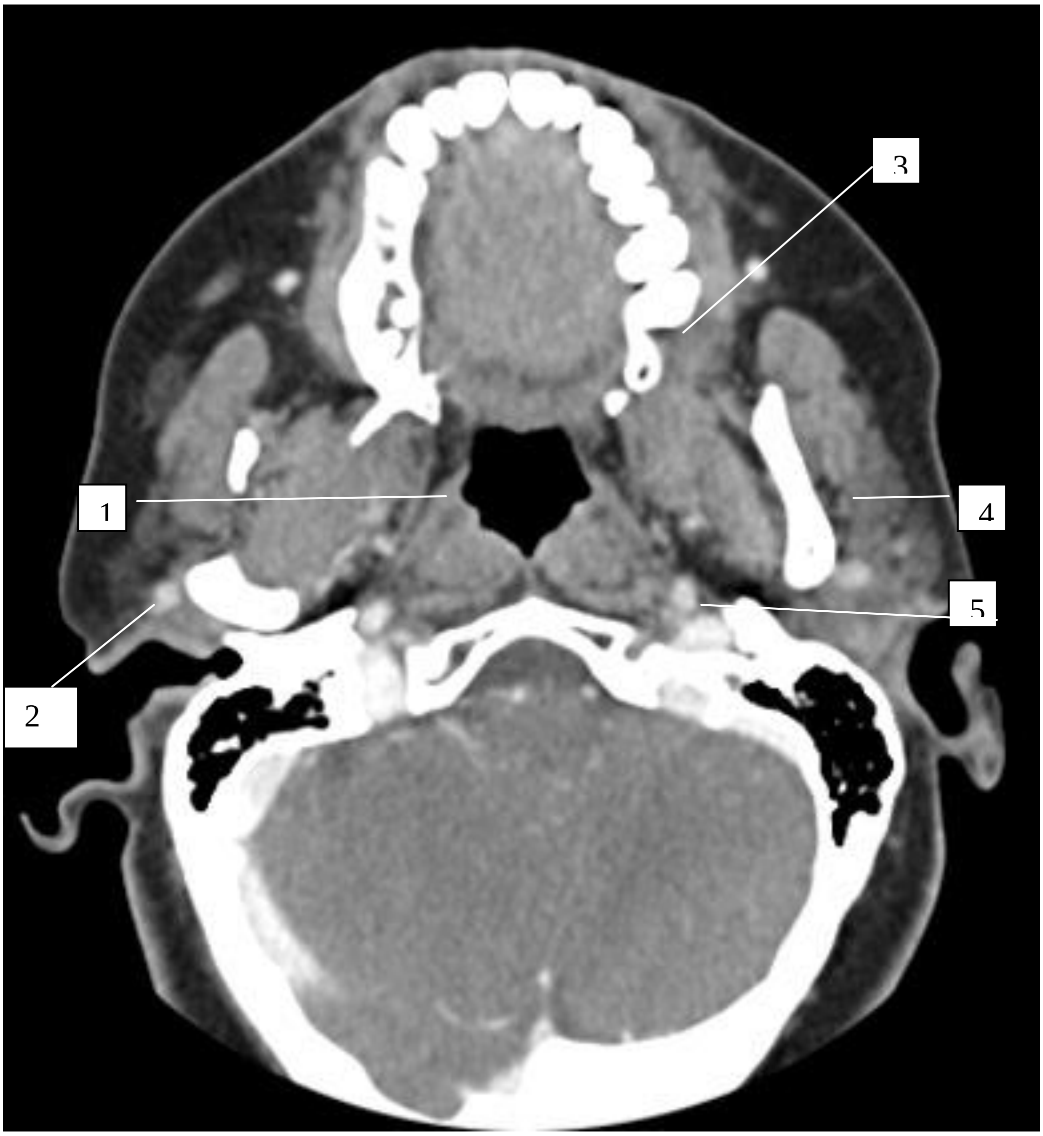

Figure 3. Cross sectional anatomy of head and neck at the level of maxilla- 1.Parapharyngeal space, 2.External carotid artery, 3.Buccinators muscle, 4.Parotid gland, 5.Internal carotid artery.

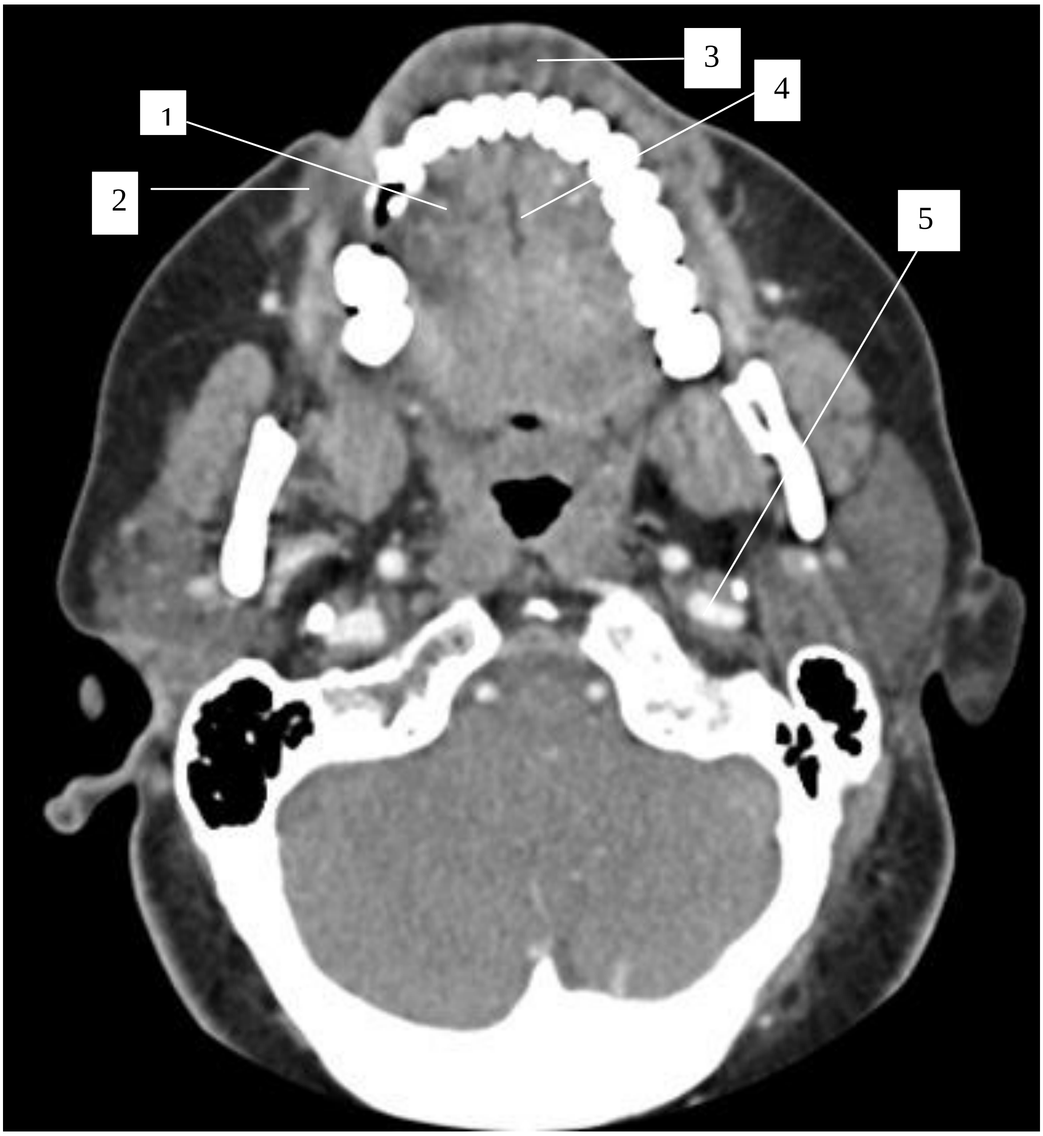

Figure 4. Cross sectional anatomy of head and neck at the level of nasopharyx- 1.transverse muscle of tongue, 2.Depressor angulioris muscle, 3.Orbicularisoris muscle, 4.Median raphe of tongue, 5.internal jugular vein

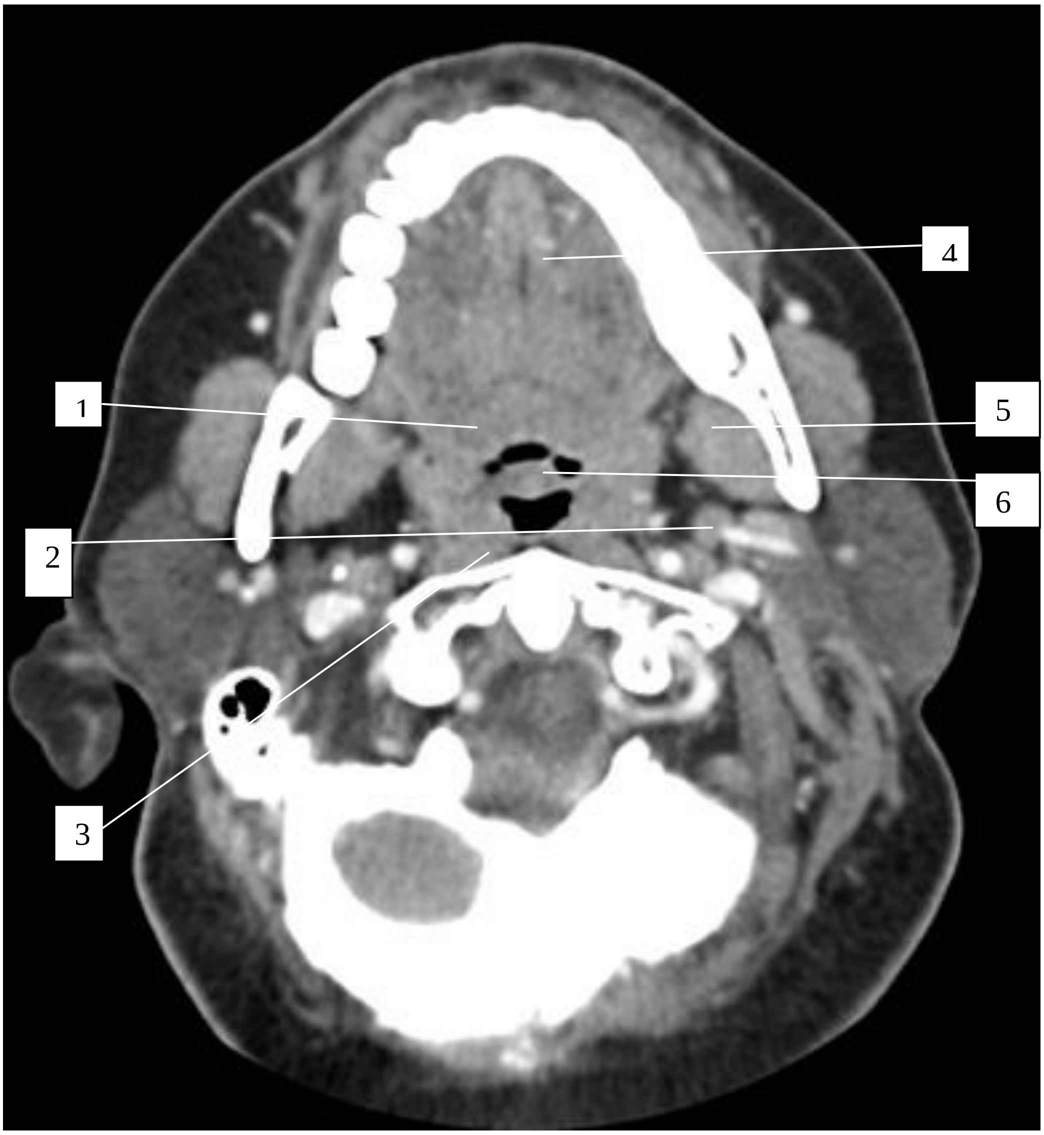

Figure 5. Cross sectional anatomy of head and neck at the level of uvula -1, base of tongue, 2.dtyloglossus muscle, 3.Longuscollis muscle, 4.Genioglossus muscle, 5.Pterygo-mandibular space, 6.Uvula.

Figure 6. Cross sectional anatomy of head and neck at the level of mandible- 1.Depressorangulioris muscle, 2.Sub-mandibular gland, 3.Mentalis muscle, 4.Mylohyoid muscle, 5.Sternocledo-mastoid muscle.

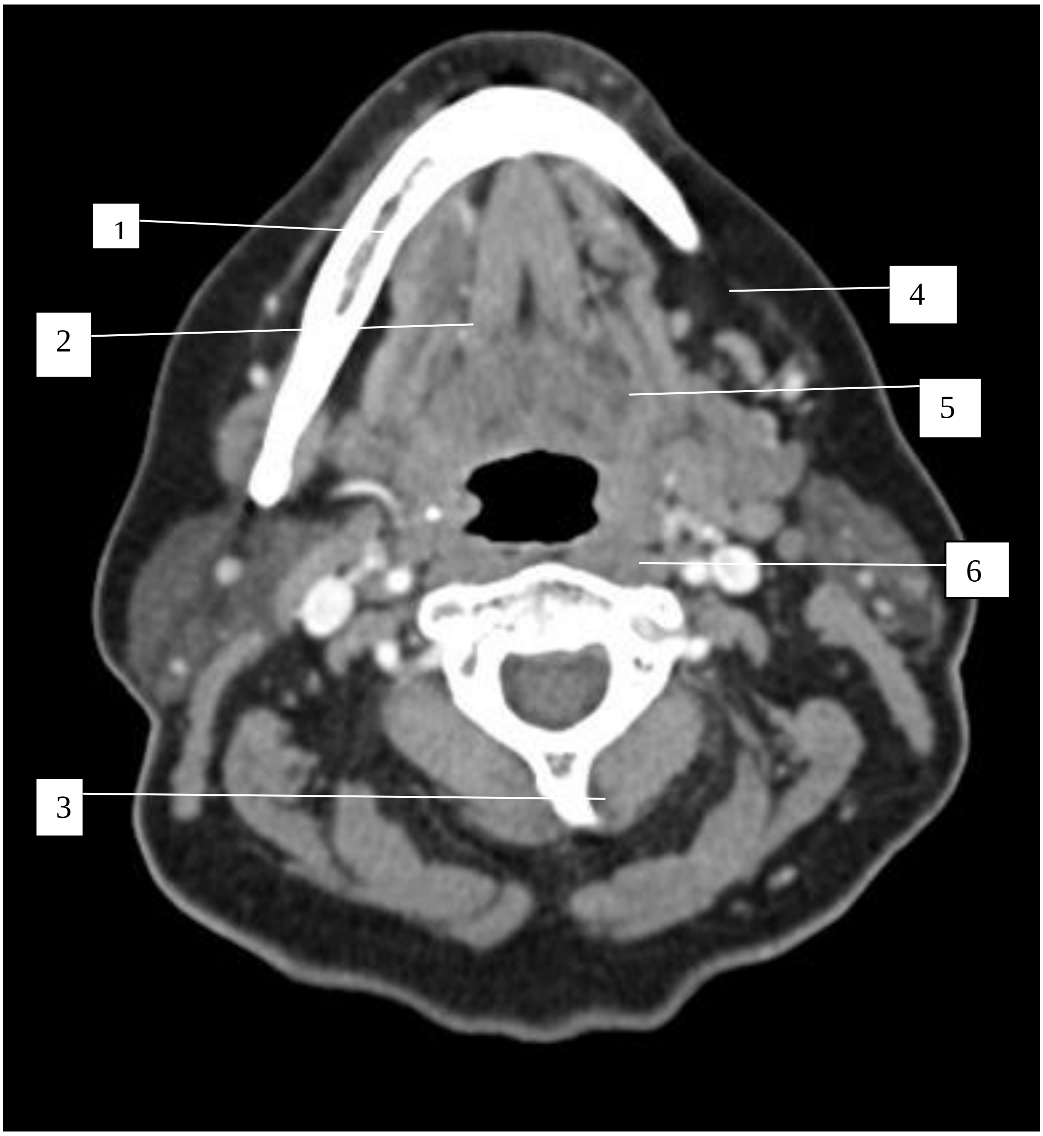

Figure 7. Cross sectional anatomy of head and neck at the level of oropharynx- 1.Anterior belly of digastrics muscle, 2.Geniohyoid muscle, 3.Semispinalis cervicis muscle, 4.Platysma, 5.Mylohyoid muscle, 6.Longuscaptis muscle.

Figure 8. Cross sectional anatomy of head and neck at the level of epiglottis- 1.Platysma, 2.Sub-mandibular gland, 3.External jugular vein, 4.Hyoglossus muscle, 5.Epiglottis.

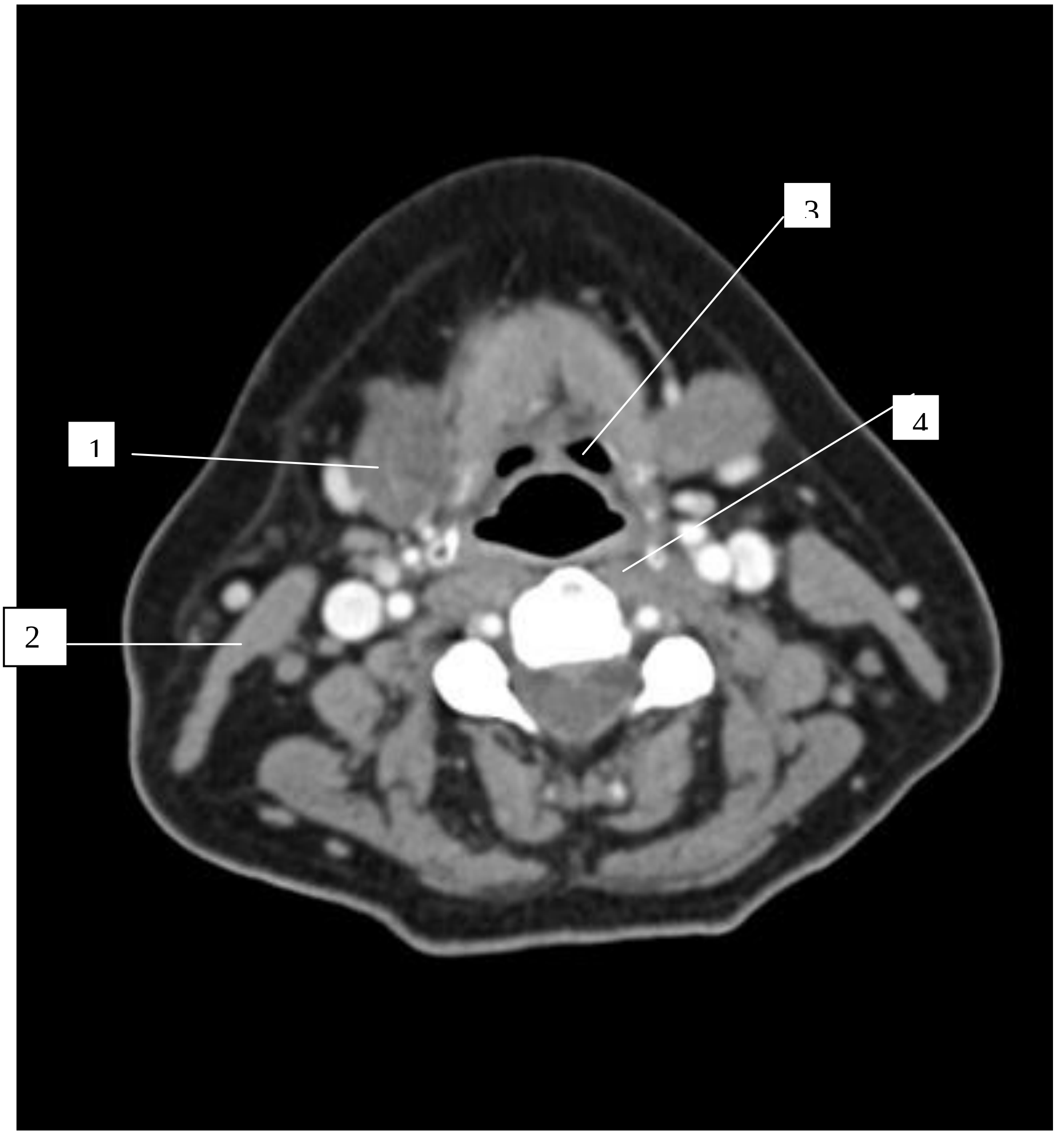

Figure 9. Cross sectional anatomy of head and neck at the level of valleculae- 1.Sub-mandibular gland, 2.Sternocleido-mastoid muscle, 3.Vallecula, 4.Longuscollis muscle.

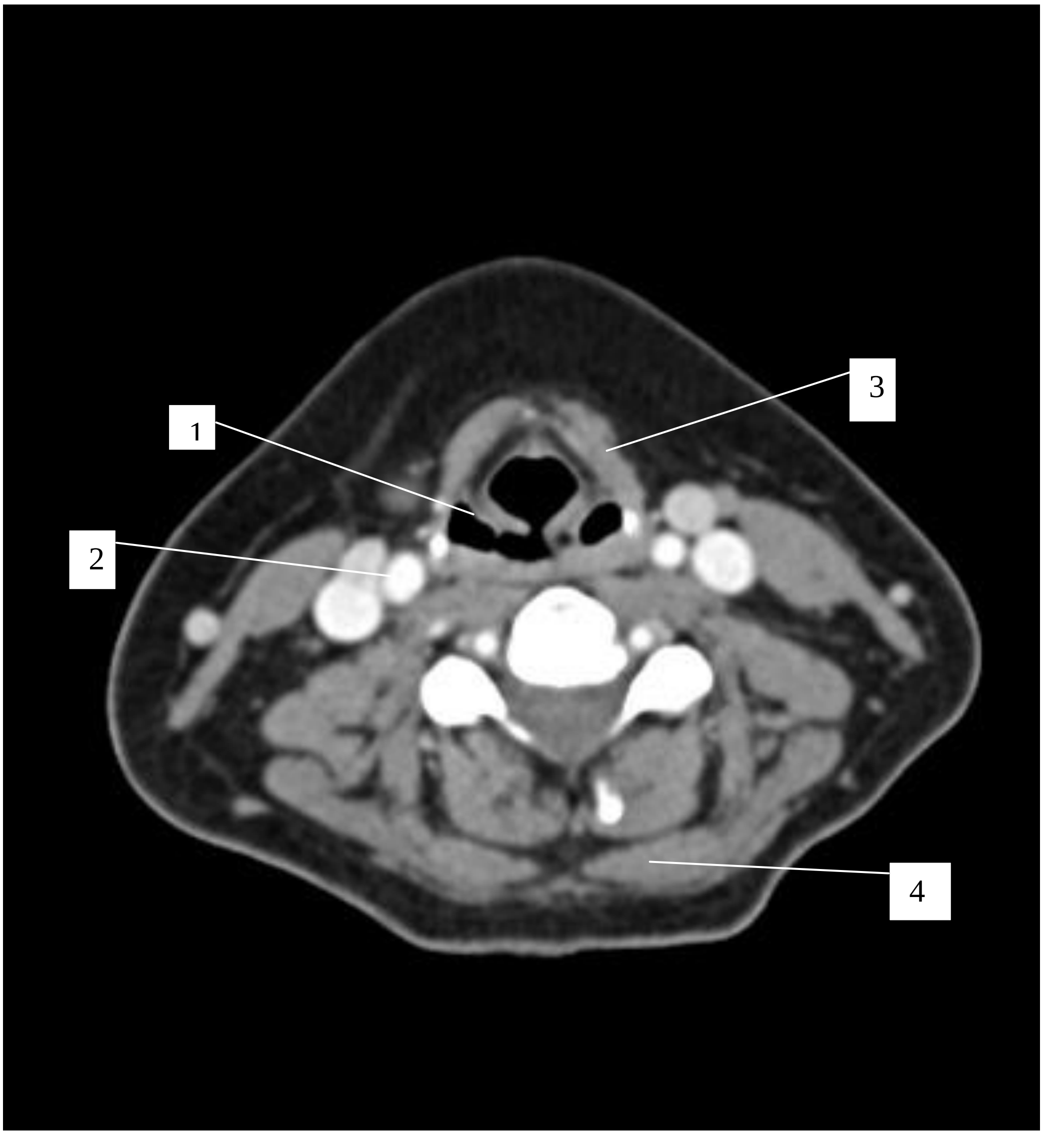

Figure 10. Cross sectional anatomy of head and neck at the level of aryepiglottic folds -1.Aryepiglottic fold, 2.Common carotid artery, 3.Sterno-hyoid and thyro-hyoid muscles, 4.Trapezius muscle.

Figure 11. Cross sectional anatomy of head and neck at the level of false vocal cords -1.Thyroid cartilage, 2.Pyriform sinus, 3.Sterno-hyoid and thyro-hyoid muscles, 4.Vertebral artery

Figure 12. Cross sectional anatomy of head and neck at the level of true vocal cords- 1.True vocal cords, 2.Thyroid cartilage, 3.Glottic airway, 4.Cricoid cartilage.

Regions and Patterns of Tumor Spread

About 95 % of all lip carcinomas originate in the lower lip about halfway between the midline and commissure[13,14,15,16,17]. Carcinoma of upper lip is an uncommon primary lesion to develop, but lesions of upper lip act more aggressively than carcinoma of the lower lip. Squamous cell carcinomas are of three types: exophytic, ulcerative, and verrucous. The ulcerative form is more infiltrative than the exophytic variety and verrucous carcinomas[12].

Advanced lower lip carcinomas may spread to the submental and submandibular lymph nodes, while upper lip lesions metastasize to the preauricular, submental, and submandibular lymph nodes[12].

Usually advanced lesions will undergo imaging where the margin of the tumor cannot be evaluated clinically. On CT images the primary tumor may appear as a mass with or without areas of ulceration . Subtle bone erosion usually occurs along the buccal surface of the mandibular or maxillary alveolar ridge and is best detected in CT bone window. Large tumors may also extend directly into the mandible or involve the mental nerve without cortical bone destruction. As CT detects the and helps in staging of oral cancer, thereby necessitating treatment either by marginal/segmental mandibulectomy (in lower lip tumors) or partial maxillectomy (in upper lip tumors).[18,19]Most carcinomas of the lip are treated by surgical excision, although small carcinomas my be treated by either surgery or radiation therapy. While small lesions are usually excised with primary closure, defects not amenable to primary closure are reconstructed with local or regional flaps[12].

Carcinoma of the Floor of the Mouth

Squamous cell carcinoma of the floor of the mouth arises from the mucosa covering the U-shaped area between the lower gum (inner surface of the lower alveolar ridge) and the undersurface of the anterior two-thirds of the tongue[14,17]. The majority of tumors originate in the anterior portion of the floor of the mouth at the midline and lateral to or involving the frenulum[20,21,22,23]. At its onset, the lesion may be very small , but with progression of time the characteristic exophytic or papillary appearance is obtained. The lesion begins only very rarely as an ulcer. Tumors of the floor of the mouth may spread in a variety of directions, inferior spread occurs into the sublingual spaces and may result in obstruction of the submandibular duct and chronic inflammation or infection of the submandibular gland. Inferior spread may also occur into the genioglossus and hyoglossus muscles and eventually through the mylohyoid muscle into the anterior bellies of the digastric muscles, as well as into the submandibular spaces. Superiorly and posteriorly the tumors tend to involve the ventral surface of the tongue, the adjacent lingual neurovascular bundle, the base of the tongue, and the glossotonsillar suIcus[19,24,25,26,27]. The relationship of floor of the mouth cancer with the midline lingual septum and with the contralateral lingual neurovascular bundle must be determined by CT. Anteriorly and laterally, the neoplasm may advance into the adjacent gingival mucosa, may then spread along the periosteum and may destroy the lingual cortex of the mandible and involve the marrow space of the mandible. The location and amount of mandibular invasion alters the prognosis and surgical approach. The prevalence of lymph node metastases in floor of the mouth cancers is between 30 % and 70 %; however, metastases to cervical lymph nodes are usually a later manifestation than that observed in carcinoma of the tongue. Lymphatic drainage is either into the submandibular region or into the upper deep jugular chain, depending upon the precise location of the primary neoplasm. Bilateral involvement is common. Early carcinomas of the floor of the mouth can be treated by radiation therapy or surgery with equal effectiveness. A combination of surgery and radiation therapy is usually recommended for advanced cancers. While small lesions are usually excised with primary closure, defects not amenable to primary closure are reconstructed with regional flaps, or micro vascular free flaps[12].

Carcinoma of the Oral Tongue

Squamous cell carcinomas of the tongue arise in the oral portion of the tongue (anterior two-thirds) [14,17,28] . It involves the anterior two-thirds of the tongue usually originate along the lateral border (middle third) or ventral surface of the tongue .The tip and dorsum of the tongue are infrequent sites of origin. In general, the prognosis of carcinoma of the anterior tongue is more favorable than that of carcinoma of the tongue base, which tends to be histologically moderately differentiated. The growth pattern of tongue cancers is usually infiltrative, ulcerative, and exophytic, and most lesions are more than 2 cm in diameter at the time of first clinical examination. Large tumors arising from the lateral border of the tongue tend to grow into the glossotonsillar sulcus, base of the tongue, tonsillar fossa, floor of the mouth, and subsequently the submandibular space .The neoplasms arising from the ventral surface extend directly toward the floor of the mouth, and in many instances it is difficult to determine the exact site of origin. Large anterior tongue lesions may extend into the base of the tongue and vice versa. Neoplastic involvement of the lingual nerve is responsible for the pain in the ear on the affected side in patients with advanced carcinoma of the tongue or floor of the mouth. On initial presentation, 40 % of anterior tongue cancers present with regional adenopathy, half of these bilaterally. In additional to routine axial images, coronal CT images may provide additional information about the exact extent of tongue neoplasms and their relationship to the neurovascular bundle. Therapeutic options (local excision, partial or total glossectomy, radiation therapy) depend upon tumor extent, bilaterality, and involvement of the ipsilateral and contralateral neurovascular bundle[12].

Carcinoma of the Buccal Mucosa and Gums

The cheek forms the lateral wall of the oral cavity and is made up of the buccal mucosa, buccinator muscle, external fibro-adipose tissue, and skin. The mucosal surface connected with the cheek extends from the upper to the lower gingivobuccal gutters, where the mucosa reflects itself to cover the upper and lower alveolar ridges and forms the commissures of the lips and the related ramus of the mandible. Squamous cell carcinomas are typically encountered at the commissure of the mouth, along with the occlusal plane of the teeth, retromolar areas, or along the gums[14,17,28]. Buccal carcinomas are also divided into three subtypes: exophytic, ulcerative, and verrucous. Squamous cell carcinoma of the buccal mucosa tends to invade the masticator space, the buccinator muscle with subsequent involvement of the skin, the anterior tonsillar pillars, and the soft palate. Infiltration of the medial pterygoid muscle causes trismus and this may be the first presenting symptom. Pathways of lymphatic spread in buccal carcinoma are variable and include the submandibular, facial, intraparotid, and preauricular nodes. Lymph node metastases in T3 and T4 are present in approximately 50 % of cases. Early buccal cancers may be difficult to visualize on sectional imaging, as they may be indistinguishable from the orbicularis oris muscle. Large tumors are easily seen on CT. Low-volume lesions may be treated by a transoral excision. However, tumors that extend to the pterygomandibular raphe require a more extensive resection and bone invasion requires additional partial mandibulectomy or maxillectomy[19]. Cancers originating in the retromolar trigone may grow anteriorly into the buccal region and thus mimic a buccal carcinoma. They may grow posteriorly along the superior constrictor pharyngeal muscle into the tonsil. Superior growth along the pterygomandibular raphe allows for access to the skull base and nasopharynx. Whereas inferior growth results in invasion of the floor of the mouth. Owing to the close vicinity of the ascending ramus of the mandible. osseous invasion is common. Low-volume superficial lesions may be treated by transoral surgical approach. Large tumors with invasion of adjacent structures at imaging will undergo either surgery including partial mandibulectomy/maxillectomy or organ-preserving combined radiation therapy and chemotherapy[12,19,26,27].

Squamous cell carcinoma of the gums (gingiva and alveolar mucosa) frequently occurs in the molar and premolar regions along the gingival margin of a tooth or tooth socket with the lower jaw affected more often than the upper jaw[14,17,26,27,28]. Destruction of the underlying bone is a frequent finding occurring in nearly 50 % of carcinomas of the gums[29,30]. The usual route of invasion is through the edentulous alveolar ridge. Bone destruction is in many cases clinically occult and is seen only at imaging. Radiographs, including dental views, Panoramic view, CT, Dental Scan or MRI augment the evaluation. Nearly 50 % of patients have submandibular lymph node metastases at initial presentation and, as a general rule, metastases tend to be less differentiated than the primary tumor. Cervical metastases from the lower alveolar ridge are more common than from the upper alveolar ridge. Both sites tend to metastasize to the submandibular lymph nodes ; however, upper alveolar ridge cancers may also metastasize to the upper deep cervical lymph nodes[12].

Carcinoma of the Hard Palate

Squamous cell carcinoma of the hard palate may arise in the midline or to one side or the other of the hard palate close to the upper gingiva. The neoplasm is only rarely localized and is often surrounded by areas of leukoplakia. Although the tumor is often confined to its site of origin at the time of diagnosis, advanced tumors may invade the maxilla, nasal cavity, buccal mucosa, tongue, or retromolar trigone. Perineural extension via the greater and lesser palatine nerves into the pterygopalatine fossa is a common pathway not only for adenoid cystic carcinoma but also for squamous cell carcinoma. Therefore, perineural tumor spread should be sought with Imaging to evaluate the pterygopalatine fossa and foramen rotundum. Small tumors may be very difficult to see on CT, as they may appear only as a slight asymmetry. However, CT is the ideal modality to evaluate subtle bone erosion. Coronal sections (CT) are extremely useful for evaluating these tumors. Approximately 30 % of patients with squamous cell carcinoma of the hard palate present with cervical lymph node metastases. Lymphatic spread occurs along the facial and retropharyngeal lymph nodes and along the upper jugular chain. The management of squamous cell carcinoma of the hard palate is similar to that of other oral tumors. Low-volume superficial lesions without bone erosion may be excised through an intraoral approach, while extensive tumors with bone erosion may require partial maxillectomy[12].

Carcinoma of the Tonsils and Palatine Arches

Oropharyngeal squamous cell carcinomas are usually poorly differentiated and locally advanced at the time of clinical presentation. The overall incidence of cervical lymph node metastasis is more than 50 % [14,17,28,31]. Tonsillar carcinomas, in their early stages, are usually found arising near the upper pole of the tonsil. The tumor is prone to spread anteriorly and posteriorly to the tonsillar pillars, thereby acquiring the potential spread pattern associated with these sites. These lesions may extend posterolaterally to the lateral pharyngeal wall, para pharyngeal space, and pterygoid muscles, inferiorly to the glossotonsillar sulcus, base of the tongue, and floor of the mouth, and superiorly to the soft palate and nasopharynx [16,24,25]. Bone erosion is an unusual finding and is present only in advanced stages. Extensive invasion of the parapharyngeal and masticator spaces may be associated with carotid artery encasement or extension superiorly along the fascial and muscle planes into the skull base. If the tumor encompasses more than 270° of the circumference of the internal carotid artery on axial images, it becomes inoperable[32]. Although the normal tonsillar fossae may be asymmetric, asymmetry of the tonsillar region should be viewed with strong suspicion when there is metastatic adenopathy in the neck from an unknown primary. Obliteration of the parapharyngeal space should be viewed with suspicion regardless of the nodal status in the neck. Lymph node metastases occur primarily n the upper jugular or retropharyngeal nodes, but the spinal accessory and submandibular nodes are also at risk. Early tumors localized in the tonsillar fossa may undergo a wide local excision through an intraoral approach. Advanced lesions extending to the parapharyngeal and masticator spaces require resection of portions of the tongue base, mandible, or maxilla. In many institutions these large tumors will be treated with combined radiation therapy and chemotherapy. Distant spread occurs most commonly to the lungs in patients with advanced disease or with pathologically proven lymph nodes at multiple levels in the neck or in the lower neck[17,28,33]. Superficial tumors involving the palatine arches typically demonstrate multifocality, commonly known as "sick mucosa." Tumors arising on the anterior tonsillar pillars are much more common than tumors arising on the posterior tonsillar pillars, Squamous cell cancers of the anterior tonsillar pillar tend to spread superiorly to invade the soft palate, and from there anteriorly into the hard palate or further superiorly into the nasopharynx, pterygoid muscles, and skull bases. [19,34]Anterior spread of anterior tonsillar pillar lesions occurs along the pterygomandibular raphe into the buccinator muscle and inferior spread occurs along the palatoglossus muscle into the base of the tongue. Lymph node metastases occur primarily in the submandibular and in the upper jugular lymph nodes. Squamous cell cancers arising within the anterior tonsillar pillar have an overall 45 % chance of having clinically positive nodal metastases at initial presentation. Squamous cell cancers of the posterior tonsillar pillar tend to spread superiorly into the soft palate, posteriorly into the posterior pharyngeal wall, or inferiorly into the pharyngoepiglottic fold. The primary lymphatic drainage is to the upper jugular nodes. However, the retropharyngeal and spinal accessory nodes are at risk in the presence of posterior pharyngeal wall involvement[12].

Carcinoma of the Base of the Tongue

Twenty-five percent of tongue neoplasms occur in the posterior one-third (base of the tongue), which is the oropharyngeal portion of the tongue. Squamous cell carcinoma of the base of the tongue is an aggressive, deeply infiltrative tumor with a 75 % incidence of lymph node metastases at presentation and with nearly 30 % of patients having bilateral level II and III lymph nodal metastases[10,28]. Base of the tongue cancers may extend laterally to involve the mandible and medial pterygoid muscles, superiorly to involve the tonsillar fossa and soft palate; anteriorly to involve the mobile tongue and floor of the mouth; and inferiorly to involve the vallecula, pre-epiglottic space, and epiglottis or portions of the hypopharynx[18,19,24,35] . In addition to routine axial images, sagittal and coronal images may provide an excellent appreciation of the volume of the tumor in the tongue base. Therapeutic options depend upon tumor volume, laterality, and invasion of the ipsilateral and contralateral neurovascular bundle [12].

Carcinoma of the Soft Palate

Most soft-palate tumors are squamous cell carcinomas; however, minor salivary gland cancers may typically be seen in the posterior soft palate[14,36,37]. They usually affect the oral aspect of the soft palate. Tumor extension may occur anteriorly to the hard palate, laterally to the tonsillar pillars and fossa, and from there extend further laterally into the parapharyngeal space, nasopharynx, and base of the skull. Lymph node metastases are seen in 60 % of cases at initial presentation. Coronal and sagittal CT images are essential to evaluate soft-palate tumors, as smaller lesions may be missed on the axial plane. On CT, the attenuation values and enhancement pattern of the soft palate and tumor may be similar, and unless there is obvious fullness at imaging, the tumors may be missed[12].

TNM Staging of Tumours

The table shows the TNM staging of tumours of oral cavity (American Joint Committee on Cancer; 2010 guidelines)[38]

TNM Staging of Cancers of Lip and Oral Cavity. Adapted from American Joint Committee on Cancer (AJCC) 7th ed. 2010.

Primary Tumor of Oral Cavity-T

Tx Primary tumor cannot be assessed

T0 No evidence of primary tumor is seen

Tis Primary tumor is carcinoma in situ

T1 Primary tumor has a maximal diameter of 2 cm or less

T2 Primary tumor has a maximal diameter of more than 2 cm but no more than 4 cm

T3 Primary tumor has a maximal diameter of more than 4 cm

T4a

Lip: Primary tumor involves cortical bone, inferior alveolar nerve, floor of the mouth, skin

Oral cavity: Primary tumor involves cortical bone, intrinsic or extrinsic muscles of the tongue, maxillary

sinus, skin

T4b Primary tumor involves masticator space, pterygoid plates, skull base, internal carotid artery

Regional Metastasis

Nx Regional lymph nodes cannot be assessed

N0 No regional lymph node metastasis is evident

N1 Ipsilateral single enlarged node with a maximal diameter of less than 3 cm

N2a Ipsilateral single enlarged node with a maximal diameter of 3–6 cm

N2b Ipsilateral multiple enlarged nodes with a maximal diameter of less than 6 cm

N2c Bilateral or contralateral enlarged nodes with maximal diameter of less than 6 cm

N3 Enlarged node with a maximal diameter of more than 6 cm

Distant Metastasis

M0 No distant metastasis is evident

M1 Distant metastasis is evident

Outline of Management for locally advanced oral cancers (T3, T4a & T4b)

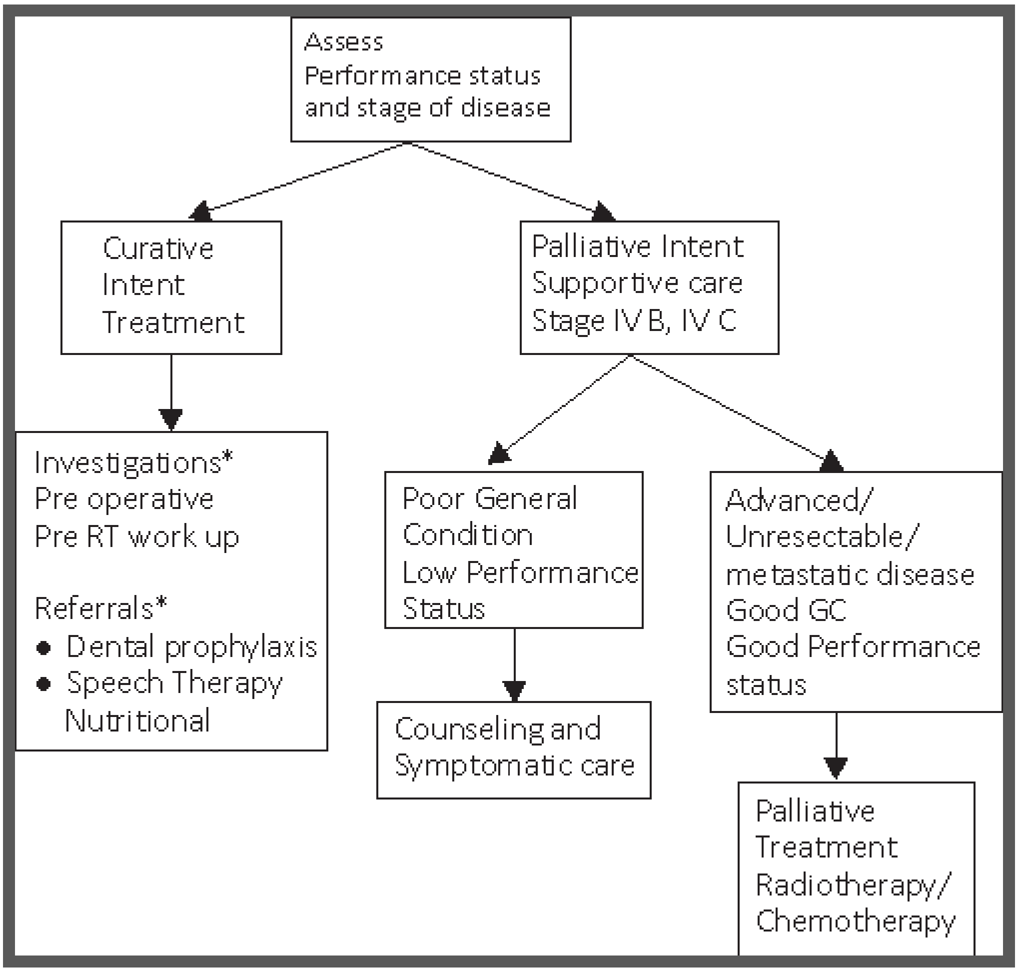

Figure 13. Evaluation of a patient with head and neck cancer for appropriate treatment

For patients with stage I / II disease requires single modality treatment either by surgery or radiotherapy but stage III & IV disease requires multimodality treatment like surgery + radiotherapy ± chemotherapy or chemotherapy + radiotherapy or neoadjuvant chemotherapy followed by chemotherapy + radiotherapy or surgery + post-operative radiotherapy.

Selection of modality depends on the subsite of cancer. When different modalities are available, the modality that gives maximum chance of cure should be used. When different modalities have similar results, a modality that gives better quality of life, with organ /function preservation is preferred.

Assessment of resectability

Tumour involvement of the following structures is considered technically unresectable:

- Erosion of pterygoid plates, sphenoid bone, widening of foramen ovale
- Extension to superior nasopharynx or deep extension into Eustachian tube or lateral nasopharyngeal wall
- Encasement of internal carotid artery, defined radiologically as tumor surrounding the carotid greater than 270 degrees.
- Involvement of mediastinal structures

Involvement of prevertebral fascia or cervical vertebrae

Principles of resection

1. En bloc resection of primary tumor whenever feasible
2. In continuity neck dissection when direct extension of primary into neck
3. Third dimension (the base) should be taken carefully into account before excision
4. Adequate margin is 1.5 – 2 cm for all sub-sites of oral cavity, except for tongue which is 1 cm.
5. Clear margin: > 0.5 cm on histopathology, after fixing the specimen in formalin.
6. Close margin < 0.5 cm
7. Frozen section confirmation for margins may be done if the facility is available
8. Contralateral neck should be addressed when the probability of bilateral / contralateral metastases is high (for example tumors crossing the midline / midline tumors).

Indications for postoperative radiotherapy

Primary:

- Large primary – T3/T4
- Deep infiltrative tumour
- High grade tumour
- Lymphovascular and perineural invasion

Lymph nodes:

- Bulky nodal disease N2/N3
- Extra nodal extension
- Multiple level involvement
- Multiple nodes

Chemo-radiotherapy

- Positive or close margin after curative resection
- Nodes with perinodal extension

Role of Brachytherapy (BRT)

- Accessible lesions
- Small (preferable < 3 cm) tumours
- Lesions away from bone
- N0 nodal status
- Superficial lesions

Dose for radical radiotherapy

Tumours suitable for brachytherapy

T1-3 N0-1:

External RT: 56 -60Gy/28-30#/6wks

Boost BRT: Low dose rate 192Iridium: 15-20 Gy or

High Dose rate: 14Gy in 4 fractions over 2 days (4-3-3-4 Gy)

Tumours not suitable for brachytherapy

T1-4 N0-2

- Concomitant chemoradiation: 66-70Gy/33-35 fractions/6-7 wks + concomitant weekly Cisplatin, 30 to 40 mg/m2 for 6-7 wks or 3 weekly Cisplatinum, 100mg /m2 x 3 cycles Or
- External RT: 66-70GY/33-35 fractions 6-7weeks (reducing fields).

Doses and Volumes in adjuvant setting

- Primary and involved nodal disease: 56-60 Gy/28-30 fractions /6 weeks, using reducing fields.
- Site of residual disease, positive cut margins: 4-10 Gy Boost
- Uninvolved nodal stations: 45 -50 Gy

Dose of chemotherapy in the adjuvant setting in combination with radiotherapy: 30mg/m2 weekly with hydration and antiemetic prophylaxis

Management of primary tumours

Carcinoma lip

T3, T4 Tumors: Surgery + post-operative RT/ CT-RT

Surgery: Wide excision with marginal/ segmental / hemimandible resection with appropriate reconstruction.

Carcinoma buccal mucosa

T3, T4 Tumors:Surgery + Post operative RT/ CT-RT

Surgery: Composite resection of the buccal mucosa with mandible or upper alveolus or overlying skin with reconstruction.

Carcinoma oral tongue & floor of mouth

T3, T4 Tumors: Surgery + post-operative Radiotherapy/ CTRT

Surgery: Appropriate wide excision glossectomy with mandibular swing or pull through along with lingual plate / segmental / hemimandibular resection, if required (based on extent of involvement) with reconstruction.

Carcinoma lower alveolus & retro molar trigone

Mandible uninvolved or minimally involved

Surgery: Wide Excision with marginal mandibulectomy (avoided in RMT disease, edentulous mandible, paramandibular disease, post radiotherapy) if required with reconstruction.

Management of neck nodes:(Lip/Buccal Mucosa/Oral Tongue/Floor of mouth/Lower alveolus /Retro Molar Trigone)

T3, T4 Tumors

N0: SOHD followed by FS, if positive nodes MND is required

N+: MND / RND

Carcinoma upper alveolus & hard palate

If maxillary antrum is not involved - Surgery: Upper alveolectomy / Partial maxillectomy followed by radical radiotherapy / brachytherapy for selected

Reconstructive options for oral cavity

Based on the size and composition of defect, the options are: leaving the defect raw or primary closure or split thickness skin graft (STSG) or mucosal grafts

Full thickness defects –

- Local Flaps: Abbe-Estlander’s flap, Gille’s Flap (for lip)

- Regional flaps: Tongue flap, Nasolabial flap, Facial artery myomucosal flap, Masseter flap, Platysmal flap, , Forehead flap
- Distant Flaps: Pectoralis major myocutaneous flap, Deltopectoral flap, Latissimus dorsi myocutaneous flap
- Free Flaps: Radial forearm flap, Lateral arm flap, Antero-lateral thigh flap

Mandibular Defects

Anterior mandibular defect needs to be reconstructed by

- Free osteomyocutaneous flaps-Fibular osteocutaneous flap (preferred because of long bone length, easy contouring and dual bloodsupply), Radial osteo-cutaneous flap, Scapular osteocutaneous flap
- Osteomyocutaneous flaps- Pectoralis major myocutaneous flap with rib, latissimus dorsi osteocutaneous flap, spine of scapula with trapezius osteomyocutaneous flap

Lateral mandibular defects may be reconstructed with adequate soft tissue replacement, complemented by proper use of guide bite prosthesis and appropriate postoperative isometric exercises.

Criteria for Inoperability:

Primary disease: Adequate surgical clearance is not achievable.

- Extensive Infratemporal Fossa involvement
- Extensive involvement of base skull.
- Extensive induration /soft tissue disease till zygoma or hyoid.

Nodal Disease:

- Clinically fixed nodes.
- Infiltration of Internal /Common carotid artery.
- Extensive infiltration of prevertebral muscles, skull base.

These patients are usually treated with palliative intent with chemotherapy or radiotherapy. If general condition is good, then concurrent chemo radiotherapy can be offered. If general condition is poor, then only best supportive care[39].

Puff Cheek Technique

CT evaluation of oral lesions have two limitations. A small mucosal lesion is most often invisible on CT images and when two mucosal surfaces of oral cavity are apposed, it is difficult to determine from which surface the tumor arises or invades. Knowing the precise location of the abnormality usually helps the radiologist in arriving at appropriate diagnosis. Puffed-cheek CT scans helps to localize the lesion when the location is unknown or doubtful. The surfaces of the oral cavity are often in contact are the buccal (cheek) mucosa more posteriorly or the labial (lip) mucosa more anteriorly, and the alveolar (gingival) mucosa of the mandible and maxilla. In puffed-cheek CT scans of the oral cavity, air separates these mucosal surfaces. Air in the oral cavity will highlight a bulky exophytic mass, a subtle wall thickening, and an ulceration. Air makes such an excellent ‘‘contrast medium’’. The puffed-cheek maneuver is easily taught, and patients comply readily. Initially, the patients were asked to suspend respiration for the duration of the maneuver. Subsequently, it became apparent that it is possible to puff out the cheeks and continue breathing quietly. This further improved patient compliance and the quality of the study. The puffed-cheek maneuver added a negligible amount of time to the total scan duration. Puffed-cheek images show unfamiliar normal anatomy that could be mistaken for disease. The muscles of facial expression among them, the risorius, the levator anguli oris, the depressor anguli oris, and the orbicularis oris muscles create conspicuous soft tissue ‘‘masses’’ when the cheeks are stretched by air. The buccinator muscles are seen better on puffed-cheek images than on the conventional CT scans, but these broad, band like muscles are unlikely to be mistaken for disease. To date, there is no evidence that the puffed cheek maneuver obscures findings.

HISTORICAL BACKGROUND

CT IMAGING:

Medical imaging has experienced significant changes in both the technologic and clinical areas since the discovery of X-ray in **1895 by Wilhelm Conrad Roentgen,** a German Physicist. Innovations have become common in the Radiology Department, and today the introduction of new ideas and methods and refinements in existing techniques are apparent. One such evolution is the invention of computed tomography (CT) [10].

The first clinical results were presented in 1967 and it became available as practical tool in 1971[40].

Sir Godfrey Hounsfield, an electronic engineer working at the Central Research Laboratories of EMI in England commenced work on image reconstruction in 1968.His original apparatus consisted of a collimated isotope source mounted on a lathe bed. The objects examined were phantoms contained within a ten-inch water. The scan took 9 days to complete because of the low intensity of the X-ray radiation source, and a further 21/2 hours to process the reading through a computer. The resulting image though of poor quality proved that the system worked. To provide sufficient intensity the equipment was modified by replacing the isotope with an industrial X-ray tube[40].

Hounsfield and Ambrose presented their paper on CT to the annual congress of the British Institute of Radiology on 20th April 1972 to great acclaim. The first CT papers, by these authors appeared in BJR in 1973. The invention of this technique resulted in the award of 1979 Nobel prize in physiology and medicine to Sir G.N.Hounsfield, Central Research Lab., England (EMI), A.N.Cormack of Physics Department, Tufts University, Massachusetts, U.S.A. Advanced Technological Developments.Over the last ten years , four different generations of CT scan equipment were produced.The most important improvements have been in the reduction in the single image generation time from five minutes to 2.5 seconds in the third and fourth generations scanners and an increase in spatial resolution and contrast[40].

MULTI-DETECTOR CT: STATE-OF-THE-ART CT SCANNERS & THE MDCT 'SLICE-WAR'.

Multi-detector (or multi-slice) CT was introduced to maximise the effective use of available x-ray beam. The x-raybeam is widened in the z-direction (slice thickness) and multiple rows of detectors were employed for data acquisition for more than one slice at a time. This would reduce the total number of rotations of the tube and therefore the total usage of the x-ray tube for a particular length of cranio-caudal scan coverage. Multi-detector CT (MDCT) scanner differs from the single-slice CT scanner mainly in terms of design of detector assembly. The post-processing of the 'volume' data from these scanners was almost isotropic i.e. reformatted images in any plane other than the original plane exhibit spatial resolution (in the z-direction) that is equal to that of the original images. Sub-millimeter scanning really came into picture after the arrival of a 16-slice scanner in 2002. Then by 2005, 64-slice scanners were introduced with further lengthening of the detector arrays in the z-axis. MDCT thus allows 'volume' imaging of the patient which can be later post-processed into the desired number of slices in different planes depending upon the clinical indication[10] **.**

CT IMAGING IN NECK

CT allowed visualization of normal and abnormal soft tissue and bone structures and was optimal for demonstration of calcifications. The application of CT in the head and neck allowed wide application for the assessment of inflammation, cysts, and benign and malignant tumors. Diseases that were out of the reach of radiologic evaluation, particularly those in skull base, infra-temporal fossa and orbit, could now be identified. Tumor staging increased in accuracy, and surgical planning achieved greater precision, with a consequent decrease in morbidity and mortality. The conspicuity of abnormalities was further increased with the administration of iodinated contrast material. The development of spiral CT in the past few years has allowed a shorter examination time and thinner sections, with the capability of three-dimensional reconstruction. Most recently, multi–detector row CT with increased spatial resolution, with a section thickness as small as 0.5 mm and aquisition capabilities of 8 images per second, has been developed.

CLINICAL STUDIES

A retrospective study was conducted in Tata memorial Centre, Mumbai to investigate the accuracy of 16 slice MDCT in evaluating mandibular invasion in retromolar trigone (RMT) squamous cell carcinomas (SCC). A total of 37 patients who were imaged and treated between 2007 and 2010 were included in the study. All the patients underwent segmental, marginal or hemimandibulectomy within 2 weeks of imaging. CECT images of slice 2.5 mm (reconstructed to 0.625 mm) were acquired and multiplanar reconstructions was performed as required. The images were independently studied by two investigators and results were compared with histopathology reports. The 16-slice MDCT showed sensitivity, specificity and accuracy for mandibular cortical and marrow invasion was 94, 90, and 91.8% and 83, 92 and 89% respectively. Multiplanar reformations resulted in improved sensitivity and specificity. There was 100% accuracy for inferior alveolar canal invasion. The authors concluded that 16-slice MDCT when used to full potential has high accuracy for detection of mandibular invasion in RMT SCC.[41]

A retrospective study was conducted to determine the diagnostic accuracy of CT in detection of mandibular invasion of SCC of the oral cavity. The study included 49 patients with SCC of oral cavity involving mandible clinically and underwent mandibulectomy. All the patients underwent contrast CT study of neck and images were reviewed for evidence of mandibular invasion. The results were compared with histologic findings in all cases. A total of 26 cases were found to have mandibular invasion and CT could accurately detect 25 of these cases. Mandibular invasion was accurately excluded in 20 of 23 patients. The study showed that CT has a 96% sensitivity and 87% specificity and a positive predictive value (PPV) of 89% and negative predictive value (NPV) of 95%.[42]

A retrospective study compared the diagnostic accuracy of MRI and MDCT in evaluation of mandibular invasion of SCC or oral cavity with histopathological correlation. The study included 36 patients who underwent preoperative MRI and MDCT and histologically proven SCC. Study results showed high sensitivity, specificity and accuracy of MRI and MDCT in detection of mandibular involvement (93%, 82%, 86% and 79%, 82%, 81% respectively) and a PPV and NPV of 76%, 95% and 73%, 86% respectively. The authors concluded that although MRI showed higher sensitivity in this study, the difference was not statistically significant. Moreover, diagnostic accuracy between MDCT and MRI was similar.[43]

A retrospective study evaluated tumour extension of SCC of gingiva with CT and MRI techniques. The study included 122 patients with SCC of lower gingiva (n = 88) and upper gingiva (n = 34). The results showed spread to head and neck spaces in 58% of patients. The buccal space was the most common site of spread occurring in more than 40% of cases. Spread to masticator region was observed in 20% of lower gingival cancers; however was rare in upper gingival region. The RMT and buccal space immediately anterior to ramus were considered to act as a corridor for cancer extension from lower gingiva into masticator space. Sublingual site was less common site of spread from lower gingiva. The study results showed that based on primary site, gingival cancers spared into masticator, buccal, and sublingual spaces. Understanding anatomy of spaces of face and neck help in diagnosis of cancer extension and in treatment planning.

A prospective study was conducted to examine the histologic patterns of tumour invasion and route of tumor entry into mandible in 100 patients with oral SCC. The pattern of tumor invasion was significantly influenced by depth of invasion both in hard and soft tissues. Direct tumor entry to mandible at the point of abutment was seen in 13 cases. Of 42 tumors invading dentate part of mandible, 23 cases (55%) entered through occlusal (superior) surface. Direct entry to the mandible was more likely in tumors arising from tongue, floor of mouth and buccal mucosa when compared with alveolar or RMT sites. Larger tumors or deeply invading tumors were likely to be more aggressive. Knowledge of point of tumor entry for mandible is important during planning treatment.[44]

A study compared the diagnostic accuracy of MRI and CT to assess mandibular invasion of SCC of oral cavity. The study was conducted in 51 patients with SCC of oral cavity of whom 25 patients had histopathologic evidence of mandibular cortical invasion. The sensitivity and specificity for mandibular cortical invasion were 96% and 54% for MRI and 100% and 88% for CT, respectively. The sensitivity and specificity for inferior alveolar canal involvement were 100% and 70% for MRI and 100% and 06% for CT. The specificity of MRI was significantly lower compared to CT for assessing both mandibular cortical invasion and inferior alveolar canal involvement (P = .004 and P = .002 respectively). It was concluded from the study that specificity of MRI for evaluation of mandibular invasion was lower compared to that of CT.[45]

MATERIALS AND METHODS

Source of data

Data for the study was collected from patients with locally advanced oral cancers referred to the department of Radio Diagnosis of R.L. Jalappa hospital attached to Sri Devaraj Urs Medical college, Tamaka, Kolar.

***Method of collection of data*:**

Study was conducted on 39 patients with oral cancers over a period of eighteen months (January 2014- June 2015). After taking informed written consent from all the patients contrast enhanced CT neck was performed with sixteen slice Multi-detector Computed Tomography scanner (SIEMENS SOMATOM EMOTION 16) and findings were correlated with either clinical follow up, or surgical findings. They were followed up after a period of 7 to 12 months.

Inclusion Criteria:

1. Patients above 18 years of age with locally advanced cancers of oral cavity.

Exclusion Criteria:

1. Patients medically unfit for surgery.
2. Patients who have undergone earlier radiotherapy or chemotherapy.
3. Patients who have undergone any earlier head and neck surgeries.
4. Patients with deranged renal function tests.

Preparation of patient:

Risks of contrast administration were explained to the patients and written consent was obtained prior to the imaging with contrast.

Routine lateral topogram of the neck was initially taken in all patients in the supine position. Axial sections of 3 mm thickness were taken from the floor of orbit to the level of manubrium sterni. . Kilovolt peak: 120–140 kVp, milli Ampere second: 200-300 mAs for an average-sized patient. Pitch: 1.5, Field of view: 230 mm; Collimation: 3mm, Time for scan: 30-40 seconds; Matrix: 512x512.

Plain and intravenous contrast scans were done with suspended inspiration. For intravenous contrast enhancement 80-100 ml bolus of injection of (Iopromide - 300mg Iodine per ml) was administered and axial CT sections were taken.

Sagittal and coronal reconstruction were made at 0.75mm thickness. MDCT findings were analyzed with regard to location, size and extent of the disease. The findings were correlated with either clinical follow up or surgical findings.

Fig 14. SIEMENS SOMATOM EMOTION 16 SLICE CT SCANNER

RESULTS

Study included 39 cases of locally advanced oral cancer patients.

Table 1. Age Distribution

Age in years	No. of patients	Percentage
≤40	4	10.3
41-50	10	25.6
51-60	10	25.6
61-70	11	28.2
71-80	3	7.7
>80	1	2.6
Total	**39**	**100.0**
Mean: 57.15		

The youngest patient was 30 years old, and the oldest was aged 87 years. Highest number of patients were in the age group of 61 to 70 years (28.2 %). 31 patients comes in the age of 40 to 70 years

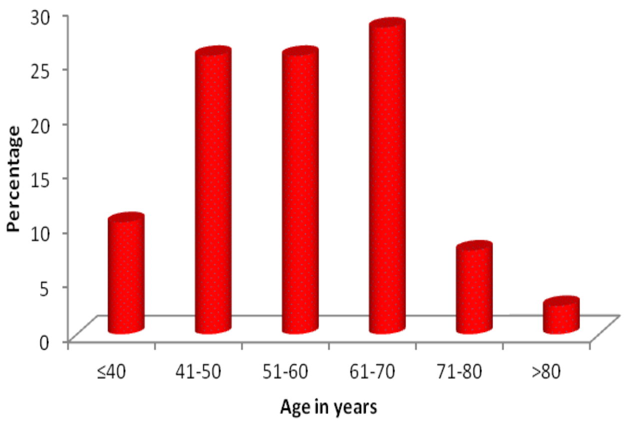

Figure 15. Age distribution

Table: 2 Gender Distribution

Gender	No. of patients	Percentage
Female	26	66.7
Male	13	33.3
Total	**39**	**100.0**

Female patients (66.7%) with carcinoma oral cavity were more compared to males (33.3 %).

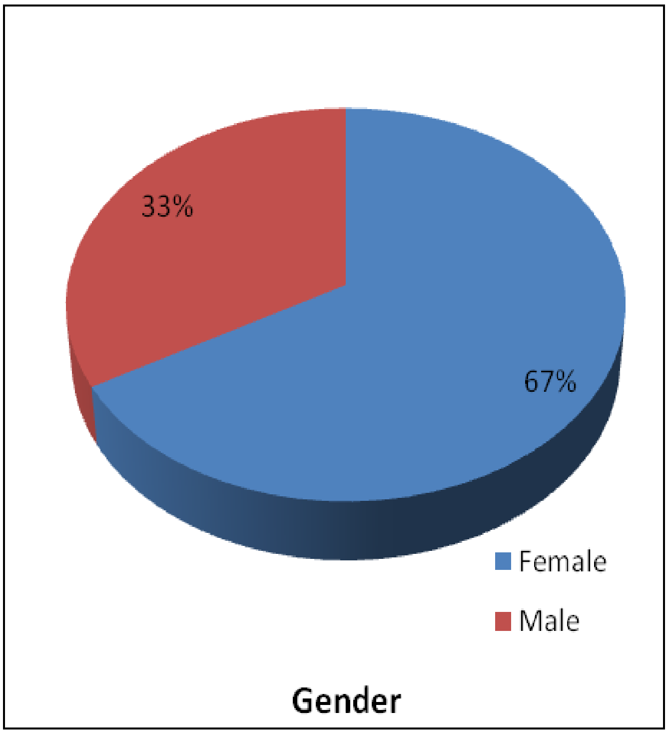

Figure: 16. Gender distribution

Table 3. Age Distribution in Relation to Gender

Age in years	Gender		Total
	Female	Male	
≤40	1(3.8%)	3(23.1%)	4(10.3%)
41-50	8(30.8%)	2(15.4%)	10(25.6%)
51-60	6(23.1%)	4(30.8%)	10(25.6%)
61-70	7(26.9%)	4(30.8%)	11(28.2%)
71-80	3(11.5%)	0(0%)	3(7.7%)
>80	1(3.8%)	0(0%)	1(2.6%)
Total	**26(100%)**	**13(100%)**	**39(100%)**

Frequency of oral cancer was highest among females in the age group of 41-50 years (n=8) and males in the age group of 61-70 and 51-60 years (n=4 each).

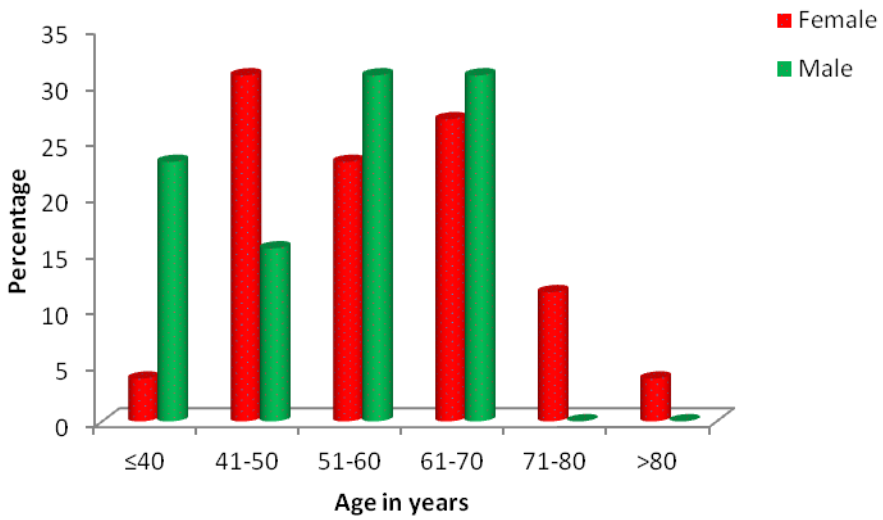

Figure 17. Age distribution

Table 4. Habits

Habits	Gender		Total (n=39)%
	Female (n=26)	Male (n=13)	
Smoking	0	5	**5(12.8%)**
Tobacco chewing	10	5	**15(38.5%)**
Betel nut chewing	15	8	**23(59%)**
Alcohol	2	4	**6(15.3%)**
No addictions	7	2	**9(23.1%)**

History of betel nut chewing, tobacco chewing, smoking and alcohol consumption was seen in 59 %, 38.5 %, 12.8% and 15.3 % respectively. Few patients had more than one addictions.

Table 5. CT Distribution of Carcinoma in Various Sub-sites of Oral Cavity

Site involved	Gender		Total
	Female	Male	
Buccal mucosa	20	8	**28**(71.8%)
Lower alveolus	2	2	**4**(10.3%)
Tongue- anterior 2/3rd	1	3	**4**(10.3%)
Upper alveolus	2	0	**2**(5.1%)
Floor of mouth	1	0	**1**(2.6%)
Total	**26**	**13**	**39**(100%)

Among various sub-sites of oral cavity, buccal mucosa is the commonest site of carcinoma followed by lower alveolus and anterior 2/3rd of tongue.

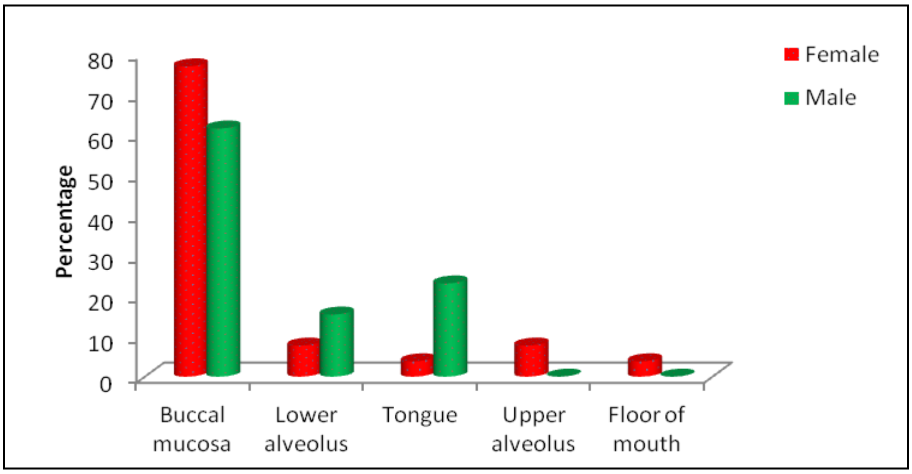

Figure 18. Distribution of carcinoma in various sub-sites of oral cavity

Table 6. CT Scan- Potential neck Spaces Involved

Spaces Involved	Gender		Total (n=39)%
	Female (n=26)	Male (n=13)	
Submandibular/sub mental	13	4	**17(43.6%)**
Parotid	0	1	**1(2.6%)**
Para pharyngeal space	3	2	**5(12.8%)**
Carotid space	0	1	**1(2.6%)**
Retropharyngeal space	0	0	**0(0%)**
Masticator space/infratemporal fossa	13	5	**18(46.2%)**
Buccal space	25	12	**37(94.9%)**
Prevertebral space	0	0	**0(0%)**

In 39 cases with oral cancer, 94.4% cases show buccal space involvement followed by masticator space (46.2%).

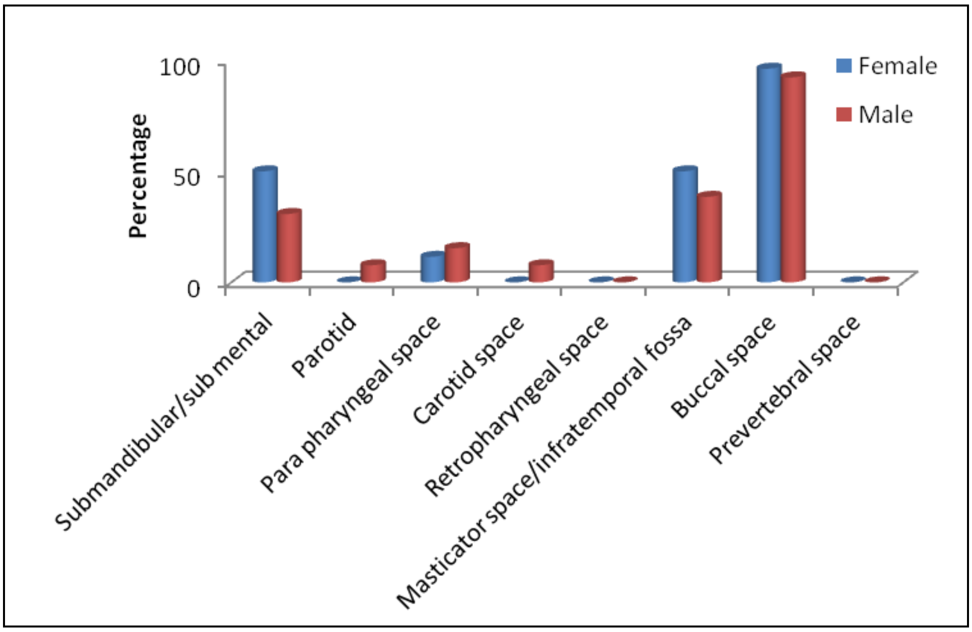

Figure 19. CT Scan- Potential neck Spaces Involved

Table 7. CT scan -Number of Potential neck Spaces Involved

Number of Spaces Involved	Gender		Total (n=39)%
	Female (n=26)	Male (n=13)	
1	6	6	12(30.8%)
2	13	3	16(41.1%)
3	6	3	9(23.1%)
4	1	1	2(5.1%)

Most of the cases had more than one space involvement, about 41.1 % cases showed involvement of two spaces by the primary tumor

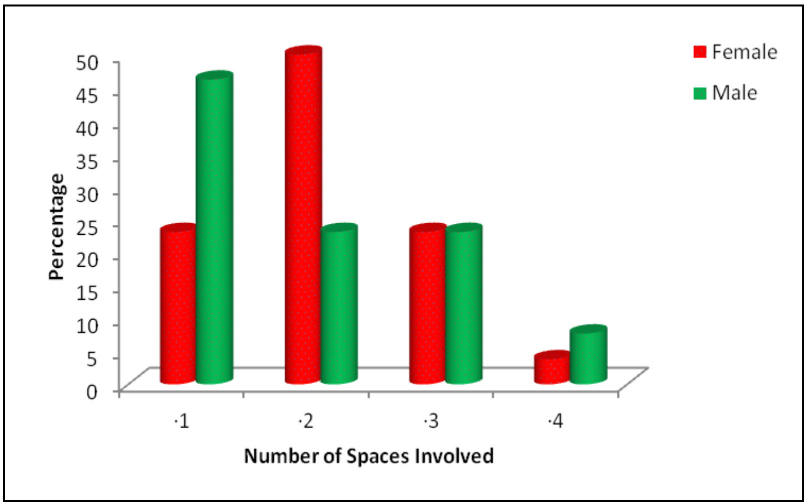

Figure 20. CT scan -Number of Potential neck Spaces Involved

Table 8. Bone Erosion

Bone Erosion	Total (n=39)%
Mandible	**18(46.2%)**
Maxilla	**13(33.3%)**
Both mandible and maxilla	**4(10.2%)**
No erosion	**12(30.7%)**

Out of 39 patients bone erosion was observed in 27 patients, with 4 patients showing erosion of both mandible and maxilla.

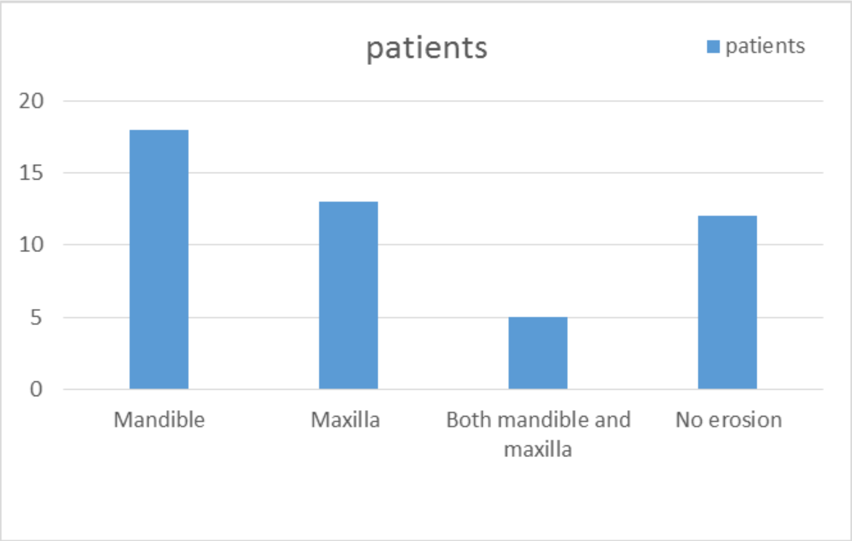

Figure 21. Bone erosion

Table 9. Clinical Staging of Primary Tumor

Clinical Tumor Staging	Gender		Total
	Female	**Male**	
T3	3	1	**4(10.3%)**
T4a	20	7	**27(69.2%)**
T4b	3	5	**8(20.5%)**
Total	**26**	**13**	**39(100%)**

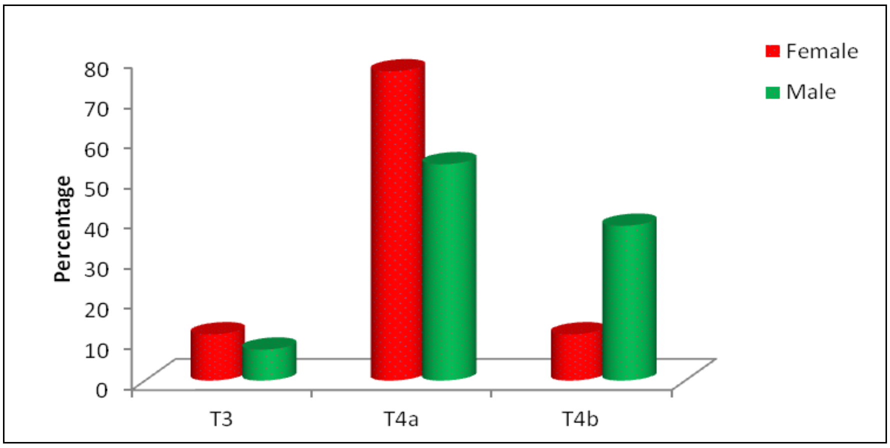

Figure 22. Clinical Staging of Primary Tumor

Table 10. CT Staging of Primary Tumor

CT tumor Staging	Gender		Total
	Female	Male	
T3	4	2	**6(15.4%)**
T4a	9	3	**12(30.8%)**
T4b	13	8	**21(53.8%)**
Total	**26**	**13**	**39(100%)**

Table 11and table 12 shows the difference in tumor staging that has been attained after performing CT.

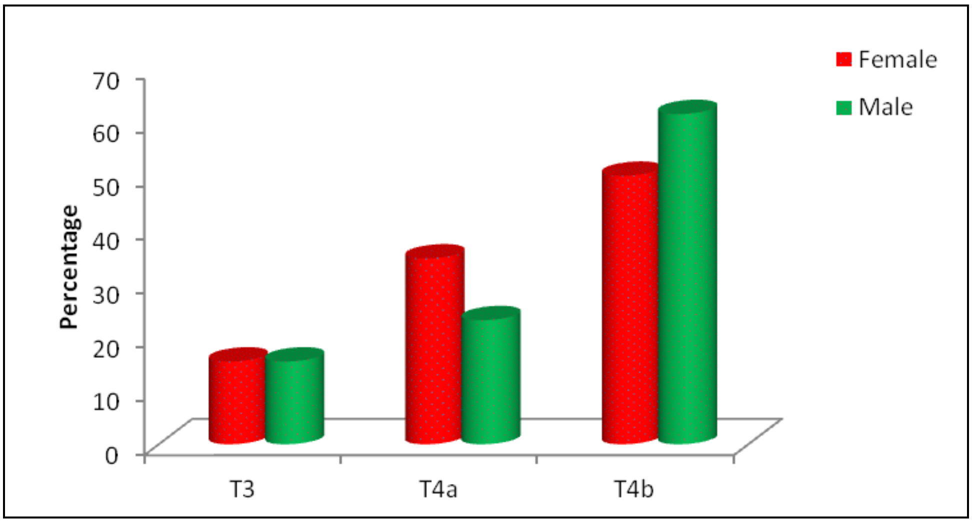

Figure 23. CT Staging of Primary Tumor

Table 11. Clinical Tumor Staging Versus CT Tumor Staging

	Clinical tumor Staging	CT tumor Staging
T3	4	6
T4a	27	12
T4b	8	21

CT tumor staging altered clinical staging of oral cancers with significant P values (p = 0.011).

Thus modifying treatment options in 13 T4 oral cancer patients, who were upstaged from T4a to T4b

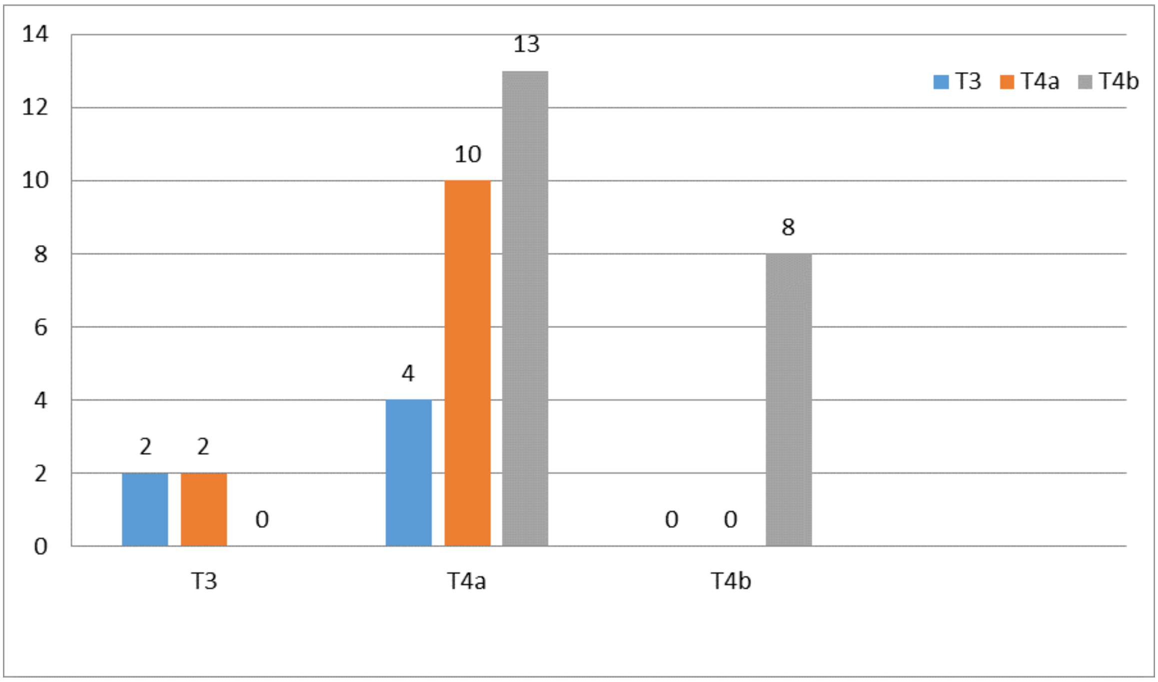

Figure 24. Clinical tumor staging versus CT tumor staging

Table 12. Treatment and Follow up Given to Patients of Stage T3 Disease

Patients with CT tumor stage T3	Underwent surgery + RT	Not taken treatment (defaulted)	
	LRC	AWD	DDOC
Male	2	0	0
Female	2	1	1
Total (n=6)	4	1	1

AWD = alive with disease; DDOC = death due to other cause; LRC = locoregionally controlled; RT = Radiotherapy

4 of 6 T3 cancer patients underwent curative surgery and are alive with loco-regionally controlled disease.

Table 13. Treatment and Follow up Given to Patients of Stage T4a Disease

Patients CT stage T4a(n=12)	SURG+RT			SURG+RT+CT	Defaulted treatment	
	LRC	DDOC	LTF	LRC	DDD	LTF
Male	2	0	0	1	0	0
Female	2	3	1	1	1	1
Total	4	3	1	2	1	1

CT = chemotherapy; DDD = death due to disease; DDOC = death due to other cause; LRC = locoregionally controlled; LTF = lost to follow-up; RT = Radiotherapy; SURG = surgery

In 12 patients of T4a disease 10 had taken treatment and 6patients are alive with loco-regionally controlled disease and 3 patient died due to other causes.

Table 14. Treatment and Follow up Given to Patients of Stage T4b Disease

Patients CT stage T4b	Neo –adj CT +SURG + CT	SURG+RT+CT		Palliative treatment		
	LRC	LRC	AWD	AW	DD	LTF
Male	1	0	0	4	2	1
Female	0	2	1	3	5	2
Total (n=21)	1	2	1	7	7	3

AWD = alive with disease; CT = chemotherapy; DDD = death due to disease; LRC = locoregionally controlled; LTF = lost to follow-up; Neo-adj = neoadjuvant; RT = radiotherapy; Surg = surgery

In T4b cases 80% of patients underwent palliative treatment. 4 patients in whom involvement of masseter, temporalis, lateral pterygoid plates and ramus of mandible below sigmoid notch were operated with better outcome.

IMAGES

Figure 25. A 87 year old female patient with carcinoma left buccal mucosa. Axial CT imasge bone window showing erosion of lateral wall of left maxillary sinus(white arrow).

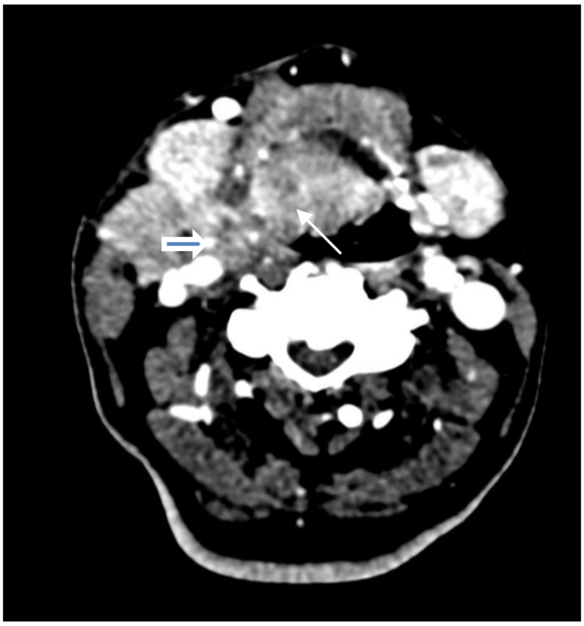

Figure 26. A 65 year old male patient with carcinoma tongue. Axial CECT image showing heterogeneously enhancing lesion on right side of tongue(white arrow) surrounding the right carotid artery and involving of right carotid space(solid arrow).

Figure 27. A 70 year old male patient with carcinoma right buccal mucosa. Axial CECT image showing involvement of right parotid space, fat plane between the lesion and right parotid gland is lost on right side (white arrow)which is maintained on the contralateral side (solid arrow).

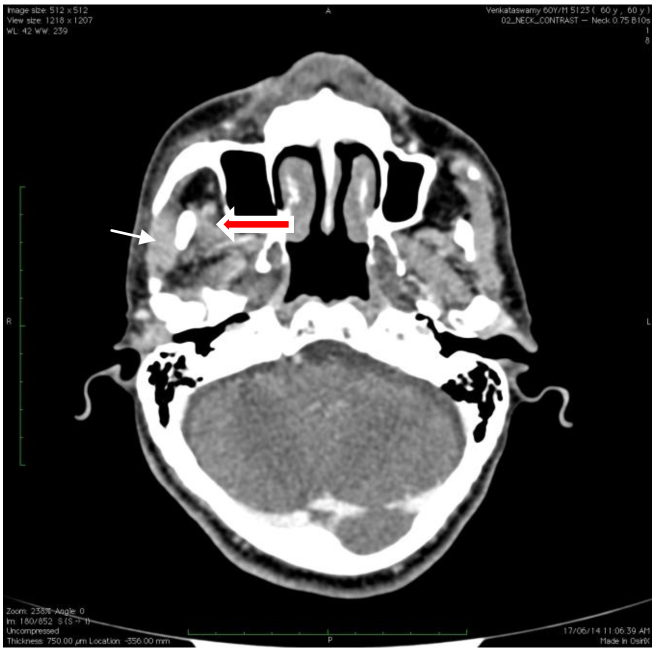

Figure 28. A 60 year old female patient with carcinoma right buccal mucosa. Axial CECT image showing involvement of right masticator space, right masseter(red arrow) and temporalis muscle(white arrow) appears bulky.

Figure 29. A 40 year old male patient with carcinoma left buccal mucosa. Axial CECT image showing involvement of the skin on left side, fat plane between the lesion and skin is lost(red solid arrow).

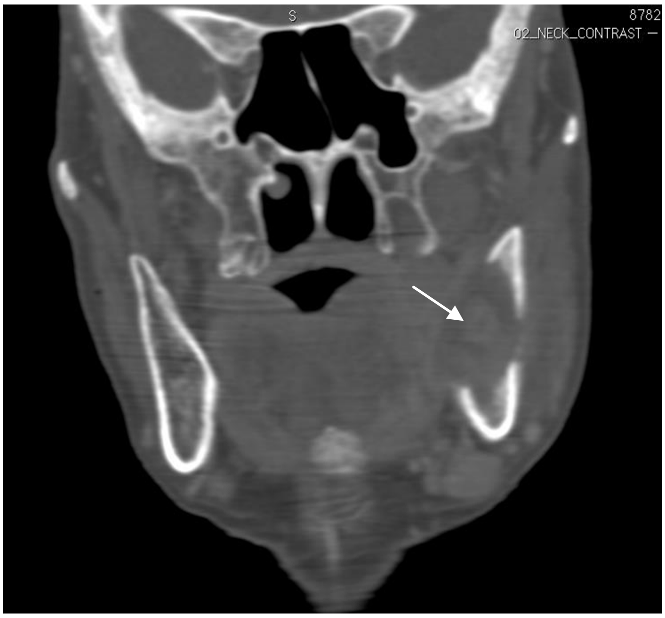

Figure 30. A 63 years old female patient with carcinoma of left buccal mucosa, CT bone window- Coronal reformatted, showing erosion of left mandible (white arrow).

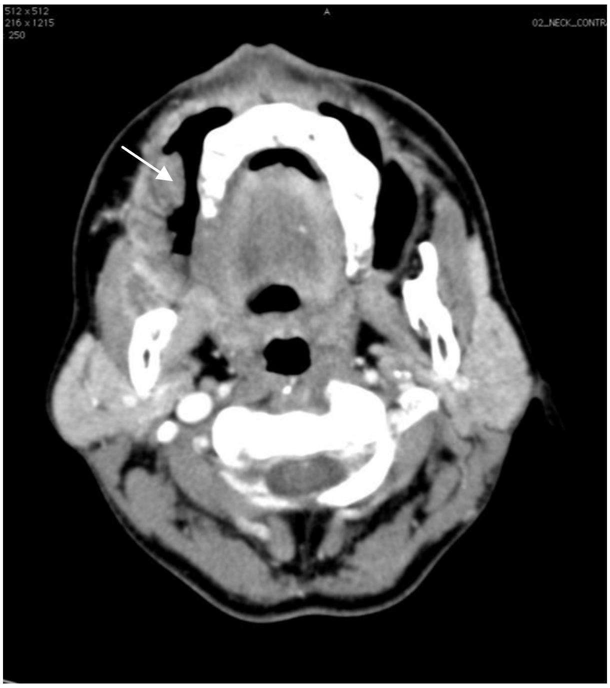

Figure 31. A 38 years old male patient with carcinoma of right buccal mucosa, axial CECT image showing heterogeneously enhancing soft tissue exophytic growth from right buccal mucosa (white arrow).

Figure 32. A 63 years old female patient with carcinoma of right buccal mucosa, axial CECT image showing heterogeneously enhancing soft tissue lesion of right buccal mucosa(white arrow)

Figure 33. A 70 years old male patient with carcinoma of left buccal mucosa, coronal CECT image showing heterogeneously enhancing soft tissue lesion of left buccal mucosa extending into adjacent maxillary sinus(white arrow)

Figure 34. A 48 years old female patient with carcinoma of right buccal mucosa, Coronal CECT image showing necrotic lymph node in right submandibular region (white solid arrow)

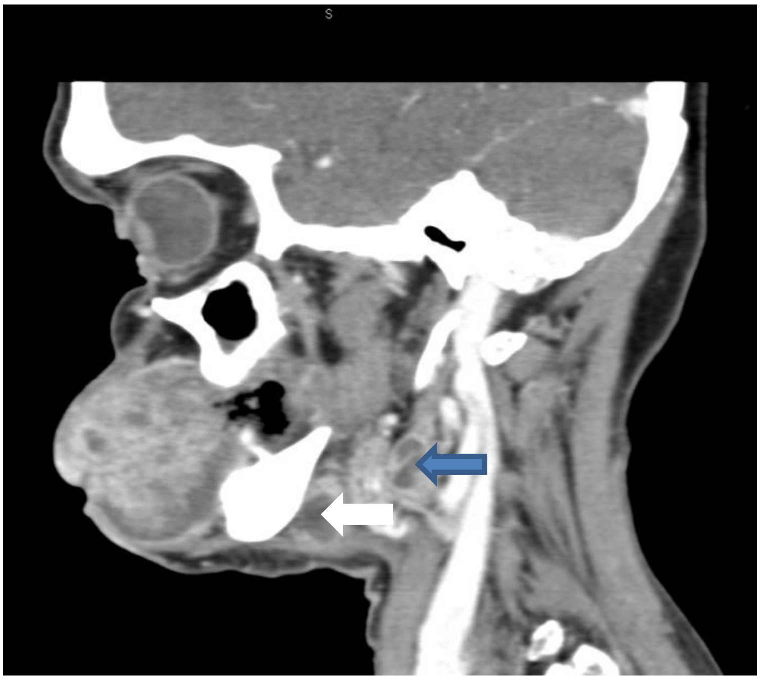

Figure 35. A 87 years old female patient with carcinoma of right buccal mucosa, CECT image showing necrotic lymph nodes in right level IB(white solid arrow) and level II(blue solid arrow).

DISCUSSION

Our study included 39 patients with locally advanced oral cancers, the youngest patient was 30 years old, and the oldest was aged 87 years. The highest percentage of patients 11(28.2 %) were in the age group of 61 to70 years, followed by the age group of 51 to 60 and 41 to 50 years (10 each; 25.6%). Other studies in literature also showed similar demographics, where the maximum percentage of patients were seen in the age group of 61-70 years followed by 41-50 years and 51 - 60 years[47].

Frequency of oral cancer in our study was highest among females in the age group of 41-50 years (n=8) and males in the age group of 61-70 and 51-60 years (n=4 each). 66.7% of our patients were women.

Female patients outnumbered males in this study except in carcinoma tongue (F:M = 3:1) unlike in a study done in Chennai which quotes male to female ratio was 1:1[48]. The female preponderance may be because of addiction of female patients in kolar region to tobacco, quid which is kept in their cheek. Oral cancer in female patients is due to smokeless tobacco and chewing habits leading to irreversible damage in oral mucosa[49,50,51].

Out of 39 patients of our study, 23 (59%) patients were addicted to betel nut chewing (15 females, 8 males), 15(38.5%) patients were addicted to tobacco chewing(10 females and 5 males) and 5 patients were addicted to smoking. Among them, few patients had multiple addictions.

Krishna et al[52] and **Khanna et al**[53] studies showed that chewing tobacco was present in 80.4 and 80.46% patients respectively and smoking habits were present in 51.5 and 31% patients respectively.

Out of 39 patients in our study, 71.8 % (28) were having carcinoma buccal mucosa, followed by 10.3%(4) with carcinoma tongue & lower alveolus, 5.1% (2) with carcinoma of upper alveolus and 2.6 % (1)with carcinoma floor of mouth.

A study conducted in south India on 997 patients of oral cancer also shown higher prevalence of carcinoma buccal mucosa (57.5%) followed by tongue (24.2%)[48].

In our study out of 39 patients with carcinoma oral cavity, 94.9% (37) patients had involvement of buccal space, followed by involvement of masticator space in 46.2%(18) patients and submandibular / sub mental space in 43.6% (17) patients. Para-pharyngeal space is involved in 12.8% (5) patients. Parotid and carotid spaces involvement is seen in 1 patient each.

Our results are similar to a large study conducted on 122 patients of gingival cancers by **Kimura Y et al**[5], showed that buccal space (more than 40% cases) was most commonly involved followed by the masticator space (20 %) from where it can extend to maxilla.

It was shown in literature that spread of buccal mucosa cancer to masticator space is along ramus of mandible, RMT and lateral pterygoid plates or along buccinators muscle or buccal fat of pad [54,55,56,57,58,59]. Literature also showed that tongue cancers spread easily to submandibular space which can be detected by CT with relatively high sensitivity and specificity[60,61].

It was **Gatenby et al** [62], who first demonstrated the advantage of CT over clinical examination for the staging of head and neck cancers. In his study involving 100 patients, the oral cancers were upstaged by CT scanning and the treatment planning was altered significantly in 36 patients.

Similarly, in our study clinically before CT was done out of 39 patients 4 patients were staged as T3, 27 were staged as T4a and 8 were staged as T4b. After CT, 6 patients were staged as T3, 12 were staged as T 4a and 21 were staged as T4b.

Among 4 clinically staged T3 patients, after CT 2 were staged as T3 who underwent surgery followed by radiotherapy and 2 patients were upgraded to stage T4a, they underwent surgery followed by radiotherapy and chemotherapy. All 4 patients are alive with loco-regionally controlled disease.

Among 27 clinically staged T4a patients, after CT 4 patients were down-staged to T3, in whom 2 patients underwent surgery followed by radiotherapy and are alive without disease. 10 patients were staged as T4a in whom 8 underwent treatment, among them 4 patients are alive with loco-regionally controlled disease and 3 were dead due to other causes. 13 Patients were upstaged to T4b, 9 of them were given palliative treatment and only 4 selected cases were surgically treated with curative intent. CT findings were histopathologically confirmed in operated patients.

All 8 clinically staged T4b patients, after CT remained as stage T4b and took palliative treatment. 3 of them were dead due to disease and 4 patients are alive with disease.

Thus in our study it is evident that CT was more accurate compared to clinical examination for staging oral cancers and altered treatment planning in 19 patients.

In literature it was shown that sensitivity and specificity of CT for mandibular cortical invasion in a study conducted on 49 patients of oral SCC was 96 and 87% [42] and in another study conducted on 51 patients of oral SCC was 100 and 88% respectively[45].

In our study, CT evidence of bone erosion was seen in 27 patients. Out of 27 patients 14 patients underwent surgery and proved to have bone erosion histopathologically.

In 4 surgically treated T4b patients 2 of the tumors involved temporalis muscle alone, at the level of insertion, 1 tumor involved temporalis and masseter muscle and 1 tumor involved temporalis, lateral pterygoid muscles and ramus of mandible below sigmoid notch

Out of 4 patients with T4b disease who underwent surgery, 75% (3) patients are alive without disease after surgery and 25% (1) patients are alive with disease (local recurrence).

Liao et al [9] study conducted on 103 surgically operated T4a and T4b patients (58 patients with T4a and 45 patients with T4b disease) showed that 41.3% of the T4a patients were alive. 46.7% of the T4b patients were alive. Their study was done retrospectively and patient was followed-up for 5 years after surgery where as ours is a prospective study and follow-up period is shorter.

They also showed in their study about the involvement of various components of masticator space (MS components include the ramus of the mandible, masseter, medial & lateral pterygoid and temporalis muscle), including the pterygoid plates in surgical operated T4b patients. Of the 45, T4b patients, 37.8% of the tumors (17 of 45) involved 1 anatomic component, 62.2% tumors (28 of 45) involved multiple components. Five patients had PP invasion, 28 had ramus of the mandible invasion, 26 had masseter and medial pterygoid muscle invasion, 4 had lateral pterygoid muscle invasion, and 3 had temporalis muscle invasion

CONCLUSION

The challenge in management of oral cancers is to identify the site of primary tumor and to know its local extensions into various neck spaces for staging the tumor and for appropriate treatment planning, as different stages of tumor have different treatment options.

Most of our cases were of carcinoma buccal mucosa (71.8 %) followed by carcinoma tongue (10.3%) and lower alveolus (10.3%), showing female preponderance (F:M-2:1), this is probably due to prevalence of tobacco and betel nut chewing in this area.

Most commonly involved anatomically potential face and neck space in locally advanced (T3, T4a & T4b) oral cancers is buccal space (94.9 %), followed by masticator space/ infratemporal fossa (46.2 %) and Submandibular space (43.6 %). CT was 100% sensitive in detecting the bone erosion, was confirmed in 18 patients who underwent surgery.

It is proved that CT is useful over clinical examination for the staging of advanced oral cancers as CT scan helped in accurate staging and treatment planning in 19 patients (out of 39 patients).

Hence, CECT evaluation of neck spaces in locally advanced oral cancers is a superior diagnostic tool in tumor staging and appropriate treatment planning.

SUMMARY

Malignancy of the oral cavity account for about 7.6% of total cancer in India. Many Indians present at late stage of disease by the time of diagnosis. Local anatomical spread of oral cancers into the face and maxilla and further extension into neck spaces is critical for staging of cancers. Cancer staging helps in the treatment of oral cancers. CT is considered the primary modality of investigation as it helps in delineating the size and extent of primary tumor and also helps to evaluate bone involvement.

The aims of the study was to evaluate the usefulness of Multi-detector Computed Tomography in detection of neck spaces involvement in locally advanced oral cancers, which in turn helps in accurate staging of oral cancers in order to accurately determine choice of management - operative versus palliative.

This study was carried out in 39 patients with locally advanced oral cancers from January 2014 to June 2015 at department of Radio diagnosis of R L Jalappa hospital and research Centre, attached to Sri Devaraj Urs Medical college, Tamaka, Kolar. All patients underwent plain and contrast CT neck. MDCT findings were analyzed with regard to location, size and extent of the disease with sixteen slice MDCT scanner (SIEMENS SOMATOM EMOTION 16) and findings were correlated with either clinical follow up or surgical findings.

This study highlighted that buccal mucosa was the most common subsite of oral cancers. The majority of the patients involved were in the elderly age group of 61-70 years with female preponderance probably because of their social and cultural practice of chewing habits (betel nut and tobacco). The most commonly involved neck space was buccal space. CT was 100% sensitive in detecting bone erosion.

The overall CT analysis of neck spaces in this study directed the appropriate management protocols in our patients and successful surgical management of T4b oral cancer patients with involvement of temporalis, masseter, lateral pterygoid muscles and ramus of mandible below sigmoid notch showed good results with more than 50% of patients showing loco-regionally controlled disease after surgery, which were considered to be inoperable as per AJCC, 2002 staging.

In this study, as CT scan helped in accurate staging and treatment planning in 19 patients who were inaccurately diagnosed clinically it is concluded that CT is a superior diagnostic modality in the diagnosis of advanced oral cancers and helps in appropriate management of disease.

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ANNEXURE – I

PROFORMA

Name:

Age:

Sex: Male☐ Female☐

Hospital No:

Chief complaints:

Duration:

Associated with pain: Yes☐ No☐

Ear pain: Yes☐ No☐

Difficulty in opening mouth: Yes☐ No☐

Loose tooth: Yes☐ No☐

Habits: Smoking☐ Tobacco chewing☐ Betel nut chewing☐

Local Examination:

Site: Buccal mucosa☐ Lower-alveolus☐ Upper-alveolus☐

Hard palate☐ Anterior 2/3rd of tongue☐ RMT☐ Floor of mouth☐

Extension to oropharynx: Yes☐ No☐

Bleeds on touch: Yes☐ No☐

Tooth loss: Yes☐ No☐

Lymph nodes status:

Palpable: Yes☐ No☐

CT findings:

Location of the lesion:

Spaces involved

Submental/submandibular space☐ Parotid space☐ Para pharyngeal space☐

Carotid space□ Retro pharyngeal space□ Masticator space/ ITF□

Buccal space□

Bone erosion: Present□ Absent□

CT lymph nodal status:

Number:

Primary Tumor Staging: T3□ T4a□ T4b□

Treatment Given:

Curative□ Surgery+RT

Neoadjuvant chemotherapy□ Surgery + RT/CTRT

Palliative□ CT+ RT□

CT□

RT□

Symptomatic therapy□

Follow Up:

Loco-regionally controlled□

Alive with disease- Local recurrence□ Regional recurrence□

Locoregional recurrence □ Distant metastasis□

Death due to disease□

Death due to other causes□

Lost to follow up□

ANNEXURE – II

INFORMED CONSENT FORM

I, Mr/Miss/Mrs____,

have been invited to participate in Research project titled "**Multi Detector Computed Tomographic evaluation of deep neck spaces in locally advanced oral cancers**". It has been communicated to me in my vernacular language about the purpose of the procedure and the associated possible complications.

My participation in this research project is purely voluntary. I am also aware that I can withdraw from the project at any point of time without citing any reasons whatsoever. Hereby I give my consent by my own free will and in complete consciousness without any influence to participate and co-operate in the study.

Name and Signature/thumbprint.

Name and signature of third person

(in case the participant is illiterate)

ANNEXURE – III

KEY TO MASTER CHART

AWD	Alive with disease
BM	Buccal mucosa
BS	Buccal space
CS	Carotid space
DDD	Death due to disease
DEF	Defaulted treatment
DDOCS	Death due to other causes
F	Female
FOM	Floor of mouth
ITF	Infratemporal fossa
LA	Lower alveolus
LRC	Loco-regionally controlled
M	Male
MS	Masticator space
N	No
P	Palliative
PPS	Parapharyngeal space
PS	Parotid space
PVS	Prevertebral space
RPS	Retropharyngeal space
SMAN	Submandibular space
SMEN	Submental space
T	Tongue
UA	Upper alveolus
Y	Yes

SL N	NAME	HOSPITAL. No	AGE	SEX	ASSOCIATED WITH			HABITS				CT FINDINDS													CLINICAL TUMOR STAGING	CT TUMOR STAGING	TREATMENT GIVEN	FOLLOW-UP
													SPACES INVOLVED								BONE EROSION		LYMPH NDES				
					PAIN	EAR ACHE	LOOSE TOOTH	SMOKING	TOBACCO CHEWING	BEETEL NUT CHEWING	N HABITS	LOCATION OF LESION	SMAN/SMEN	PS	PPS	CS	RPS	MS/ITF	BS	PVS	MANDIBLE	MAXILLA	NUMBER				
1	CHINNAKKA	70905	65	F	N	N	N	N	N	Y	N	BM	Y	N	N	N	N	N	Y	N	N	N	0	T4a	T3	DEF	DDOCS
2	RATHNAMMA	76003	45	F	Y	N	N	N	Y	N	N	BM	N	N	N	N	N	N	Y	N	Y	N	2	T4a	T4a	SUR + RT	LRC
3	RATHNAMMA	80775	60	F	Y	N	N	N	N	N	Y	FOM	N	N	Y	N	N	N	N	N	N	N	2	T3	T3	SUR + RT	LRC
4	MUNILAKSHMAMMA	85294	60	F	Y	N	N	N	N	Y	N	BM	Y	N	N	N	N	Y	Y	N	N	N	3	T4a	T4b	P	DDD
5	AKKALAMMA	153100	67	F	Y	N	Y	N	Y	N	N	LA	Y	N	N	N	N	N	Y	N	Y	N	4	T4a	T4a	SUR + RT	LRC
6	REDDAPPA	98125	40	M	N	N	N	Y	N	Y	N	LA	N	N	N	N	N	N	Y	N	Y	N	3	T3	T4a	SUR + RT + CT	LRC
7	SUFIYA BEE	102294	80	F	Y	Y	N	N	N	N	Y	BM	N	N	N	N	N	Y	Y	N	N	Y	2	T4a	T4b	SUR + RT + CT	LRC
8	RAMAKKA	44811	55	F	Y	N	N	N	Y	Y	N	BM	Y	N	N	N	N	Y	Y	N	Y	N	2	T4b	T4b	P	DDD
9	THIPPAMMA	48507	63	F	Y	N	N	N	Y	Y	N	LA	Y	N	N	N	N	Y	Y	N	Y	Y	3	T4a	T4b	P	AWD
10	THIMMARAJU	46773	41	M	Y	N	N	N	Y	Y	N	LA	N	N	N	N	N	N	Y	N	Y	N	2	T4a	T4a	SUR + RT	LRC
11	RATHNAMMAM	24650	48	F	Y	N	Y	N	N	N	Y	BM	Y	N	N	N	N	Y	Y	N	N	Y	4	T4a	T4b	P	AWD
12	CHOTE MA	987910	60	F	Y	N	N	N	Y	Y	N	BM	N	N	N	N	N	N	Y	N	Y	N	3	T4a	T4a	SUR + RT	DDOCS
13	LAKSHMIDEVAMMA	978491	87	F	Y	N	N	N	N	Y	N	BM	Y	N	Y	N	N	Y	Y	N	Y	Y	3	T4a	T4b	P	DDD
14	VENKATARAMAPPA	5224	70	M	Y	N	N	N	Y	Y	N	BM	N	N	N	N	N	Y	Y	N	N	Y	2	T4b	T4b	P	AWD
15	SONNAPPA	999918	60	M	Y	N	N	Y	N	N	N	BM	N	N	N	N	N	Y	Y	N	N	Y	3	T4a	T4b	P	DDD
16	ANJANAPPA	998486	55	M	N	N	N	N	N	N	Y	BM	N	N	N	N	N	N	Y	N	N	N	1	T4a	T3	SUR + RT	LRC
17	SARANGAPANI	1002042	70	M	Y	N	Y	N	Y	Y	N	BM	N	Y	N	N	N	Y	Y	N	Y	Y	4	T4b	T4b	P	AWD
18	YELLAPPA	1001563	38	M	Y	N	N	N	N	N	Y	BM	Y	N	N	N	N	Y	Y	N	Y	N	3	T4a	T4b	NEOADJCT +SUR	LRC
19	CHIKKA KRISHNAPPA	1003707	64	M	Y	Y	N	Y	N	N	N	T	N	N	Y	N	N	N	N	N	N	N	6	T4b	T4b	P	AWD
20	LAKSHMAMMA	1004604	65	F	Y	N	N	N	Y	N	N	BM	N	N	N	N	N	N	Y	N	Y	N	3	T4a	T4a	SUR + RT	LTF
21	NARAYANAMMA	1018358	40	F	Y	N	N	N	N	N	Y	BM	N	N	N	N	N	Y	Y	N	N	Y	4	T4a	T4b	SUR + RT + CT	AWD
22	AKKAYAMMA	9918	45	F	N	N	N	N	Y	Y	N	UA	N	N	N	N	N	Y	Y	N	N	Y	2	T4a	T4b	SUR + RT + CT	LRC
23	VENKATASWAMY	17818	60	M	Y	N	N	N	N	Y	N	BM	N	N	N	N	N	N	Y	N	N	Y	3	T4a	T4a	SUR + RT	LRC

					ASSOCIATED WITH			HABITS				CT FINDINDS															
													SPACES INVOLVED								BONE EROSION		LYMPH NDES				
SL N	NAME	HOSPITAL. No	AGE	SEX	PAIN	EAR ACHE	LOOSE TOOTH	SMOKING	TOBACCO CHEWING	BEETEL NUT CHEWING	N HABITS	LOCATION OF LESION	SMAN/SMEN	PS	PPS	CS	RPS	MS/ITF	BS	PVS	MANDIBLE	MAXILLA	NUMBER	CLINICAL TUMOR STAGING	CT TUMOR STAGING	TREATMENT GIVEN	FOLLOW-UP
24	GANGULLAM	985005	44	F	Y	N	N	N	Y	N	N	BM	N	N	N	N	N	Y	Y	N	N	N	2	T4b	T4b	P	DDD
25	SHIVANNA	38564	42	M	Y	N	N	N	N	Y	N	BM	N	N	N	N	N	N	Y	N	N	N	3	T4a	T3	SUR + RT	LRC
26	AKKALAMMA	93537	73	F	Y	N	N	N	N	Y	N	BM	Y	N	N	N	N	N	Y	N	Y	N	3	T4a	T4a	DEF	DDD
27	NARASAMMA	30956	65	F	Y	N	Y	N	N	Y	N	BM	Y	N	N	N	N	Y	Y	N	Y	N	2	T4a	T4b	P	DDD
28	MUNIYAPPA	141053	60	M	Y	N	N	N	Y	Y	N	BM	Y	N	N	N	N	Y	Y	N	N	N	2	T4a	T4b	P	LTF
29	CHOWDAMMA	1019507	48	F	Y	N	N	N	N	N	Y	T	N	N	N	N	N	N	Y	N	N	N	2	T3	T3	SUR + RT	LRC
30	PARVATHAMMA	141389	65	F	Y	N	N	N	N	N	Y	BM	Y	N	N	N	N	N	Y	N	N	N	2	T4a	T3	DEF	AWD
31	NIRMALA	149673	47	F	Y	N	N	N	N	Y	N	BM	Y	N	N	N	N	N	Y	N	Y	N	4	T3	T4a	SUR+RT+CT	LRC
32	MUNIYAMMA	141397	70	F	Y	N	N	N	Y	Y	N	UA	N	N	N	N	N	N	Y	N	N	Y	3	T4a	T4a	DEF	LTF
33	PATTI SIDDAPPA	1000694	65	M	Y	N	N	Y	Y	N	N	T	Y	N	Y	Y	N	N	Y	N	N	N	6	T4b	T4b	P	DDD
34	AKBAR BASHA	986014	30	M	Y	Y	N	Y	N	Y	N	T	Y	N	N	N	N	N	Y	N	N	N	3	T4b	T4b	P	AWD
35	VENKATAMMA	68366	50	F	Y	N	N	N	N	Y	N	BM	N	N	N	N	N	Y	Y	N	Y	N	2	T4b	T4b	P	LTF
36	PILLAKKA	50694	55	F	Y	N	N	N	Y	Y	N	BM	Y	N	N	N	N	Y	Y	N	Y	Y	6	T4a	T4b	P	LTF
37	RAJAMMA	66479	47	F	Y	N	N	N	N	Y	N	BM	N	N	N	N	N	Y	Y	N	N	Y	2	T4a	T4b	P	AWD
38	MUNIYAMMA	63075	72	F	Y	N	N	N	N	Y	N	BM	Y	N	N	N	N	N	Y	N	Y	N	3	T4a	T4a	SUR + RT	DDOCS
39	JAYAMMA	77179	58	F	N	N	N	N	N	N	Y	BM	N	N	Y	N	N	N	Y	N	Y	N	4	T4a	T4a	SUR + RT	DDOCS