OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

MANDIBULECTOMY FOR CANCERS OF RETROMOLAR TRIGONE, INFERIOR ALVEOLUS AND MANDIBLE

Johan Fagan

Squamous cell cancers (SCC) of the inferior alveolus and retromolar trigone (RMT) are treated with primary surgery. Postoperative (chemo)radiation therapy is given for advanced T stages, perineural invasion, close or involved margins, bone involvement, multiple cervical nodes or extranodal extension.

Because of the proximity of these cancers to the bone, patients generally need marginal, segmental, or hemimandibulectomy to achieve clear resection margins.

When resecting mandible, surgeons must consider how best to preserve oral function such as speech, mastication, oral transport and swallowing. Resecting mandible beyond the midline for an alveolar SCC such as in *Figure 1*, is only advisable if one reconstructs the anterior mandibular arch a to avoid an *Andy Gump* deformity with loss of oral competence, drooling, and a poor cosmetic result *(Figure 2)* and reattaches the suprahyoid muscles (digastric, geniohyoid, mylohyoid, genioglossus).

Figure 1: SCC approaching midline of inferior alveolus

Readers are referred to chapters on cancers of the buccal mucosa, floor of mouth and oropharynx given the proximity of these regions to the mandible, and the chapter on dental extraction, as well as reconstructive surgery procedures listed at the end of this chapter.

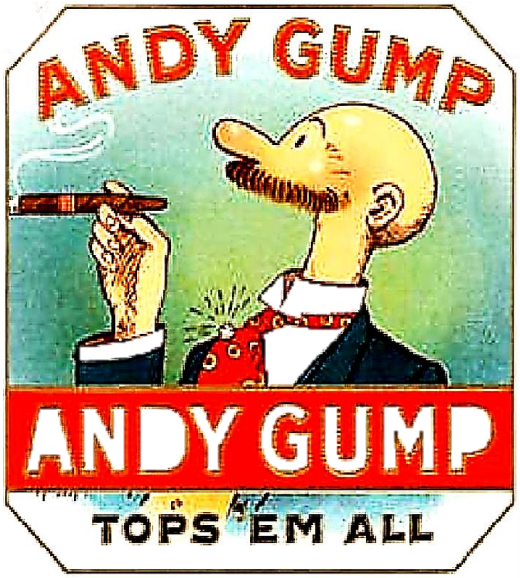


Figure 2: Andy Gump deformity

Surgical anatomy of the mandible

The mandible articulates with the skull base at the temporomandibular joints. A number of muscles that attach to the mandible and the complex mechanism of the temporomandibular joint allow movement of the jaw and ensure accurate dental occlusion. Knowledge of the surgical anatomy of the mandible and its associated muscles, nerves and blood supply is therefore important not only for oncological, but also for functional outcomes.

Bone anatomy

The ***horizontal ramus / body*** of the mandible is the U-shaped part of the mandible that extends between its 2 angles. The horizontal rami meet in the midline at the ***symphysis*** marked externally by the ***mental protuberance*** *(Figures 3a, b).*

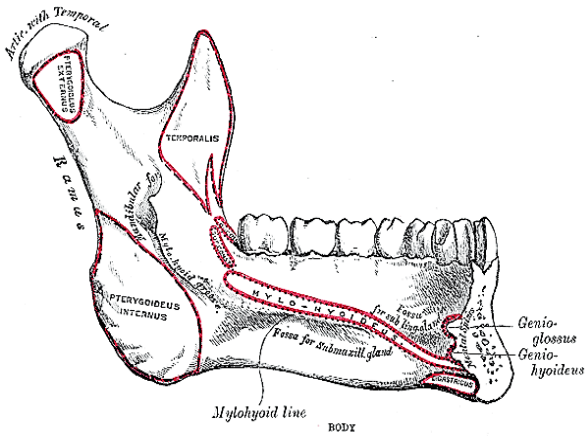


Figure 3a: Attachments of mylohyoid, geniohyoid, genioglossus, digastric, medial and lateral pterygoid, and temporalis muscles to inner aspect of mandible

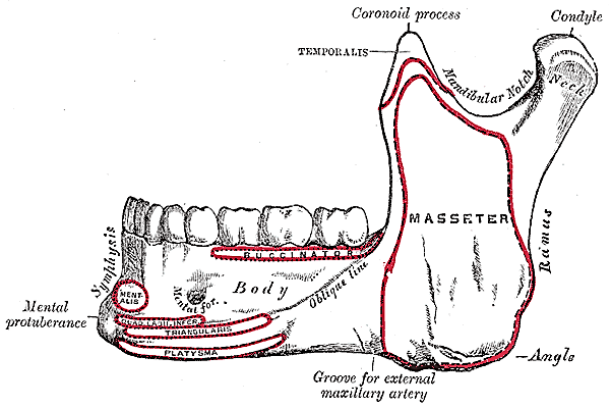


Figure 3b: Attachments of muscles to outer aspect of mandible and location of mental foramen

The superior part of the horizontal ramus is the ***alveolar bone*** which contains the dental sockets and is covered by mucoperiosteum called the ***gingiva***.

When planning for a possible marginal mandibulectomy, the ***height of the body of the mandible,*** the ***depth of the dental roots*** *(Figures 2a, b)* and the ***position of the mandibular canal*** must be carefully assessed.

The ***mandibular canal (inferior alveolar canal)*** traverses the body of the mandible and is clearly visible on a Panorex (Orthopantomogram) Xray or CT scan *(Figure 4)*. The ***inferior alveolar nerve, artery*** and ***vein*** enter the ***inferior alveolar canal*** at the ***mandibular foramen*** and exit the canal anteriorly at the ***mental foramen*** *(Figure 3b)*.

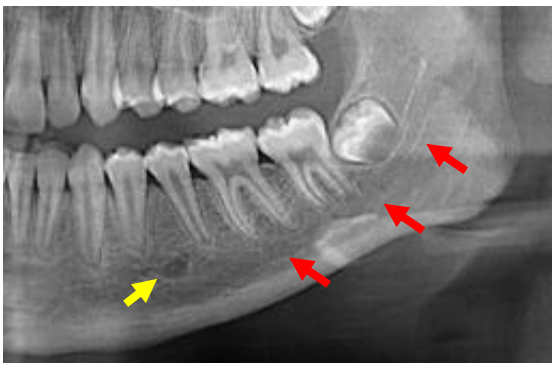


Figure 4: Mental foramen (yellow arrow) and mandibular canal (red arrows)

The ***mental foramen*** is located midway between the upper and lower borders of the mandibular body, most commonly between the 1st and 2nd second premolars *(Figures 3b, 4)*. The mental foramen and inferior alveolar nerve may be very close to the superior surface of a ***resorbed mandible*** such as is seen in older, edentulous patients *(Figure 5)*. A marginal mandibulectomy may not be possible in such cases due to the lack of residual bone.

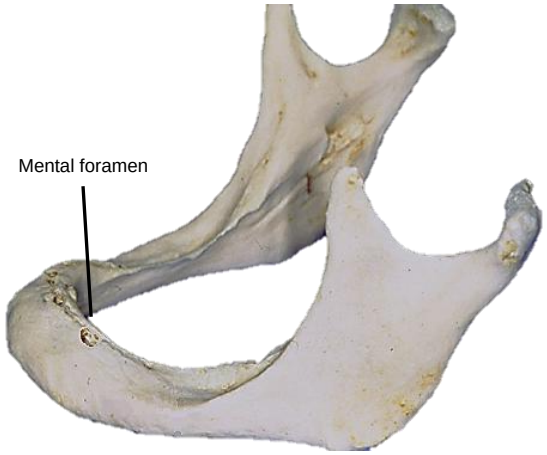


Figure 5: Superficial position of mental foramen in a resorbed mandible

The ***mylohyoid line*** runs obliquely along the lingual surface of the horizontal ramus

and marks the ***attachment of the broad, flat mylohyoid muscle*** that forms the diaphragm of the mouth *(Figure 3a, 6)*; it starts just below the third molar and runs antero-inferiorly.

Below the central part of the mylohyoid line is the ***submandibular fossa*** that contains the superficial part of the submandibular gland *(Figure 3a)*. To either side of the midline are the ***sublingual fossae*** *(Figure 3a).* They are located above the mylohyoid line and contain the sublingual glands.

On the lingual surface of the mandible anteriorly are ***four genial tubercles***, which serve as attachments for the ***genioglossus*** (superiorly) and ***geniohyoid*** muscles (inferiorly) *(Figures 3a, 6, 7).*

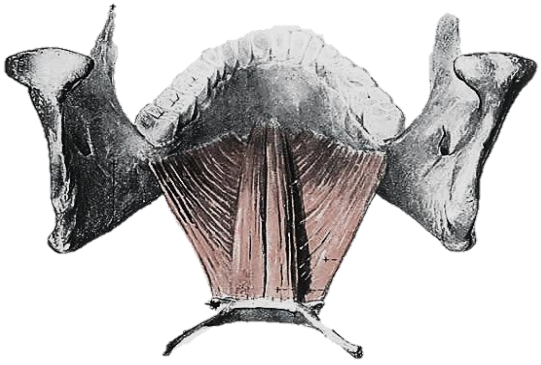


Figure 6: Geniohyoid and mylohyoid

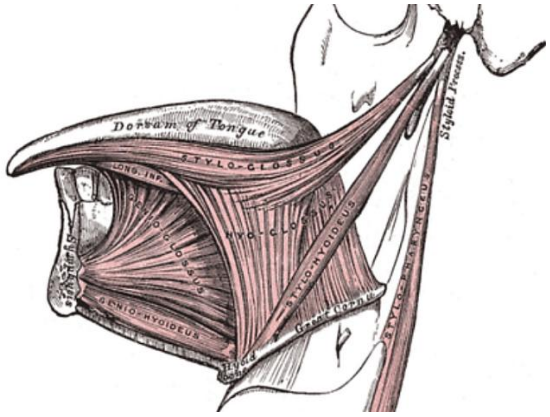


Figure 7: Attachment of geniohyoid and genioglossus muscles to genial tubercles

Note the line of attachment of the ***buccinator muscle*** on the buccal aspect of the horizontal ramus along the inferior edge of the alveolar bone *(Figure 3b)*, and the attachment of the ***anterior belly of digastric*** *(Figure 3b)*.

The ***vertical ramus*** of the mandible extends superiorly from the angle *(Figures 3a, b, 8)*. The ***mandibular foramen*** is located on the medial surface of the vertical ramus midway between its anterior and posterior borders at the level of the occlusal surfaces of the lower teeth. The inferior alveolar nerve and vessels pass through the foramen to enter the mandibular canal. The ***lingula*** is a small bony extension that overlies the anterior part of the mandibular foramen to which the ***sphenomandibular ligament*** attaches *(Figure 8)*.

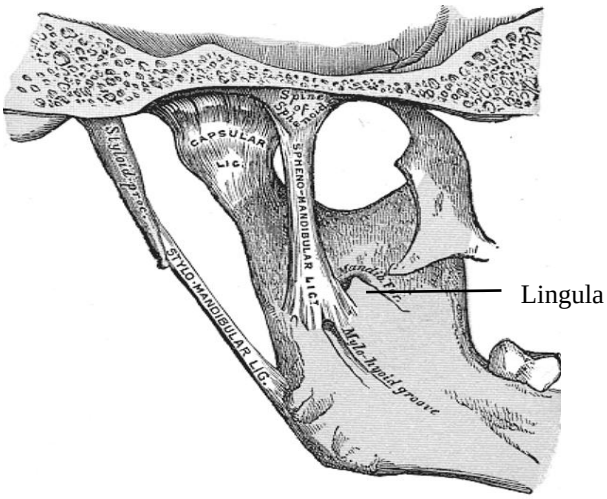


Figure 8: Vertical ramus with sphenomandibular and stylomandibular ligaments, and the lingula obscuring the mandibular foramen

The ***coronoid process*** is located anteriorly at the superior end of the vertical ramus. The ***temporalis muscle*** and ***masseter*** insert on the medial and lateral surfaces of the coronoid process *(Figures 3a, b, 9)*. The ***mandibular notch*** separates the coronoid process from the ***mandibular condyle***.
The ***mandibular condyle*** forms the temporomandibular joint with the ***mandibular***

fossa of the temporal bone, separated by a biconcave fibrocartilaginous ***articular disc*** *(Figure 3a, b, 11).*

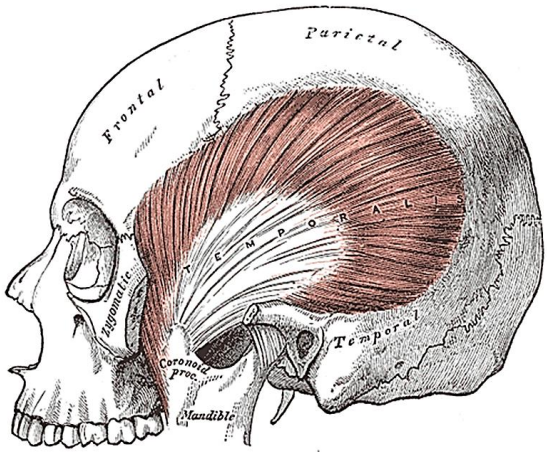


Figure 9: Temporalis muscle inserts into coronoid and anteromedial surface of vertical ramus of mandible

Muscle anatomy

Muscles that may be encountered when resecting mandible for oral cancer include the ***digastric, mylohyoid, buccinator, geniohyoid, genioglossus, masseter, temporalis, and medial and lateral pterygoids.***

The ***anterior belly of digastric*** inserts on the inferior aspect of the mandible anteriorly *(Figure 3a)*. The anterior belly is innervated by V_3, and the posterior belly by VII.

The ***mylohyoid*** muscle is the "diaphragm" of the mouth and separates the oral cavity from the neck. It is transected along the medial margin of the mandible when resecting mandible or doing a mandibular swing approach to the oropharynx *(Figures 3a, 6)*. It is innervated by V_3.

The ***genioglossus*** and ***geniohyoid*** muscles attach anteriorly to the mandible by the genial tubercles close to the midline *(Figures 3a, 6, 7)*. The genioglossus is innervated by XII), and the geniohyoid is innervated by fibres from the 1st cervical spinal nerve travelling with the XII nerve.

The ***buccinator*** muscle is just deep to the buccal mucosa and attaches to the length of the horizontal ramus at the junction between the alveolus and the body of the mandible *(Figure 3b, 10)*. It is innervated by VII.

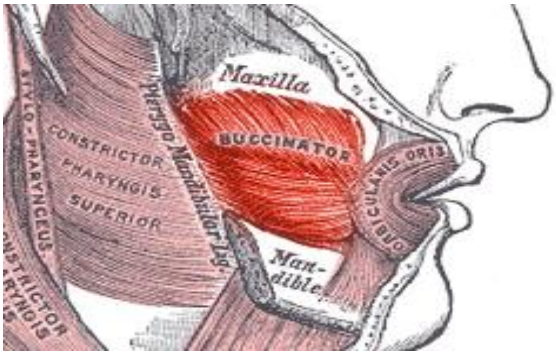


Figure 10: Buccinator muscle inserts alveolar processes of mandible and maxilla

Dissecting along the lateral surface of the mandible, one encounters the ***masseter muscle*** *(Figures 3b, 11)*. It is a thick quadrilateral muscle with superficial and deep portions, the fibers of which insert onto the lateral aspect of the vertical ramus of the mandible. Both the superficial and deep portions arise from the zygoma. Laterally the muscle is in contact with the parotid gland and branches of the VIIn. It is innervated by V_3.

The next muscle one encounters as one dissects along the lateral surface towards the coronoid process of the mandible is the ***temporalis muscle*** *(Figures 3a, b, 8)*. The muscle arises from the temporal fossa and temporalis fascia and passes behind the zygomatic arch to insert onto the coronoid process and anteromedial surface of the vertical ramus *(Figures 3a, b, 8)*. It is innervated by V_3. It receives its blood supply from the deep temporal arteries; preserving these arteries is crucial if a temporalis muscle flap is to be used to reconstruct a surgical defect.

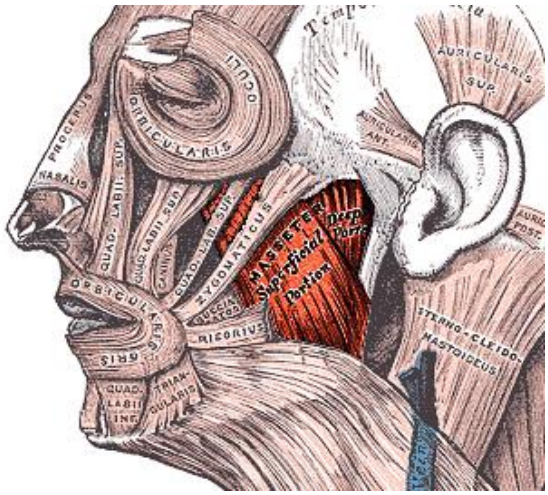


Figure 11: Masseter

The next muscle along the medial aspect of the mandible is the ***medial pterygoid*** *(Figures 3a, 12)*. It has two heads *(Figure 12)*: the larger deep head arises from just above the medial surface of the lateral pterygoid plate; the smaller superficial head arises from the maxillary tuberosity and the pyramidal process of the palatine bone *(Figure 12)*. The muscle passes inferolaterally to insert onto the inferomedial surface of the ramus and angle of the mandible *(Figures 3a, 12)*. It is innervated by V_3.

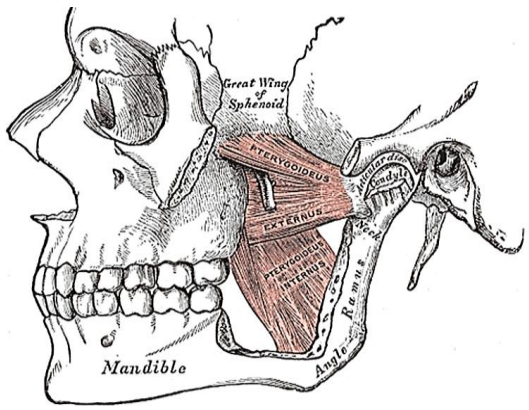


Figure 12: Medial and lateral pterygoids; the 2nd part of the internal maxillary artery passes either superficial or deep to the lateral pterygoid

The final muscle that may be encountered if the condyle is included in the mandibulectomy is the ***lateral pterygoid***; its superior head originates from the infratemporal surface and crest of the greater wing of the sphenoid, and its inferior head from the lateral surface of the lateral pterygoid plate *(Figure 3a, 12)*. It inserts onto the neck of mandibular condyle and the articular disc and capsule of the temporomandibular joint. It is innervated by V_3. The 2nd part of the ***internal maxillary artery*** passes either superficial or deep to the lateral pterygoid *(Figures 12, 14)*.

Vascular anatomy

Three arteries and their branches supply the mandible *i.e.* ***inferior alveolar, facial*** and ***lingual***. Care should be taken to preserve the blood supply to the mandible by avoiding unnecessary stripping of muscle and soft tissue from the bone to reduce the risk of osteoradionecrosis and to maximise the chances of bony union of a microvascular free bone flap to the mandible.

The ***inferior alveolar artery*** is responsible for most of the perfusion of nerves, gingiva, and teeth of the mandible. The ***mylohyoid artery*** branches from the inferior alveolar artery just before it enters the mandibular foramen. It is encountered when elevating the submandibular gland from the lateral surface of the mylohyoid; it crosses the mylohyoid and then disappears anteriorly behind the digastric *(Figures 13, 14)*.

The ***facial artery*** supplies the mandible via its ***submental branch*** that courses along the inferior, inner margin of the mandible. It is the artery that the submental artery island flap is based on *(Figure 13)*.

The ***lingual artery*** supplies the mandible via its ***sublingual*** branch.

These vessels are all interconnected; the ***mylohyoid artery*** has connections with the ***submental artery***, and via a defect in the mylohyoid with the ***sublingual artery*** in the floor of the mouth.

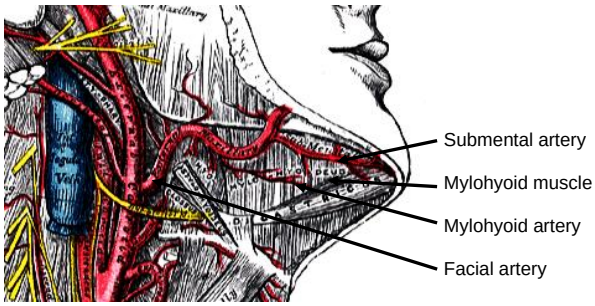


Figure 13: Facial artery emerges from behind posterior belly of digastric (removed), and gives rise to a few branches including submental artery

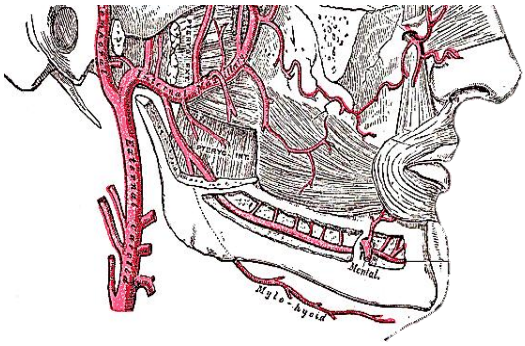


Figure 14: Mylohyoid artery is a branch of the inferior alveolar artery

Nerve anatomy

The ***lingual nerve*** originates from V_3 after it exits from *foramen ovale (Figure 15)*. From its origin from V_3 it courses inferiorly, passing between the medial pterygoid muscle and the inner aspect of the vertical ramus of the mandible where it gives off the ***inferior alveolar nerve*** that enters the mandibular foramen *(Figures 15, 16)*. The lingual nerve continues inferiorly just below the mucosa of the posterolateral floor of mouth (FOM), remaining above the mylohyoid muscle *(Figure 16)*, The nerve crosses deep to the submandibular duct in the lateral FOM; in the anterior FOM it is located posterior to the duct *(Figures 15, 17)*. It provides sensory innervation to the floor of the mouth and oral tongue. It is important to look out for and attempt to preserve the lingual nerve when resecting tumours in the retromandibular trigone, FOM and tonsil regions. ***The nerve is most at risk of surgical injury in the postero-lateral floor of mouth when resecting mandible.***

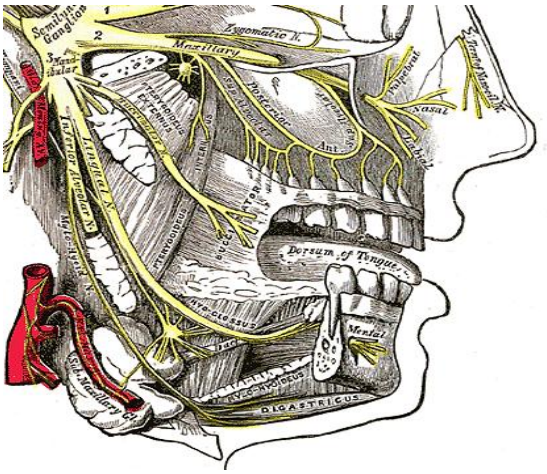


Figure 15: V3, lingual, inferior alveolar and mental nerves

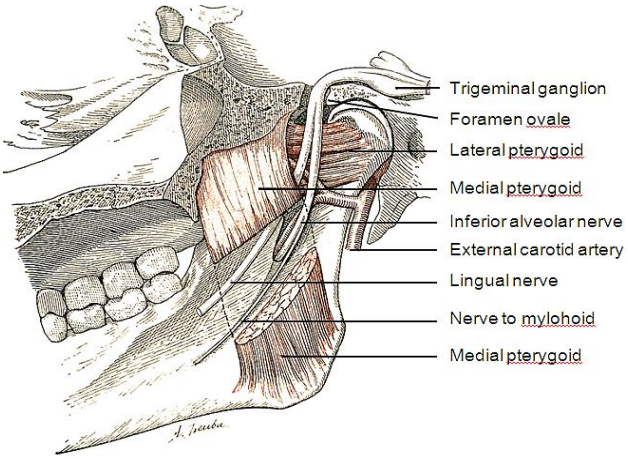


Figure 16: Anatomical relations of medial pterygoid, lingual nerve, inferior alveolar nerve as viewed from oral aspect of right mandible

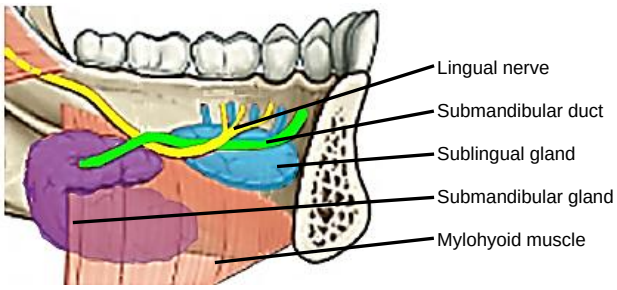


Figure 17: Intraoral view of lingual nerve sublingual gland, submandibular gland and duct, and mylohyoid muscle

The ***inferior alveolar nerve*** and its accompanying vessels enter the mandibular/inferior alveolar canal at the ***lingula*** and innervates the inferior alveolus, gums and teeth. It exits the canal at the mental foramen as the ***mental nerve*** that provides sensory innervation to the anterior buccal mucosa, lower lip, and skin of the chin ventral to the foramen. The inferior alveolar nerve is transected whenever a segmental mandibulectomy is done and should be preserved (if possible) when doing a mandibulotomy for access by placing the osteotomy anterior to the mental foramen.

Retromolar trigone

The ***retromolar trigone (RMT)*** is a triangular area overlying the horizontal ramus of the mandible behind the last molar tooth *(Figure 18)*.

Figure 18: Retromolar trigone

It extends up the face of the vertical ramus of the mandible. ***Because of its location, SCC of the RMT is prone to invade mandibular periosteum and bone as well as medial pterygoid, masseter, and temporalis muscles, and the lingual and inferior alveolar nerves***. Therefore, careful assessment of all these anatomical structures is important to plan surgery. The presence of trismus, indicating muscular involvement, and sensory change in the distributions of the lingual and inferior alveolar nerves are important to note. Marginal or segmental mandibulectomy is generally required to achieve clear margins.

Key Questions

1. ***Are there synchronous primaries, or cervical or distant metastases?***

2. ***Is the tumour resectable?*** Pointers to unresectability include ***trismus*** due to invasion of the muscles of mastication, proximal ***PNI of V3*** to the foramen ovale or to trigeminal ganglion, and extension posteriorly to involve the ***carotid sheath***. Another key consideration is ***surgical morbidity***; this in turn is dependent on the range and reliability of reconstructive surgery that is available e.g. resection of the mandible beyond the midline can only be done if it is possible to reconstruct the bone to avoid an Andy Gump deformity with *e.g.* a free fibula flap or composite pectoralis major osteomyocutaneous flap incorporating 5th or 6th ribs *(Figure 3).*

3. ***Is there clinical evidence of perineural invasion (PNI)?*** Examine the patient for neurological deficits of the mental, inferior alveolar and lingual nerves. Involvement of the ***lingual nerve*** requires detailed assessment of the rest of the trigeminal nerve to determine the extent of PNI and resectability. This requires assessment of the rest of V3 as well as V2 and V1 for involvement also of the trigeminal ganglion. MRI should be requested to determine the extent of PNI. Should there be evidence of PNI then the affected nerve should be dissected proximally towards *foramen ovale* until a clear margin is obtained on frozen section, and a Liga

clip placed on the nerve stump for targeted radiotherapy. With PNI of the ***inferior alveolar nerve***, the alveolar canal may be widened on Panorex *(Figure 19)*. Surgery requires a hemi- or segmental mandibulectomy that encompasses the entire inferior alveolar canal and extends anteriorly to include the mental foramen to ensure clear nerve margins.

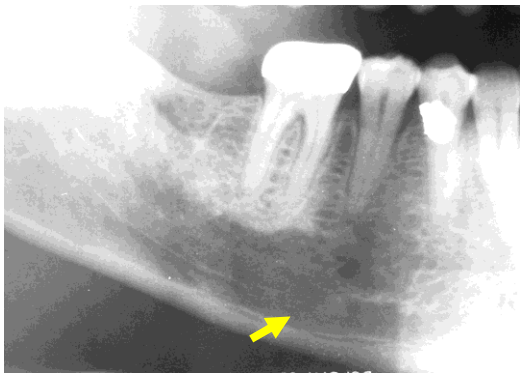


Figure 19: Widening and destruction of mandibular canal in patient with perineural invasion of inferior alveolar nerve

4. ***State of dentition?*** Carious teeth seen on Panorex may be removed before or at the time of the surgery (see chapter on dental extraction) to avoid osteoradionecrosis.

5. ***Mandible:*** Cancers involving the mandible require adequate oncological margins and may require osseous flap reconstruction. Cancers may involve periosteum, or invade only the bony cortex, or involve the medullary bone. Tumours involving only the alveolar mucosa adjacent to mandible but not invading bone, or eroding cortex only, require only a marginal mandibulectomy, whereas frank invasion of mandible with involvement of the medulla requires segmental resection.

   Risk factors for tumour invasion of the mandible include size, site, and depth of invasion of the soft tissues; larger and deeper tumours are more likely to invade the mandible. The pattern of spread within bone is related to tumour extent, rather than anatomic factors providing potential routes and barriers to tumour spread [1]. Tumours enter the mandible at points of abutment (often junction of attached and reflected mucosa in both dentate and edentulous mandibles) rather than preferentially through the occlusal surface, neural foramina, or periodontal membranes. The presence or absence of teeth does not influence patterns of invasion, and increased height of alveolar bone in dentate jaws does not delay invasive patterns of bone involvement [1]. Resistance of bone to tumour spread may be reduced in previously irradiated bone, making segmental mandibulectomy more appropriate [1].

   There are ***two patterns of tumour invasion of the mandible*** [1]***;*** with an ***invasive pattern***, fingers and islands of tumour advance independently into the cancellous spaces with little osteoclastic activity and no intervening connective tissue; with an ***erosive pattern***, tumour advances over a broad front with a connective tissue layer and active osteoclasts separating tumour from bone. An erosive pattern can progress to an invasive pattern, depending on the extent and depth of invasion. An invasive pattern is associated with a significantly higher local recurrence rate and lower 5-year disease specific survival [2].

   Panorex is inexpensive and provides an excellent view of the body, ramus, and inferior alveolar canal *(Figures 20, 21)*. It has 80-92% sensitivity and 72-88% specificity for invasion of mandible [3,4]. The overlying spine can obscure the symphyseal region, and it may be difficult to differentiate between perio-

dontal disease and tumour erosion. ***CT scan*** *(Figure 22)* has a sensitivity of 40-60%, and specificity of 89-100% specificity, while ***MRI*** has 56-94% sensitivity and 73-100% specificity [1].

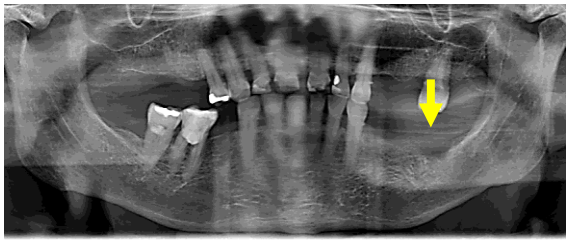


Figure 20: Panorex view of superficial erosion suited to marginal mandibulectomy

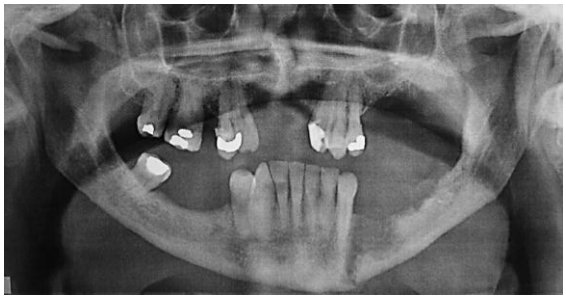


Figure 21: Panorex view of erosion and pathological fracture and poor dentition

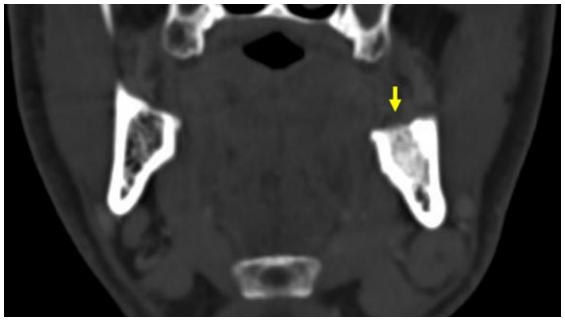
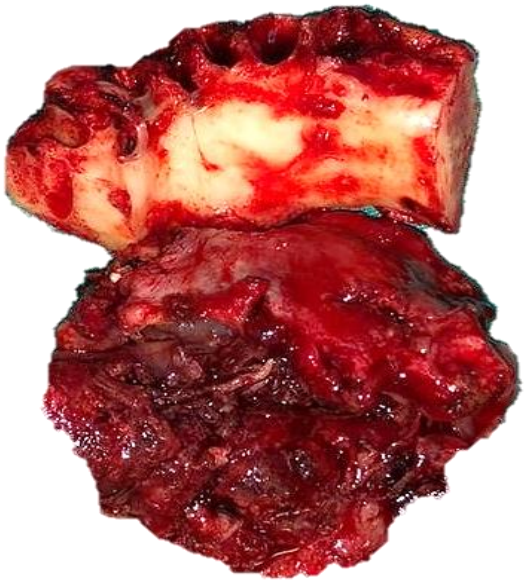


Figure 22: CT illustrating invasion of medullary bone requiring segmental mandibulectomy

When doubt exists about cortical bone erosion, a surgeon may elect to do ***subperiosteal stripping*** of tumour off the bone at the time of resection to inspect the bone for evidence of tumour invasion and to decide how to proceed. Periosteal stripping is easily done using a periosteal elevator and is the most accurate method to determine bone erosion. It has a sensitivity of 96% and specificity of 65%.[3] *(Figure 23)*



Figures 23: Periosteal stripping reveals normal bone and suitability for marginal mandibulectomy

Indications for bone resection include preoperative clinical or radiographic findings of mandibular involvement; or if tumour is adherent to mandible even if radiographic invasion is absent. Intraoperative periosteal stripping can be done for evidence of bone invasion as the extent of the invasion will dictate whether a marginal or segmental resection is indicated.

Marginal mandibulectomy is indicated for cancers encroaching on, adherent to, or superficially invading mandibular cortex; gingival carcinoma with superficial bone invasion at the level of the dental alveolus; and for cortical invasion, but ***only if 1-1,5cm height of the lower contour of remaining mandible can be retained***. Therefore, it is important to determine the vertical height of the mandible clinically or by

Panorex to predict whether a free bony composite flap would be required to onlay onto the remaining mandible to avoid it fracturing, or whether segmental mandibulectomy should be done.

Segmental mandibulectomy is indicated for medullary invasion; intra-alveolar SCC (arising from dental root and often misdiagnosed as primary dental pathology); previous radiation therapy; to maintain an oncological safety margin of soft tissue in more deeply invading tumours; and if inadequate bone would remain if marginal mandibulectomy is done. With segmental mandibulectomy, ***resection margins*** of at least 1-2cm of uninvolved bone from the edge of macroscopic tumour or bone involvement is required. This may require removal of teeth on either side of the tumour in dentate patients. Some surgeons include the entire nerve bearing segment when bone marrow invasion is present.

6. ***What type of reconstruction is required?*** This can sometimes only be determined once the resection has been done and the defect assessed.

7. ***Is a tracheostomy required****?* This is a judgement call by the surgeon. However, whenever the anterior mandibular attachments of the mylohyoid, geniohyoid and genioglossus muscles are lost, and especially when a flap is used to reconstruct a FOM defect, the patient is at risk of airway obstruction and should have a temporary tracheostomy.

Preoperative workup

History

- Duration of symptoms
- Pain referred to ear
- Trismus
- Sensory changes in lingual and inferior alveolar nerve distributions
- Risk factors e.g. smoking, alcohol (HPV not relevant in oral SCC)

Past medical history

- Previous SCC in head and neck
- Previous radiation to head and neck as it may modify treatment strategy
- Past surgery, trauma to legs, or claudication that may affect use of free fibula flap
- Medical fitness for surgery or CRT
- Alcoholism and substance abuse (withdrawal syndrome)

Mental and social status

- Overcoming challenges related to swallowing and speech
- Social support
- Type of employment
- Financial means to undergo treatment and deal with sequelae of treatment

Physical Examination

- If pain or trismus hinders assessment, administer morphine before examining the oral cavity and oropharynx
- ***Local extent*** of cancer
  - Posterior margin
    - Oropharynx
    - Masticator space (trismus))
  - Lateral (buccal) margin
  - Medial (Floor of mouth)
  - Mandible: Tumour mobile/adherent /invading
  - Invasion of major nerves

        - Lingual nerve (sensation of anterior tongue and FOM)
        - Inferior alveolar nerve (gum, teeth and mental nerve)
        - Other divisions of trigeminal
- ***Mandible***
    - Thickness/height: Thin mandible precludes marginal mandibulectomy and requires segmental mandibulectomy and free fibula flap
    - State of dentition for postoperative radiation
- ***Neck***
    - Nodal metastases
    - Previous surgery and scars that may affect surgery
- ***Synchronous primaries*** in oral cavity, pharynx, and larynx?
- ***Donor sites for flaps***
    - Free fibula (peripheral vascular disease or leg vein harvest)
    - Radial free forearm flap
    - Anterolateral thigh flap
    - Pectoralis major +/- rib
- ***General health***
    - Nutrition
    - Cardiovascular
    - Respiratory
    - Mental

Imaging

- ***Chest Xray / CT scan***
    - Metastases
    - Synchronous lung primary
    - Pulmonary and cardiac status
- ***Dentition: Panorex*** *(Figure 19)*
    - Extract/rehabilitate teeth prior to radiation (see chapter on dental extraction)
    - To plan mandibulotomy placement
- ***Mandible: Panorex and/or CT***
    - ***Bone invasion?*** *(Figures 19-22)*
    - ***Pathological fracture?*** *(Figure 21)*
    - ***Depth of invasion?*** If invasion extends beyond mandibular cortex into medullary bone, then segmental mandibulectomy required *(Figures 21, 22)*
    - ***CT scan*** if concern that mandible invaded despite normal Panorex *(Figure 22)*
    - ***Perineural invasion*** of inferior alveolar nerve may cause widening or destruction of inferior alveolar canal *(Figure 19)*
    - ***Vertical height of mandible body***
        - Is marginal mandibulectomy possible?
        - If too little bone then segmental mandibulectomy required
    - ***Placement of mandibulotomy cuts***
        - For cancer resection
        - For mandible reconstruction
    - ***CT scans for virtual surgical planning-guided mandibular reconstruction*** (if available / affordable)
- ***CT scan head and neck (Not always)***
    - Not for occult cervical metastases if elective neck dissection to be done anyway
    - Ipsilateral elective neck dissection is always required, other than for very early T1 cancers, and would be done anyway when microvascular free flap reconstruction is done for soft tissue or bony reconstruction
- ***MRI (Not always)***
    - Invasion of muscles of mastication
    - Clinical evidence of invasion of lingual or inferior alveolar nerves to determine proximal and distal extent of PNI
    - Extent of marrow space invasion
- ***PET-CT***
    - Not routinely required
    - To exclude distant metastases

Contraindications to Surgery

- ***Patient factors***
    - Medically unfit
    - Very malnourished

    - Inability to overcome challenges related to perioperative management
    - Inadequate social support
    - Unable to complete adjuvant radiation therapy
- ***Tumour factors***
    - Unable to achieve clear margins (especially with salvage surgery)
    - Distant metastases
- ***Surgical factors***
    - Inadequate surgical expertise
    - Inadequate reconstructive expertise

Preoperative Preparation

- ***Evaluation by***
    - Oncologic surgeon
    - Oncologist
    - Reconstructive surgeon
    - Speech and swallowing therapy
    - Anaesthesiology
- ***Optimise nutrition***
- ***Postoperative high care***

Anaesthesia

- Insert nasal endotracheal tube opposite to the cancer to ensure unobstructed access to the oral cavity
- The surgeon must be present during induction if a patient has trismus or with bulky cancers that may make it difficult or impossible to intubate
- Inject local anaesthetic in preparation for a possible emergency tracheotomy or cricothyrotomy if concern about being able to intubate a patient
- Should the anaesthetist be unable to intubate the trachea, the surgeon may have to intubate with an operating laryngoscope or do an emergency tracheostomy or cricothyroidotomy
- A tracheostomy is done during the course of the operation if there are concerns about potential postoperative airway compromise due to bleeding, soft tissue swelling, or a bulky flap
- Insert a nasogastric tube for postoperative feeding
- Position the anaesthetic machine at the foot of the table to create space for the surgeons around the head of the patient
- Do not paralyze the patient to facilitate finding and preserving the spinal accessory and marginal mandibular nerves
- Optimize conditions for a free microvascular tissue transfer flap by regulating core temperature, hydration, and haemoglobin

Antibiotic prophylaxis

- Clean contaminated surgery
- Antibiotics therefore administered at induction of anaesthesia and continued for 24 hours
- Common choices
    - Amoxicillin-clavulanate
    - Cephalosporin and metronidazole
    - Clindamycin

Positioning

- Surgery is done with the patient supine, and with neck extended
- The lower face, neck, and selected donor site for the flap are cleaned and draped
- Position the patient so that both the resection and reconstruction teams can work simultaneously to reduce the length of the surgery
- With free fibula reconstruction, the opposite leg is used if the skin paddle is to be placed intraorally

Equipment to have available

- Head and neck cancer surgery set
- Dental extraction set
- Oscillating saw and osteotomes for marginal mandibulectomy or for osteotomies

- Gigli saw (if oscillating saw not available) *(Figure 23)*
- Mandibular plating set (if required)
- Power drill
- Tracheostomy tubes and anaesthetic tubing

Figure 23: Gigli saw

- Microvascular reconstructive surgery
  - Microvascular instrument set
  - Microvascular sutures
  - Liga clips
  - Heparin-saline solution
  - Operating loupes and/or operating microscope
  - Tourniquet (if free fibula or radial forearm flaps used)

Surgical approaches

Good surgical access is essential to achieve adequate resection margins, to control bleeding, and for reconstruction. A combination of surgical approaches can be used. Access depends on the location of the tumour, dentition, and the ability to widely open the mouth under anaesthesia, and what surgical procedure is to be done. ***Level 1 of the neck should first be dissected*** before proceeding to address the primary tumour if neck dissection is indicated.

Transoral marginal mandibulectomy

- Transoral access varies considerably
- Edentulous patients are generally better suited to transoral marginal mandibulectomy; if dental extractions are needed, they should therefore be done before the resection
- Take care not to injure the lips with the oscillating saw or diathermy
- Open the mouth either with a dental bite block *(Figure 24)*, or a self-retaining retractor, taking care to protect the teeth from injury*)*, or a tonsil gag, or Dingman retractor *(Figure 24)*.

Figure 24: Dental bite block is interposed between lateral teeth to keep mouth open

Figure 25: Dingman retractor

- Resect the tumour with at least a 1cm margin of normal tissue with electrocautery (Bovie).
- It may be useful to bend the saw blade at an angle for the marginal mandibulectomy *(Figure 26).*

Figure 26: Bent tip of saw blade

Lip split with cervicofacial flap

This affords ***excellent access*** to the entire lateral aspect of the mandible. It does however leave an unsightly facial scar; may cause deformity of the lower lip; and requires transection of the mental nerve for lateral mandibular exposure.

- Inject local anaesthetic with adrenaline into the midline of the lower lip
- Complete Level 1 of the neck dissection *(Figure 27)*
- Score or tattoo the vermillion border of the lip to ensure accurate repair *(Figure 27)*
- Divide the lower lip vertically in the midline *(Figure 28, 29)*
- Control bleeding from the inferior labial artery with bipolar cautery
- Incise the gingivolabial and gingivobuccal mucosa >0.5cms from the bone to leave a cuff of soft tissue on the bone for subsequent soft tissue closure *(Figure 30)*
- Strip soft tissue off the mandible with monopolar cautery or with a periosteal elevator stopping just short of the mental foramen

Figure 27: Skin incisions for combined lip split and selective neck dissection approach

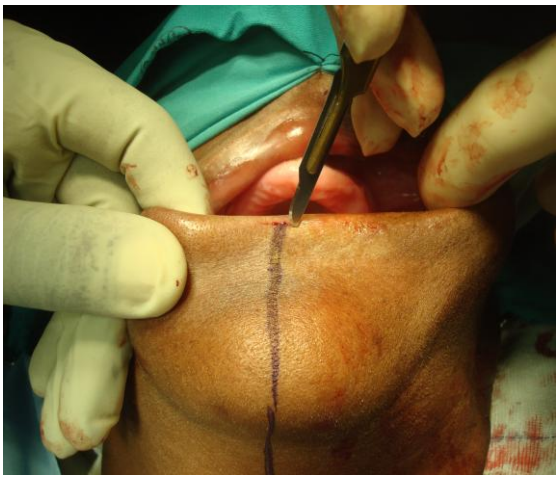


Figure 28: Score the vermillion border

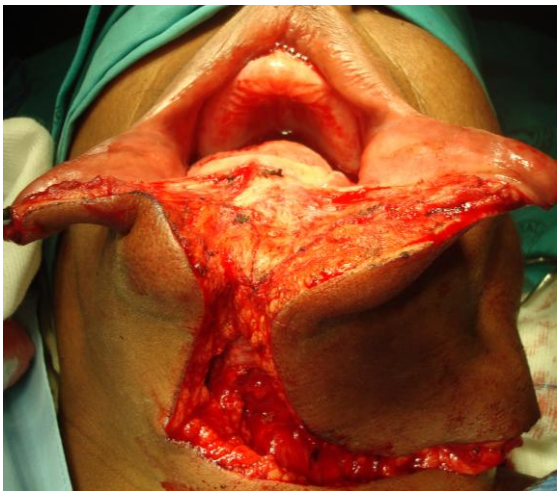


Figure 29: The lower lip is divided vertically in the midline

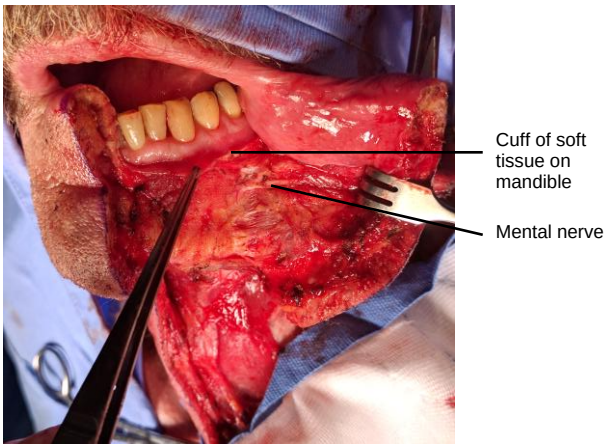


Figure 30: Mental nerve and cuff of soft tissue

- If additional exposure of the mandible is required, divide the mental nerve and artery where they exit the foramen with cautery and continue to expose mandibular horizontal ramus *(Figure 30)*
- If the vertical ramus also must be resected, strip masseter off the bone with electrocautery (unless involved by cancer) *(Figure 31)*
- This exposure can be continued posterosuperiorly to expose the coronoid process, mandibular notch and mandibular condyle *(Figure 32)*

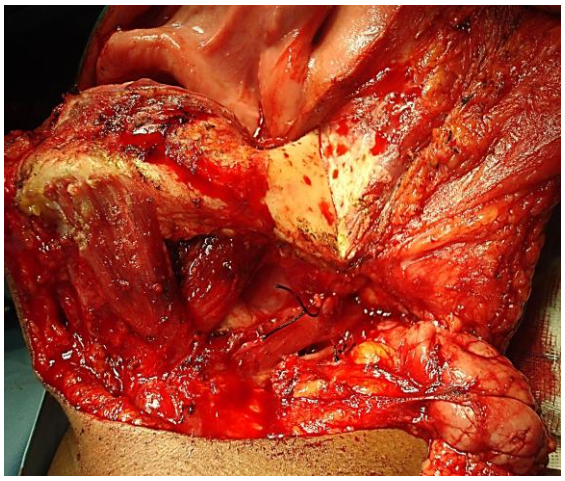


Figure 31: Stripping masseter off bone

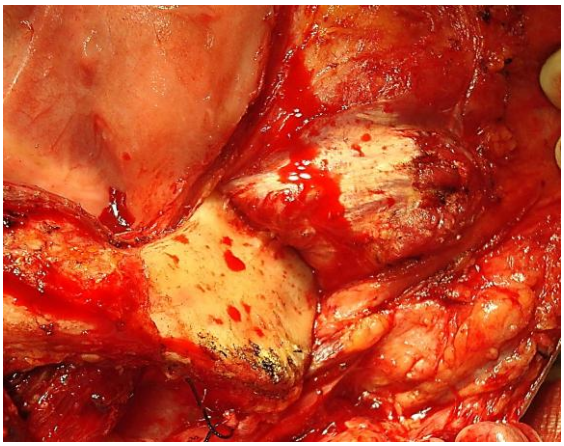


Figure 32: Exposing vertical ramus of mandible up to coronoid process, mandibular notch and neck of condyle

- Note: if the whole masseter muscle is to be included in the resection, then the peripheral branches of the VIIn are at risk of injury where they lie on the muscle; this may be an indication for a combined transparotid VIIn dissection to identify and protect the nerves

Visor approach

This may be used for segmental or marginal mandibulectomy of the lateral horizontal ramus and avoids the cosmetic effect of a lip split incision and may permit preservation of the mental nerve.

- Complete dissection of Levels 1b and 2 of the neck
- Identify and protect the marginal mandibular nerve
- Widely expose the lower margin of the mandible
- Identify mental foramen and preserve the mental nerve if possible
- Transorally incise mucosa and buccinator muscle lateral to the tumour, and the FOM medial to the tumour
- Connect the intraoral and external dissections to expose the lateral aspect of the mandible and the tumour
- Make the osteotomy cuts from laterally under direct vision

Types of Mandibulectomy

The type of mandibulectomy required for SCC of the mandible is controversial [1]. The key objective is to obtain clear margins [1]. Some surgeons consider marginal resection a reasonable option for cancers adherent to periosteum or superficially eroding mandibular cortex without invasion of medullary bone, whereas others advocate segmental mandibulectomy. Previous radiation can change cancer behaviour and is considered a relative contraindication for marginal mandibulectomy [1].

1. ***Alveolectomy:*** Removes alveolar bone, usually around an infected tooth, and is not an oncologic procedure
2. ***Marginal mandibulectomy*** *(Figure 32)* involves resecting part of the vertical height of the mandible with preservation of continuity of the mandible. It is done for access; for securing adequate oncologic resection margins; or to facilitate mucosal repair by suturing gingivolabial to gingivobuccal mucosa

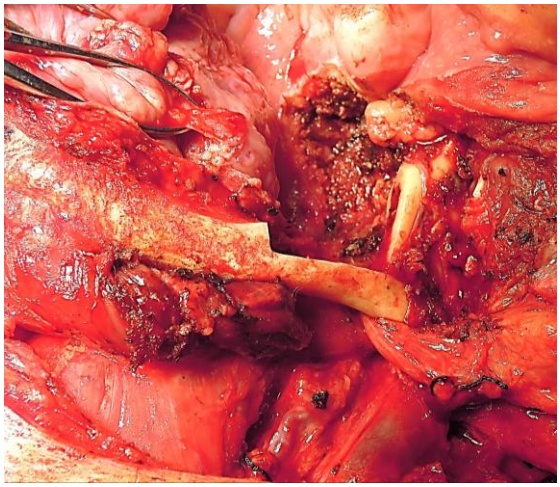


Figure 33: Marginal mandibulectomy

3. ***Segmental mandibulectomy*** *(Figure 33)* involves resecting an entire vertical segment of horizontal ramus with interruption of continuity of the mandible and is done to secure adequate oncologic margins

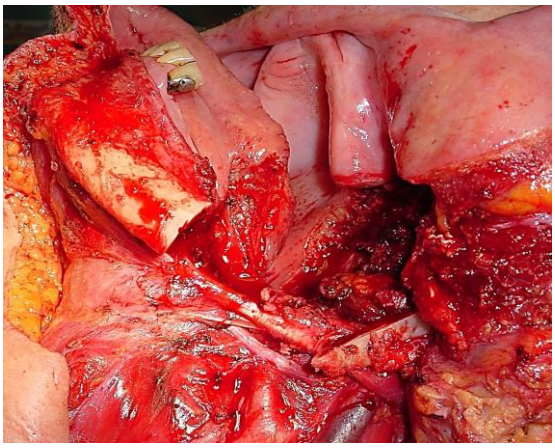


Figure 34: Segmental mandibulectomy preserving only posterior rim of vertical ramus (note preplating holes)

4. ***Hemimandibulectomy*** involves resecting an entire vertical segment of the horizontal ramus as well as the vertical ramus of the mandible to secure adequate oncologic margins
5. ***Subtotal or total mandibulectomy***

Mandibulectomy: Surgical technique

With the dental extractions done, the surgical approach completed with tumour and mandible exposed, the surgeon proceeds to mandibulectomy.

Marginal mandibulectomy

- Marginal mandibulectomy is generally used for cancers involving periosteum or with invasion of only the mandibular cortex
- If doubt exists about the depth of invasion of bone, especially with limited imaging availability, the tumour can be stripped off the bone to inspect the bone for invasion
- The resection technique consists of two vertical and one horizontal osteotomy made with an oscillating saw, retaining the inferior border of the mandible *(Figure 33, 36)*
- Bending the tip of the oscillating saw may assist with achieving better access

and angles, especially with transoral approaches *(Figure 37)*

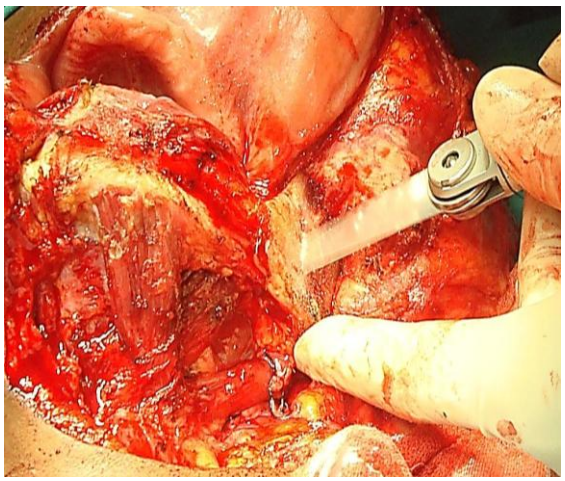


Figure 36: Osteotomy with oscillating saw

Figure 37: Bent tip of saw blade for transoral marginal mandibulectomy

- If osteotomes are used, they must be narrow and sharp to avoid fracturing the mandible
- Preserving vertical height of the bone is key to avoiding subsequent fractures
- The mandibulectomy can be angled to preserve vertical height of the lingual or buccal cortical plates *(Figure 38)*
- A curved marginal mandibulectomy design instead of acute angles reduces the risk of fracture [2]
- Avoid injuring the inferior alveolar nerve if possible
- 1-1,5cm of bone of the lower margin of the mandible must ideally be preserved

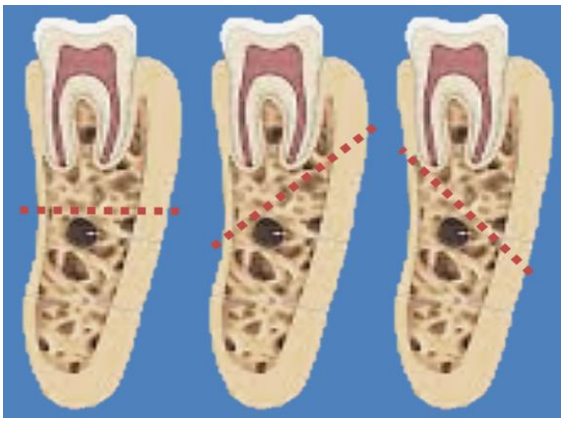


Figure 38: Transverse osteotomy (L); and oblique osteotomies to preserve vertical height and strength of mandible

- If not possible, do a segmental mandibulectomy or use an onlay radial forearm osseocutaneous or fibula free flap *(Figure 39)*

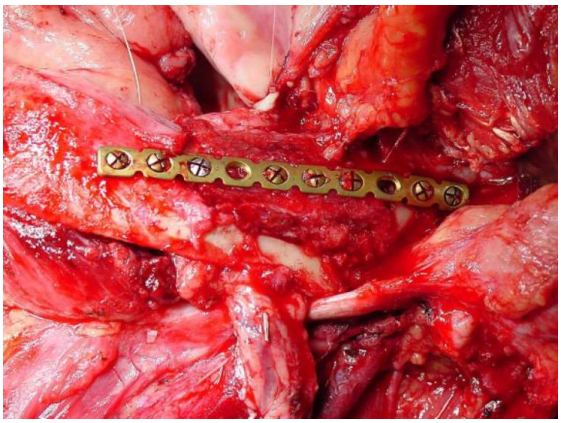


Figure 39: Marginal mandibulectomy with radial free forearm osseocutaneous onlay flap

- Avoid marginal mandibulectomy of the inferior border of the mandible for e.g. a lymph node with ECS adherent to bone as the mandible is likely to subsequently fracture
- Achieving soft tissue closure over a marginal mandibulectomy may include mobilising the adjacent mucosa with primary closure, buccinator, nasolabial or submental artery flaps, or a radial free forearm flap *(Figures 40-43)*

Figure 40: Marginal mandibulectomy defect covered by advancing gingivolabial mucosa over the bone and suturing it to the edge of the FOM defect

Figure 41: Healed split skin graft over marginal mandibulectomy defect

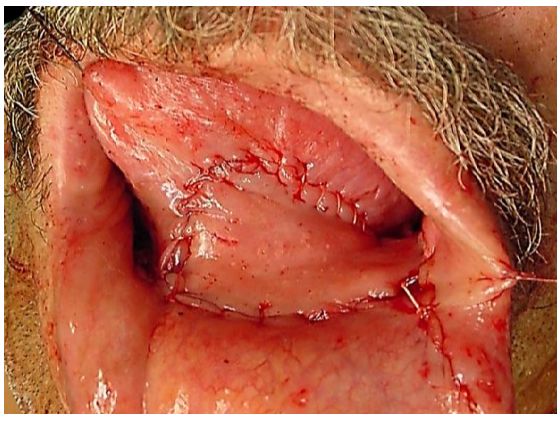


Figure 42: Buccinator flap for FOM resection with marginal mandibulectomy

Figure 43: Nasolabial flap reconstruction of anterior marginal mandibulectomy and FOM defect

Segmental mandibulectomy

- Segmental mandibulectomy is done for cancers invading beyond the mandibular cortical bone, or previous radiotherapy, or PNI of the inferior alveolar nerve, or for intra-alveolar cancers
- If doubt exists about the depth of invasion of bone, especially with limited imaging availability, the tumour can be stripped off the bone to inspect the bone for invasion
- The resection technique consists of two vertical osteotomies made with an oscillating saw or a Gigli saw *(Figures 23, 34)*
- Frozen section is not possible with bone; therefore, osteotomies are placed 1-2cms beyond visible tumour
- With PNI of the inferior alveolar nerve, osteotomies are made just anterior to the mental foramen, and posterior to the lingula
- If the mandible is to be replaced with a free fibula flap, then the reconstruction plate is bent on the exposed mandible as a template to ensure accurate dental occlusion, if it has not been pre-bent

Hemimandibulectomy

- Use an oscillating/reciprocating saw or a Gigli saw for the osteotomies *(Figure 36)*.
- Beware of the close proximity of the carotid artery to the vertical ramus when making the osteotomies *(Figures 5, 11)*
- Preplate the mandible with a reconstruction plate to ensure accurate repair and perfect dental occlusion
- To resect ***coronoid process***, strip masseter off the entire length of the vertical ramus, identify the mandibular notch, and while pulling caudad on the mandible, free the insertion of the temporalis muscle from the coronoid with cautery, keeping close to bone throughout to avoid blood vessels situated medially; this step is simpler if the distal osteotomy has already been done *(Figure 44)*

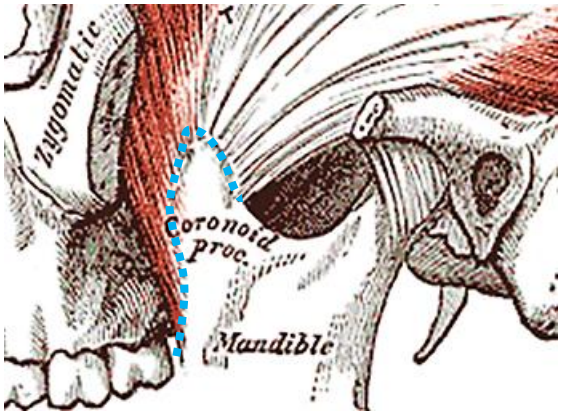


Figure 44: Broken blue line indicates where insertion of temporalis muscle is freed with cautery

- It is generally not necessary to resect the ***condyle***; rather carefully transect the condylar neck bearing in mind the proximity of the carotid artery. To resect the condyle, transect the lateral pterygoid at its insertion onto the condylar neck and the joint capsule *(Figure 45)*. The surgeon must remain aware of the locations of the internal and external carotid arteries; palpating the styloid process is useful as the internal carotid artery lies medial to the bone

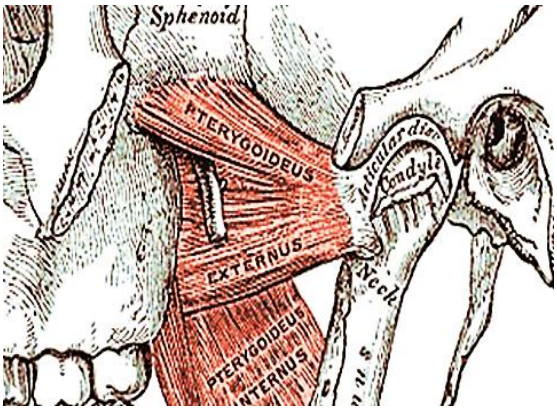


Figure 45: To resect the condyle, transect the lateral pterygoid at its insertion onto the condylar neck and the joint capsule

Repair / Reconstruction

- ***Obtain meticulous haemostasis*** using ties, monopolar and bipolar cautery before closing the defect
- Assess the defect and decide whether and what reconstruction is required to best restore form and function
- With posterolateral bony defects following segmental or hemimandibulectomy, some edentulous/elderly/frail patients may be better off not having a bone reconstruction, but simply having primary mucosal closure or a soft tissue reconstruction e.g. with a pectoralis major flap
- For bone reconstruction, readers are referred to chapters on free fibula and radial free forearm osteocutaneous flap reconstruction *(Figures 39, 46)*
- For soft tissue reconstruction, readers are referred to chapters on pectoralis major, radial forearm, and anterolateral thigh free flap reconstruction
- Note that a pectoralis major flap can be harvested with 5th or 6th rib to reconstruct mandible when free fibula flaps are not possible *(Figures 47, 48)*

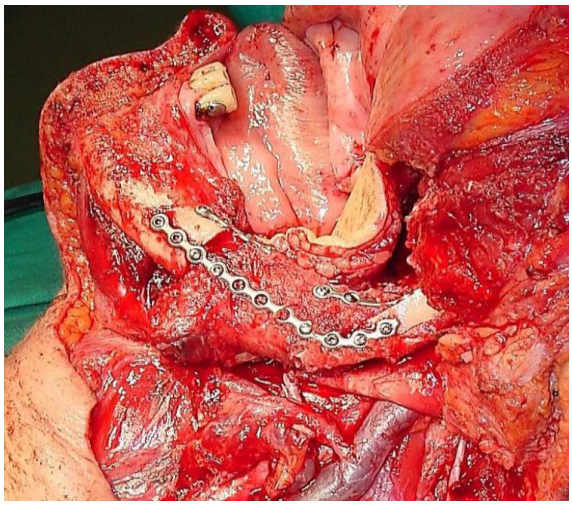


Figure 46: Free fibula flap reconstruction of segmental mandibulectomy defect

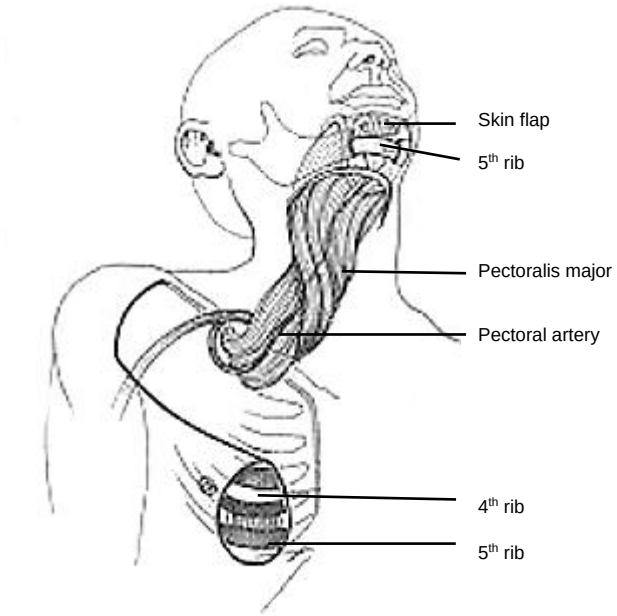


Figure 47a, b: Pectoralis major osteomyocutaneous flap technique; and used as salvage procedure following segmental mandibulectomy for osteoradionecrosis

- Inset the skin island of a flap with Vicryl sutures
- Close the mucosal incision lateral to the mandible with Vicryl
- The ***lip*** is carefully repaired in layers to ensure accurate repair of the vermillion border, and approximate the muscles as well as mucosa and skin *(Figure 48)*
- Close the neck over a suction drain.
- A temporary tracheostomy is done

Figure 46: Lip has been carefully repaired in layers with accurate repair of vermillion border

Postoperative Period

- Antibiotics for 24 hours
- Monitor viability of a flap
- Remove suction drains when less than 50 mL drainage/24 hours
- Tracheostomy
  - Maintain until certainty that patient does not need to be returned to the operating room for surgical complications
  - Once thought to be adequate airway
    - Cork tracheostomy overnight
    - Remove if airway is maintained
- Commence enteral feeding via nasogastric tube the morning after surgery
- Delay oral feeding for 5 days and until decannulated

References

1. Chiesa-Estomba CM, Mayo-Yanez M, Manelli G, *et al*. Marginal versus Segmental Mandibulectomy in the Treatment of Oral Cavity Cancer: A Systematic Review and Meta-analysis. *Int Arch Otorhinolaryngol*. 2023 Apr 11; 27(4):e733-e743. doi: 10.1055/s-0042-1750764
2. Ertem SY, Uckan S, Ozden UA. The comparison of angular and curvilinear marginal mandibulectomy on force distribution with three-dimensional finite element analysis. *J Craniomaxillofac Surg*. 2013 Apr;41(3):e54-8. doi: 10.1016/j.jcms.2012.07.014
3. Rao LP, Das SR, Mathews A, et al. Mandibular invasion in oral squamous cell carcinoma: investigation by clinical examination and orthopantomogram. *Int J Oral Maxillofac Surg*. 2004;33(5):454-7
4. Acton CHC, Layt C, Gwynne R, et al. Investigative modalities of mandibular invasion by squamous cell carcinoma. *Laryngoscope*. 2000; 110(12):2050-5

AfHNS Clinical Practice Guidelines for Oral Cancers in Developing Countries and Limited Resource Settings
https://developingworldheadandneckcancerguidelines.com/cancer-of-the-oral-cavity/

Relevant flaps described in *The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery*

- *Pectoralis major flap*
- *Buccal fat pad flap*
- *Buccinator myomucosal flap*
- *Nasolabial flap*
- *Temporalis muscle flap*
- *Submental Artery Island flap*
- *Supraclavicular flap*
- *Radial free forearm flap*
- *Anterolateral thigh (ALT) free flap*
- *Rectus abdominis flap*
- *Free fibula flap*
- *Medial sural artery perforator (MSAP) flap*
- *Gracilis microvascular flap*
- *Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery*

How to cite this chapter

Fagan JJ (2025). Mandibulectomy for cancers involving mandible and retromolar trigone. In *The Open Access Atlas of Otolaryngology, Head & Neck Operative Surgery*. Retrieved from https://vula.uct.ac.za/access/content/group/ba5fb1bd-be95-48e5-81be-586fbaeba29d/Mandibulectomy%20for%20cancers%20of%20retromolar%20trigone%2C%20inferior%20alveolus%20and%20mandible.pdf

Author & Editor

Johan Fagan MBChB, FCS(ORL), MMed
Emeritus Professor and Past Chair
Division of Otolaryngology
University of Cape Town
Cape Town, South Africa
johannes.fagan@uct.ac.za

THE OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY
www.entdev.uct.ac.za