MEDIAL MAXILLECTOMY   **Johan Fagan**

Medial maxillectomy refers to surgical resection of the medial and superomedial walls of the maxillary antrum. It is increasingly being done by transnasal endoscopic technique for suitable cases and when the required expertise and technology are available. This chapter will only deal with the open surgical medial maxillectomy technique.

Maxillectomy is potentially complicated by injuries to the orbital contents, lacrimal apparatus, optic nerve, ethmoidal arteries, intracranial contents, and may be accompanied by brisk bleeding. A sound understanding of the 3-dimensional anatomy of the maxilla and the surrounding structures is therefore essential. Hence the detailed description of the surgical anatomy that follows.

Surgical Anatomy

Bony anatomy

Figures 1 & 2 illustrate the detailed bony anatomy relevant to medial maxillectomy. Critical surgical landmarks to note include:
- The level of the floor of the anterior cranial fossa (fovea ethmoidalis and cribriform plate) corresponds with anterior and posterior ethmoidal foramina located along the frontoethmoidal suture line
- The proximity (5-11mm) of posterior ethmoidal foramen and artery to the optic nerve within the optic foramen

Figure 2 illustrates the bony anatomy of the lateral wall of the nose. The inferior turbinate (concha) is resected with a medial maxillectomy, but the middle turbinate is generally preserved, unless involved by pathology.
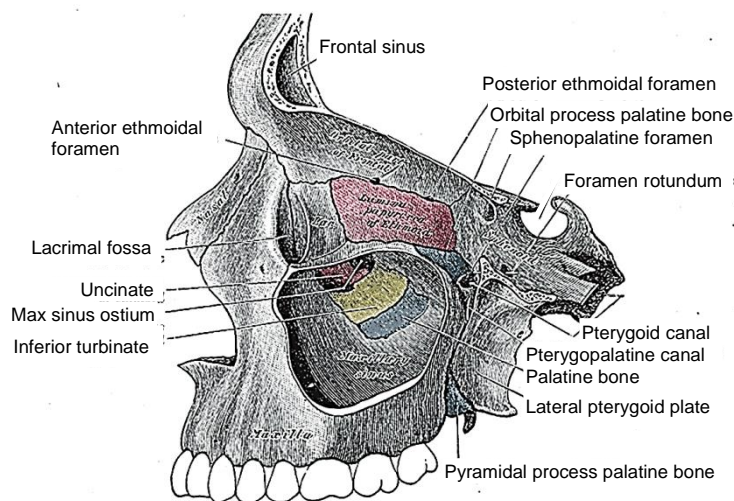

Figure 1: Lateral view of maxilla with windows cut in lateral and medial walls of maxillary sinus
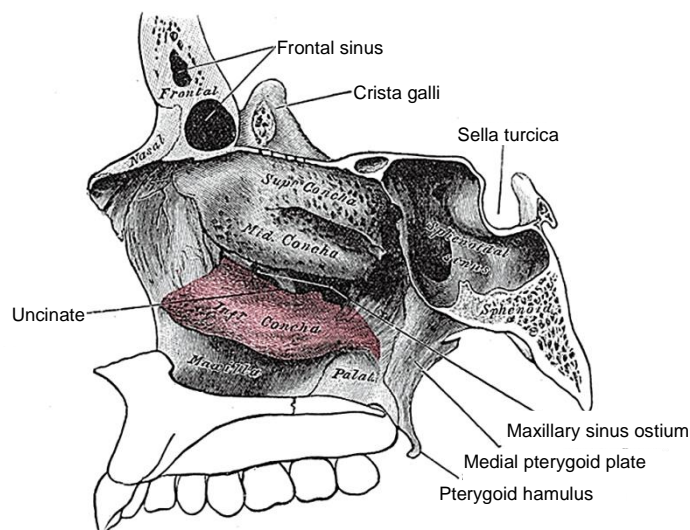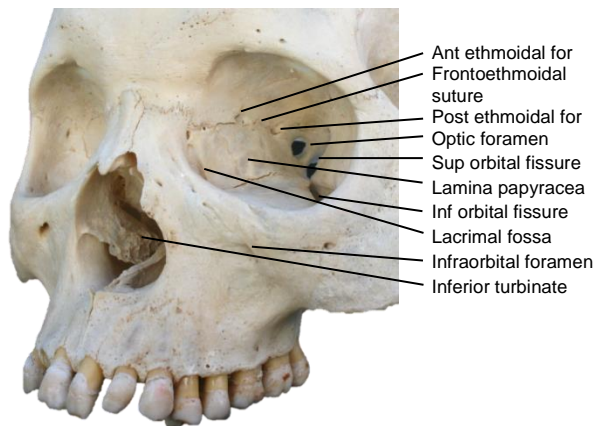

Figure 2: Bony anatomy of the lateral wall of the nose

Figure 3 demonstrates the anatomy of the medial wall of the nose in a cadaveric skull. Note in particular the thin lamina papyracea, the lacrimal fossa, the fronto-ethmoidal suture line and the anterior and posterior ethmoidal foramina and the infraorbital foramen.

Figure 3: Bony anatomy in cadaver

Figure 4 demonstrates the coronal anatomy at the level of the anterior extent of a medial maxillectomy. Specifically note the lacrimal sac, which is normally transected at surgery in the lacrimal fossa, and the relative heights of the floors of the antrum and the nasal cavity.
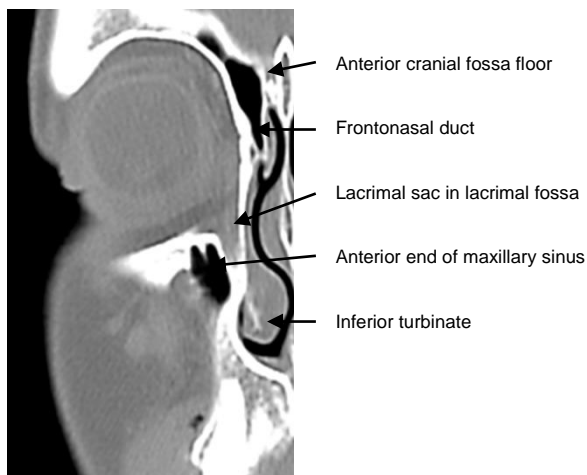

Figure 4: Coronal CT slice through lacrimal fossa

Figure 5 demonstrates the coronal anatomy midway back along a medial maxillectomy. Specifically note the infraorbital nerve in the orbital floor, the thin *lamina papyracea* and the relative heights of the floors of the antrum and the nasal cavity.
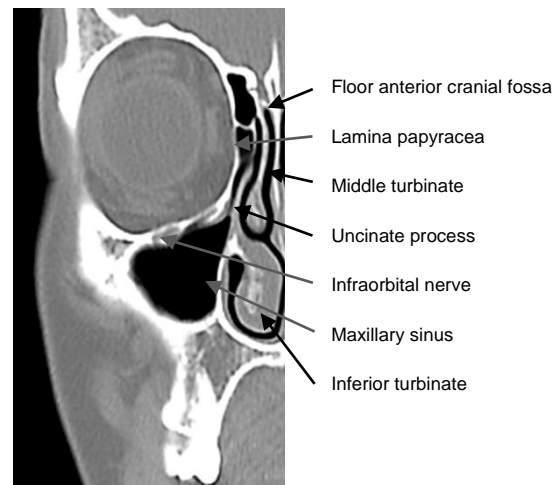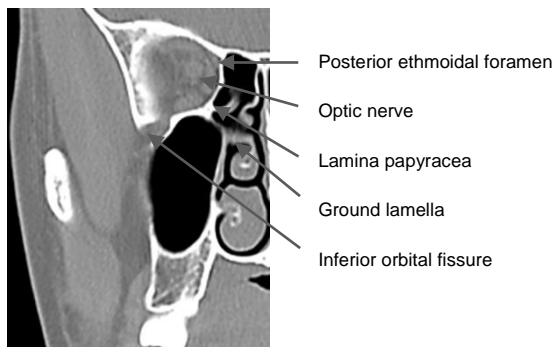

Figure 5: Anatomy in the coronal plane through the anterior ethmoids midway along a medial maxillectomy

Figures 6 & 7 demonstrate the value of using the anterior and posterior ethmoidal arteries and frontoethmoidal suture line to determine the level of the floor of the anterior cranial fossa when opening the *lamina papyracea* from the orbital side during medial maxillectomy.
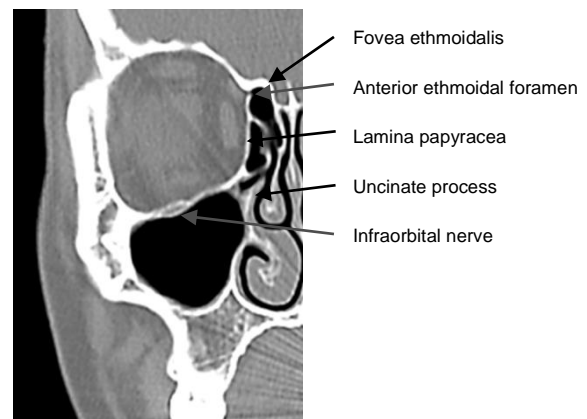

Figure 6: Note the position of the anterior ethmoidal artery where it passes through its foramen which is located in the frontoethmoidal suture line

Figure 7: Coronal slice through posterior ethmoids demonstrating posterior ethmoidal foramen and optic nerve

Figure 8 demonstrates the coronal anatomy immediately posterior to the maxillary sinus, which is in the plane through which a total maxillectomy is done, and in which the internal maxillary artery and its branches as well as the sphenopalatine ganglion and its branches are encountered within the pterygopalatine fossa. The pterygopalatine fossa communicates laterally with the infratemporal fossa via the pterygomaxillary fissure, and medially with the nasal cavity via the sphenopalatine foramen.
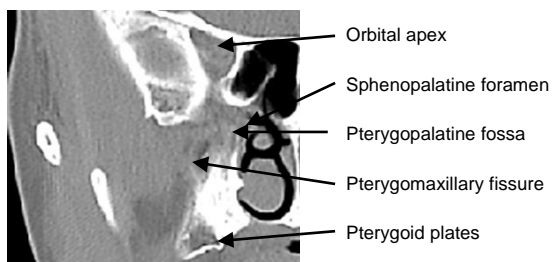

Figure 8: Coronal cut immediately behind the maxillary sinus through the orbital apex, pterygoid plates and pterygopalatine fossa.

Figures 9 & 10 show axial views of the anatomy of the maxillary sinus. The posterior resection lines of total and inferior maxillectomies pass through the pterygopalatine fossa and pterygomaxillary fissure and the anterior aspect of the pterygoid plates. Medial maxillectomy is done medial to the infraorbital nerve.
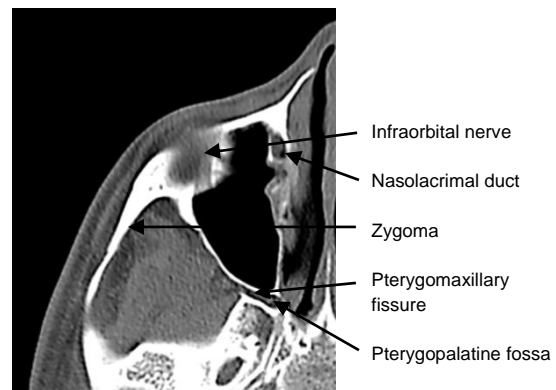
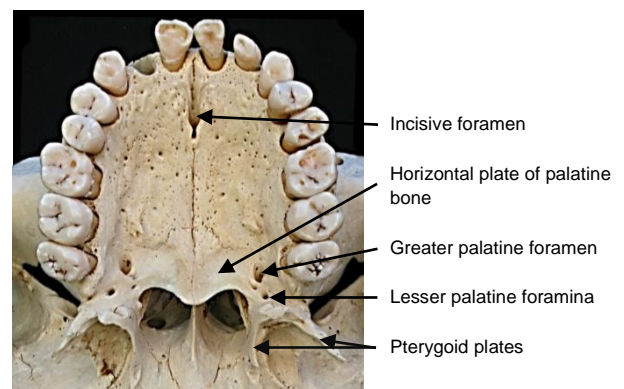
Figure 9: Axial cut at level of infraorbital nerve and orbital floor
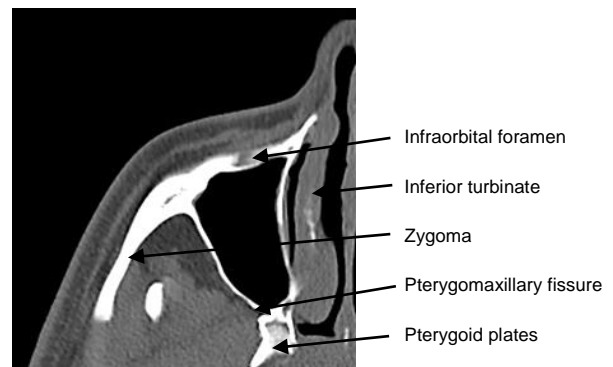
Figure 10: Axial cut at level of infraorbital foramen and pterygoid plates

The bony anatomy of the hard palate is illustrated in *Figure 11*.

Figure 11: Anatomy of hard palate

Vasculature

An understanding of the blood supply of the maxilla permits the surgeon to anticipate when and where to encounter bleed-

ing, and to plan the sequence of the surgery to reserve the bloodier parts of the surgery until last so as to minimise blood loss and to avoid blood obscuring the surgical field.

The only significant vein encountered during maxillectomy is the **angular vein** *(Figure 12)* at the medial canthus.

Figure 13: Facial artery and origin of internal maxillary artery, both branches of the external carotid artery
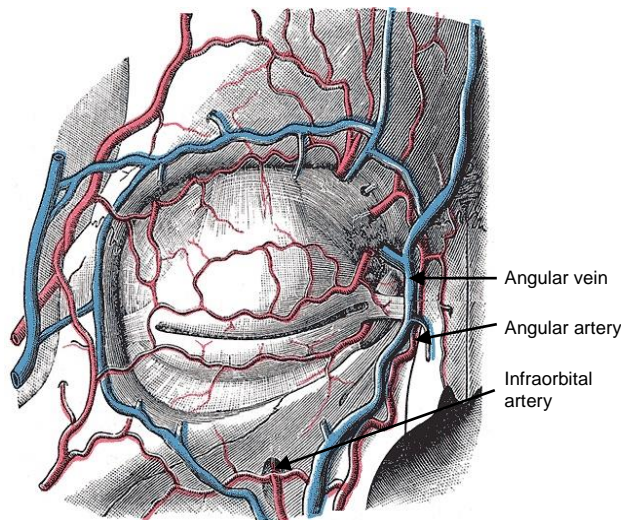

Figure 12: Vasculature around the orbit

The blood supply to the maxilla and paranasal sinuses originates both from the external and internal carotid artery systems. The arterial supply relevant to maxillectomy is as follows:

- *Facial/external maxillary artery*, a branch of the external carotid artery courses in the soft tissues of the face and past the medial canthus as the angular artery *(Figures 12, 13)*
- *Internal maxillary artery*, a branch of the external carotid artery *(Figures 13, 14a, b),* passes through the pterygomaxillary fissure to enter the pterygopalatine fossa

Branches of the internal maxillary artery of surgical significance include:
- *Greater palatine artery* (descending palatine) *(Figure 14):* It passes inferiorly from the pterygopalatine fossa

1. Deep auricular
2. Anterior tympanic
3. Middle meningeal
4. Accessory meningeal
5. Post. deep temporal
6. Pterygoid
7. Anterior deep temporal
8. Artery of pterygoid canal
9. Pharyngeal
10. Sphenopalantine
11. Infra-orbital
12. Posterior superior alveolar
13. Descending palatine
14. Buccal
15. Pterygoid
16. Masseteric
17. Inferior alveolar

Figures 14a, b: Branches of internal maxillary artery; blue shaded area is the 2nd part of artery before it enters the pterygopalatine fossa

through the pterygopalatine canal *(Figure 1)* and emerges from the greater palatine foramen of the hard palate

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(Figure 11). It then runs anteriorly medial to the superior alveolus and enters the incisive foramen *(Figure 11)*

- ***Infraorbital artery:*** It courses in the infraorbital groove and canal with the infraorbital nerve in the floor of the orbit/roof of antrum and exits anteriorly via the infraorbital foramen to supply the overlying soft tissues of the face *(Figures 12, 14)*
- ***Sphenopalatine artery*** *(Figure 14):* It enters the nasal cavity through sphenopalatine foramen at the back of the superior meatus where it gives origin to ***posterior lateral nasal branches***
- ***Posterior septal artery:*** This is a branch of the sphenopalatine artery and crosses the posterior nasal cavity just above the posterior choana to end on the nasal septum; one branch descends in a groove in the vomer to enter the incisive canal and anastomose with the greater palatine artery

Branches of the internal carotid artery of surgical significance include:

- ***Anterior ethmoidal artery:*** It originates from the ophthalmic artery and enters the orbit through the anterior ethmoidal foramen *(Figure 3)* which is located 25 mm from the anterior lacrimal crest
- ***Posterior ethmoidal artery:*** It originates from the ophthalmic artery and enters the orbit through the posterior ethmoidal foramen *(Figures 3, 7).* It is located approximately 36mm from the anterior lacrimal crest, and 12mm (8-19 mm) from the anterior ethmoidal foramen
- ***Ophthalmic artery:*** It emerges with the optic nerve from the optic canal, 44mm from the anterior lacrimal crest and approximately 6 mm (5-11 mm) from the posterior ethmoidal foramen

Nerves

The ***maxillary division of V*** (V2) enters the pterygopalatine fossa via foramen rotundum. The only branch of surgical significance is the ***infraorbital nerve***. It runs in the floor of the orbit/roof of the antrum to exit from the infraorbital foramen *(Figure 15).* The only other major nerve that must be considered at maxillectomy is the ***optic nerve***.
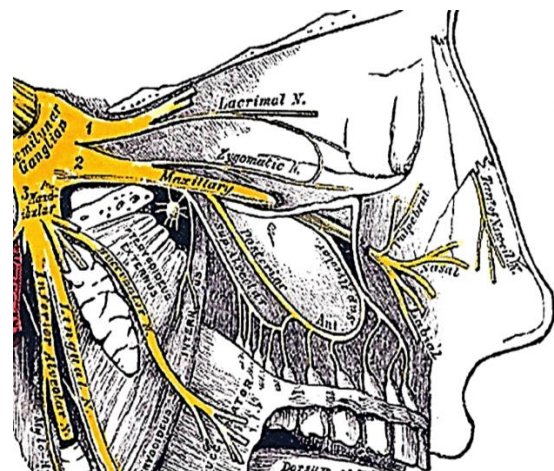

Figure 15: V2, pterygopalatine ganglion and infraorbital nerve
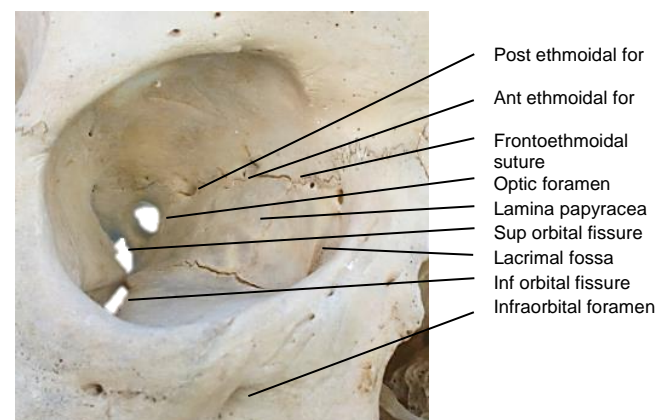
Orbital structures

Figure 16: Right medial orbital wall

Figure 16 shows the detailed bony anatomy of the orbit. During dissection of the orbit, the following structures are encountered: medial palpebral ligament, orbital septum, lacrimal sac, periosteum, anterior

and posterior ethmoidal arteries and inferior orbital fissure *(Figure 16, 17).* Only when doing orbital exenteration is the superior orbital fissure encountered.

- ***Orbital septum** (Figure 17):* This connective tissue structure attaches peripherally to the periosteum of the orbital margin and acts as a diaphragm that retains the orbital contents. Laterally, it is attached to the orbital margin 1.5mm anterior to the attachment of the lateral palpebral ligament to the lateral orbital tubercle. The septum continues along the superior orbital rim. Superomedially it crosses the supraorbital groove, passes inferomedially anterior to the trochlea, and follows the posterior lacrimal crest behind the lacrimal sac. It then crosses the lacrimal sac to reach the anterior lacrimal crest, passes inferiorly along the anterior lacrimal crest and then laterally along the inferior orbital rim.
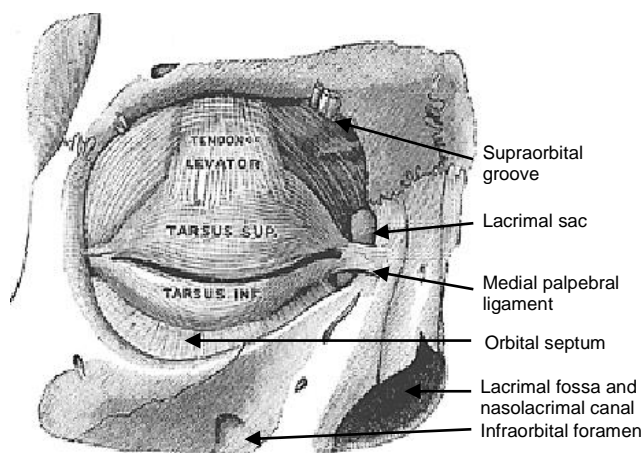

Figure 17: Right orbit showing medial palpebral ligament, orbital septum, lacrimal sac and lacrimal fossa

- ***Medial palpebral ligament (medial canthal tendon)** (Figure 17):* This is a fibrous band that fixes the tarsi to the medial orbital wall. It is intimately related to the lacrimal drainage system. It lies anterior to the canaliculi, but a deep head inserts into the posterior

lacrimal crest and onto the fascia of the lacrimal sac.

- ***Lacrimal sac** (Figures 1, 3, 4, 16, 17, 18):* It is located in the lacrimal fossa, which is bound medially by the lacrimal bone and the frontal process of the maxilla *(Figure 1, 16).* It is related anteriorly, laterally, and posteriorly to the medial palpebral ligament.
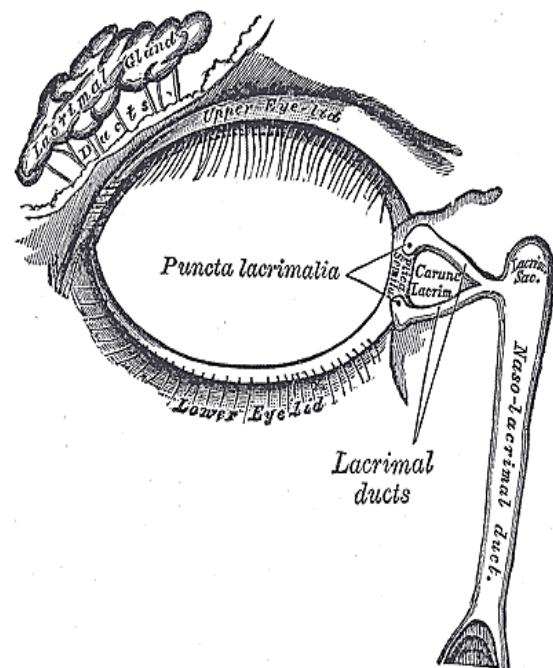
Figure 18: Right lacrimal system

- ***Inferior orbital fissure** (Figure 16, 19):* This fissure is situated in the floor of the orbit and separates the sphenoid bone from the maxilla. It transmits the maxillary nerve and a few minor nerves, but no vessels of surgical significance

- ***Superior orbital fissure** (Figure 16, 19):* This fissure lies between the lesser and greater wings of the sphenoid bone. Important anatomical structures that pass through the fissure are cranial nerves III, IV, VI; and the superior and inferior divisions of ophthalmic vein
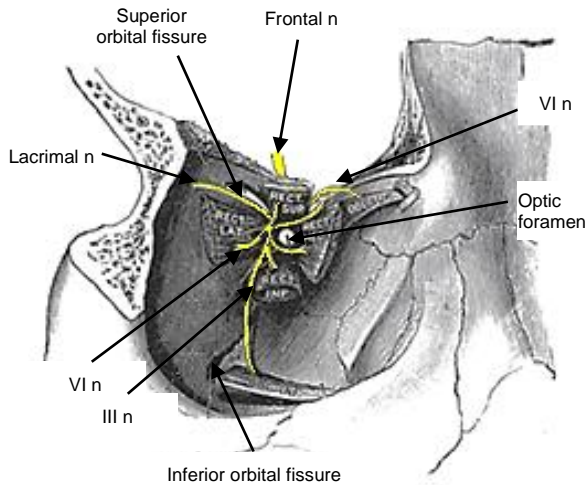
Figure 19: Inferior and superior orbital fissures of (R) orbit

Medial Maxillectomy

Medial maxillectomy entails resection of the lateral wall of the nasal cavity (medial wall of antrum and orbit), the ethmoid sinuses and the medial part of the orbital floor *(Figure 20)*.
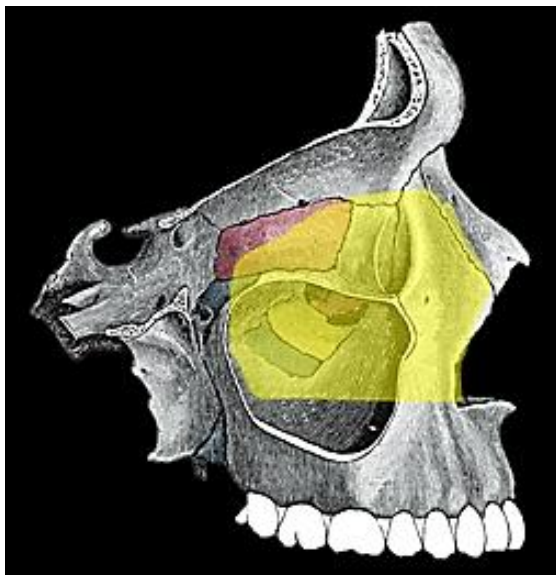
Figure 20: Yellow area indicates extent of bony resection of medial maxillectomy

It is employed with tumours (including inverting papilloma) involving the lateral wall of the nose, the lacrimal sac, and ethmoids. CT scan is an important means of anticipating the extent of maxillectomy that is required and to assess the anatomy of the skull base and paranasal sinuses. Once a tumour involves orbital fat, extends inferiorly to invade the palate or nasal floor, extends laterally beyond the infraorbital foramen, or involves the posterior antral wall and beyond, then more extensive resection is required.

Surgical steps

Preoperative consent includes discussing the facial incisions, injury to the optic and infraorbital nerves, diplopia, epiphora, enophthalmos, telecanthus, and CSF leak. The operation is done under *general anaesthesia*, with orotracheal intubation. Perioperative broad-spectrum antibiotics are administered for 24hrs. Local anaesthetic with vasoconstrictor is injected along the planned skin incisions. The nasal cavity is decongested with a topical vasoconstrictor. The eyelids are sutured together with 6/0 silk taking care not to invert the eyelashes to avoid corneal abrasions.

The operation may be considered in 3 stages: soft tissue dissection/bone exposure; bone resection; and closure/reconstruction.

It is important to complete the soft tissue dissection and bone exposure before doing any bone work to avoid excessive blood loss.

Soft tissue dissection/bone exposure

- Medial maxillectomy may be done via ***midfacial degloving or lateral rhinotomy approach** (Figure 21).* The midfacial degloving approach avoids facial scars and is suited to resections that do not extend above the orbital floor *i.e.* do not include resection of the lamina papyracea and ethmoids. Once the resection requires removal of the medial wall of the orbit and the eth-

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moids, lateral rhinotomy provides better access.

Figure 21: Lateral rhinotomy incision. Very rarely is the lip split extension required for access

The skin is incised with a scalpel. The remainder of the soft tissue dissection may be done with electrocautery. The incision is extended onto the nasal bone and the maxilla. The angular vessels are cauterised or ligated adjacent to the medial canthus of the eye *(Figure 12)*

- The *soft tissues of the face* are elevated off the face of the maxilla using cautery or an elevator, remaining hard on bone while doing this dissection. Expose the entire face of the maxilla. Stop the dissection laterally at the infraorbital foramen taking care to preserve the infraorbital nerve and to avoid bleeding from the infraorbital artery
- Sequentially identify the *medial palpebral ligament, anterior lacrimal crest*, the *lacrimal sac* in the *lacrimal fossa*, and the *posterior lacrimal crest*. Elevate the *lacrimal sac* from its fossa and transect it as distally as possible with a scalpel, to facilitate a dacryo-cystorhinostomy. Expect some bleeding from the transected sac

- Next, the *medial and inferior orbit is exposed*. The periosteum is stripped from the nasal bone and frontal process of the maxilla, taking care to remain in a subperiosteal plane. Strip the orbital contents in an extraperiosteal plane from the *lamina papyracea* and frontal bone taking care not to fracture or penetrate the thin bone of the *lamina papyracea*
- Identify the *frontoethmoidal suture line*. This is a crucial surgical landmark as it corresponds with the level of the cribriform plate and the anterior and posterior ethmoidal foramina. Retract the orbital contents laterally and identify the *anterior ethmoidal artery* as it bridges the divide between the *anterior ethmoidal foramen* and the periorbita *(Figure 22, 23)*. The anterior ethmoidal artery is ligated, clipped or bipolared and divided, thereby providing access to the *posterior ethmoidal artery*. It is generally not necessary to divide this vessel
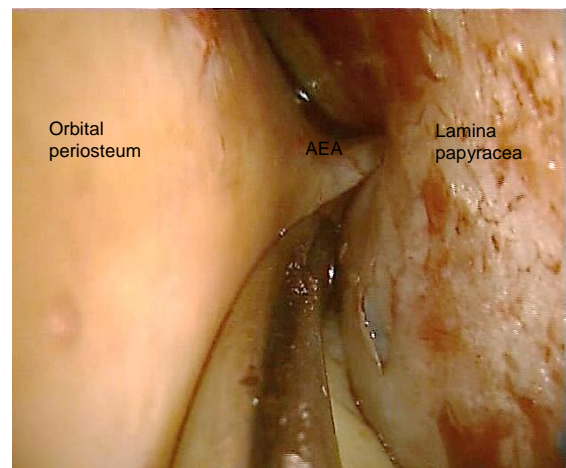

Figure 22: Anterior ethmoidal artery (AEA) exiting foramen at level of fronto-ethmoidal suture line (right eye)
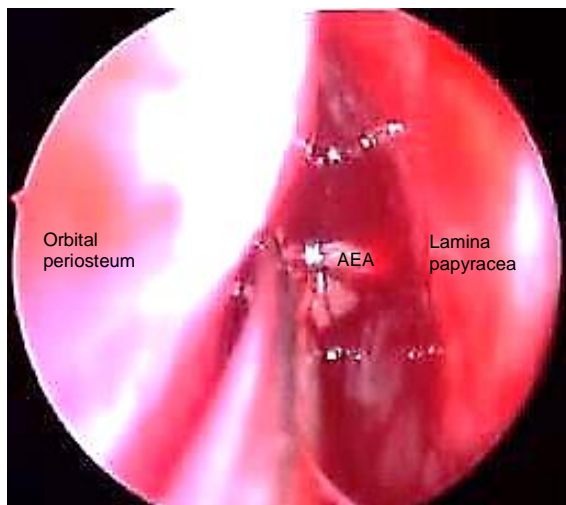
Figure 23: Liga clips being applied to anterior ethmoidal artery (AEA)

- Now strip along the ***floor of the orbit*** in an extraperiosteal plane. Take special care not to tear the periosteum at the inferior orbital margin at the attachment of the orbital septum to avoid entering the orbital fat and causing extrusion of the fat
- Next free the soft tissues from the bone up to the ***anterior free margin of the nasal aperture*** with diathermy. Retract the nasal ala and incise the lateral wall of the nasal vestibule to expose the ipsilateral nasal cavity and inferior turbinate, taking care not to injure the inferior turbinate of septum to avoid troublesome bleeding

At this point the soft tissue dissection is complete

Bony resection

- ***An antrostomy*** is made in the anterior face of the maxilla with a hammer and gouge or a burr, entering the antrum through the thin bone in the canine fossa. A punch or bone nibbler is used to remove the majority of the bone of the anterior wall of the maxillary sinus up to the orbital rim superiorly, but taking care to leave a margin of bone

around the infraorbital foramen so as to protect the nerve and to avoid bleeding from the infraorbital vessels *(Figure 24)*. Inspect the antrum to determine the extent of the tumour and to plan the subsequent bony cuts

Figure 24: Anterior antrostomy, taking care not to injure infraorbital nerve

- The ***medial maxillectomy*** can now been done. The extent of the bony resection is tailored to the primary tumour
- *Figures 25 – 27* illustrate the extent of the bone resection with a classic medial maxillectomy

Figure 25: Coronal CT anteriorly demonstrating resected lateral nasal wall, orbital walls and transected lacrimal sac

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Figure 26: Coronal CT demonstrating resected lateral nasal wall including inferior turbinate and uncinate process, orbital floor up to infraorbital nerve, lamina papyracea and anterior ethmoidectomy, with preservation of the middle turbinate

Figure 27: Coronal CT more posteriorly demonstrating resected lateral nasal wall, inferior turbinate and inferomedial orbital wall, and ethmoidectomy with resection remaining below the level of the posterior ethmoidal foramen, and with preservation of middle turbinate

- **The sequence of the osteotomies** is planned to reserve troublesome bleeding to the end **(Figure 28)**. This may have to be adjusted depending on the location and extent of the tumour.

    1. **Osteotomy through inferior orbital rim:** A sharp osteotome/power saw/ bone nibbler is used to cut through the thick inferior orbital rim just medial to the infraorbital nerve

    2. **Osteotomy connecting antrostomy with nasal vestibule:** A sharp osteotome is used to connect the anterior antrostomy with the floor of the nasal vestibule

    3. **Osteotomy across frontal process of maxilla:** This part of the dissection is often best done with a Kerrison's rongeur or oscillating saw. There is often persistent minor bleeding from the bone that may be controlled with bone wax or cautery. The osteotomy is stopped short of the level of the frontoethmoidal suture

    4. **Osteotomy along orbital floor:** While retracting and protecting the orbital contents with a narrow copper retractor an osteotomy is continued posteriorly through the thin bone of the orbital floor/antral roof using either a sharp osteotome or heavy scissors, aiming for the posteromedial corner of the roof of the maxillary sinus

    5. **Osteotomy along floor of nose:** A sharp osteotome or heavy scissors is used to divide the lateral wall of the nose/medial wall of the antrum along the floor of the nasal cavity up to the posterior wall of the antrum. When doing this dissection with an osteotome, the dissection is halted when the osteotome hits up against the solid pterygoid bone (signalled by a change in the sound)

    6. **Osteotomy through lacrimal bone, lamina papyracea and anterior ethmoids:** It is critical that this osteotomy be placed below the level of the frontoethmoidal suture line and the ethmoidal foramina so as to avoid fracturing or penetrating through the cribriform plate. The osteotomy is done be gently tapping on an osteotome to enter the ethmoid air cell systems while care-

fully retracting the orbital contents laterally. The osteotomy stops short of the posterior ethmoidal artery to safeguard the optic nerve

7. ***Vertical posterior osteotomy through posterior ethmoids and along posterior wall of antrum and pterygopalatine fossa:*** The final posterior vertical cut is made with a heavy curved (Mayo) scissors as a downward continuation of the osteotomy in (6). It runs though the medial wall of the maxillary sinus, starting superiorly at the posterior end of the previous osteotomy, and ending at the level of the nasal floor
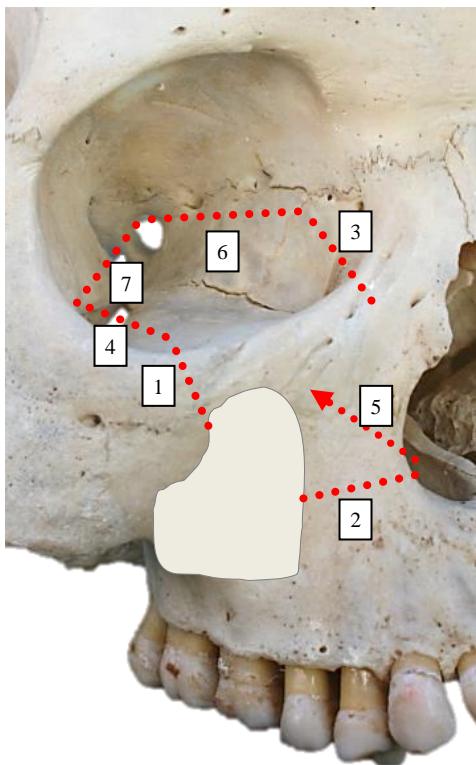

Figure 28: A sequence for osteotomies

- The ***medial maxillectomy specimen is then removed*** by gently levering it inferiorly and laterally with the Mayo scissors while completing the posterior osteotomy, in the process fracturing through the apex of the orbital floor and the posterior ethmoids cells and remaining lateral to and preserving the middle turbinate
- The specimen is inspected to determine the adequacy of the tumour resection.
- An external ethmoidectomy may safely be completed up to the cribriform plate.
- The ***ethmoids*** are carefully inspected to determine whether an external fronto-ethmoidectomy +/- sphenoidectomy is required, and for evidence of a CSF leak

Clinical example

Figure 29: Malignancy of the lacrimal sac resected with a medial maxillectomy

Closure/Reconstruction

Haemostasis is achieved with cautery, bone wax and or topical haemostatics. It is only rarely necessary to pack the nose.

The objectives of closure are to minimise enophthalmos, diplopia, epiphora and an unsightly scar. It is not unusual for patients to complain of some diplopia, but this usually resolves with the passage of time. Suture any tears in the periorbita to avoid herniation of orbital fat. The lacrimal sac is

slit open along its longitudinal axis and the edges are sutured to the surrounding tissues to avoid epiphora. If an extensive resection of the orbital floor has been done, then consideration should be given to reconstructing the floor with fascia / bone / titanium mesh. The skin is carefully repaired to optimise the cosmetic results.

Patients are instructed about nasal douching and are recalled for nasal toilette.

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