OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

# CALDWELL-LUC (RADICAL ANTROSTOMY), INFERIOR MEATAL ANTROSTOMY & CANINE FOSSA AND INFERIOR MEATUS PUNCTURES

**Johan Fagan**

The ***Caldwell-Luc operation*** involves creating an opening into the maxillary antrum through the canine fossa via a sublabial approach.

***Canine fossa (CFP) & inferior meatal puncture*** are used to obtain samples of pus from the antrum, to irrigate the antrum ("antral washout"), or as an adjunct to endoscopic ethmoidectomy.

## Surgical anatomy

The Caldwell-Luc operation involves entering the maxillary sinus via an opening in the thin bone of the ***canine fossa*** *(Figures 1-3)*.

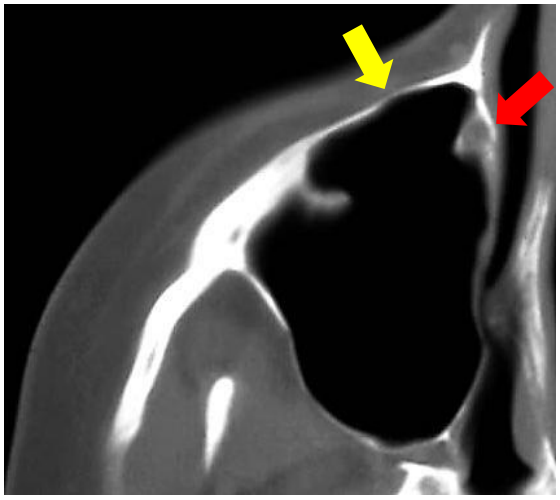

*Figure 1: Thin bone of canine fossa (yellow arrow); nasolacrimal duct (red arrow)*

A ***series of eminences*** overlie the roots of the teeth on the inferior part of the face of the maxilla *(Figures 2, 3)*. Just above the eminences of the incisor teeth is a depression called the ***incisive fossa***; it gives origin to the *depressor alae nasi*. The *nasalis* muscle arises just lateral to it *(Figure 2)*.

The ***canine fossa*** is a depression on the anterior surface of the maxilla below the infraorbital foramen and lateral to the ***canine eminence*** and the ***incisive fossa*** *(Figures 2, 3)*. It is larger and deeper than the incisive fossa, and is separated from it by the ***canine eminence***, a vertical mound overlying the socket of the canine tooth. The *caninus* muscle arises from the canine fossa.

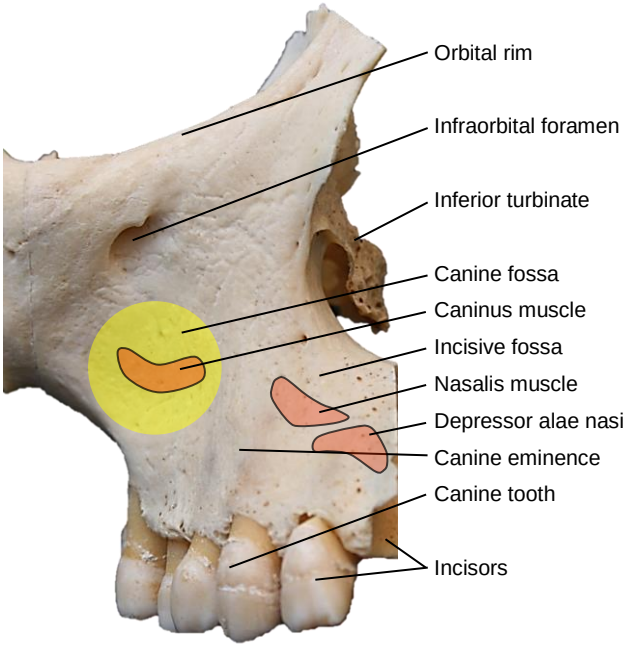


*Figure 2: Right canine fossa (yellow), incisive fossa and canine eminence*

The ***infraorbital foramen*** transmits the ***infraorbital nerve***, artery, and vein. The infraorbital neurovascular bundle traverses a groove in the orbital floor/roof of the sinus which can be dehiscent. It exits through the infraorbital foramen, located approximately 5mm below the midportion of the inferior orbital rim to enter the soft tissues of the cheek. Branches of the nerve supply the lower eyelid, nose, cheek and upper lip *(Figures 3, 4)*. Care must be taken when elevating the periosteum from the anterior

wall of the sinus to avoid injury to the infraorbital nerve where it exits the canal. Branches of the ***anterior and posterior superior alveolar nerves*** travel through bone to supply the upper teeth and gums *(Figures 3, 4)*. These nerves may be injured when extending the antrostomy too low and cause loss of sensation to the teeth and gums.

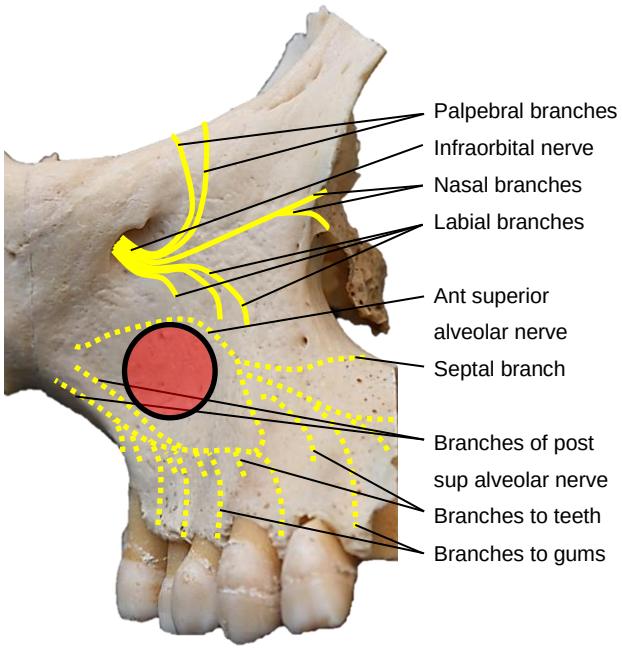


*Figure 3: Infraorbital nerve and branches of the anterior superior alveolar and posterior superior alveolar nerves; antrostomy in canine fossa (red circle); stippled lines indicate nerves within the bone*

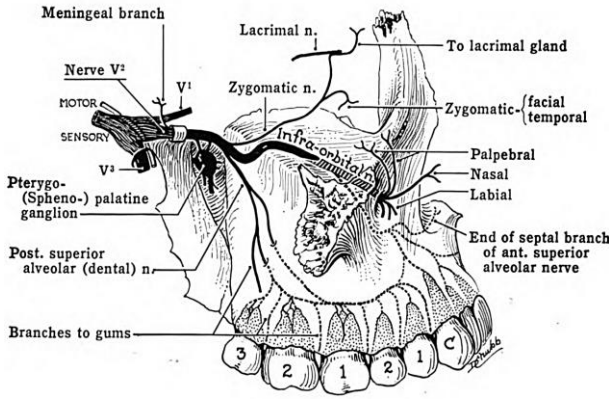


*Figure 4: Branches of V2 (An Atlas of Anatomy, by regions; 1962: Grant)*

The ***maxillary sinus*** is lined by ***ciliated columnar epithelium***. The cilia move secretions toward the natural sinus ostium; this explains the limited efficacy of an inferior meatal antrostomy. The adult maxillary sinus is 25-35mm wide, 36-45mm high, and 38-45mm long, and has an average volume of 15ml. The ***superior wall*** is formed by the orbital floor which is thin and often dehiscent. The infraorbital nerve is in the roof of the sinus. Medially and posteriorly the roof is composed of the floor of the ethmoid sinuses *(Figure 10)*. The ***anterior wall*** contains the nerves and vessels that supply the upper teeth. It is thinner anteriorly and thickens posterolaterally where it joins the zygomatic process *(Figure 1)*. Septae are present in about a third of cases, mainly anteriorly *(Figure 1)*. The ***medial wall*** of the maxillary sinus separates it from the nasal cavity *(Figures 5, 6)*.

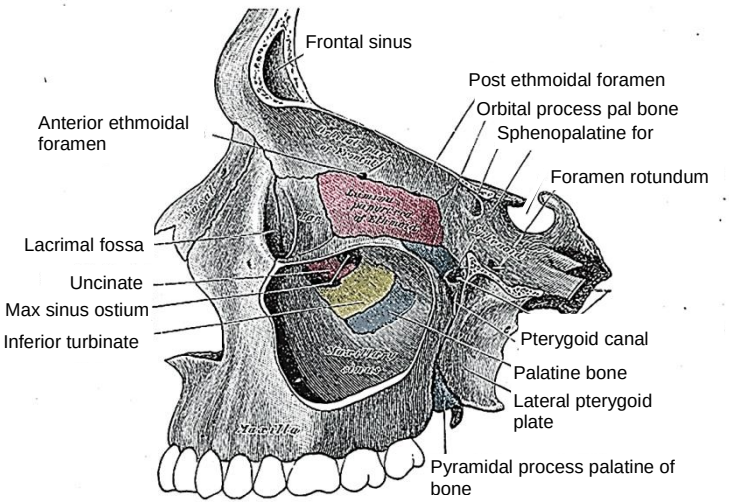


*Figure 5: Lateral view with windows cut in lateral and medial walls of maxillary sinus*

The inferior turbinate is attached along the nasal wall below the level of the maxillary sinus ostium *(Figure 6)*. The nasolacrimal duct traverses the thicker bone at the junction of the medial and anterior walls before opening into the nose below the inferior turbinate *(Figures 1, 12)*. The sinus communicates with the nasal cavity via the maxillary sinus ostium in the *hiatus semi-*

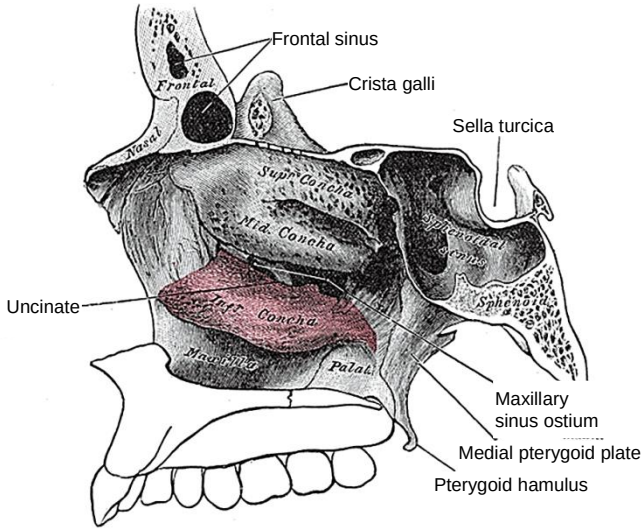


*Figure 6: Bony anatomy of the lateral wall of the nose*

*lunaris* of the middle meatus *(Figures 8, 9)*. The ***posterior wall*** is the infratemporal surface of the maxilla and separates the sinus from the pterygomaxillary fissure and the pterygopalatine fossa which contains the internal maxillary artery and its branches and the pterygopalatine ganglion and its branches *(Figure 4)*.

The ***radiological anatomy*** of the maxillary sinus is assessed on plain X-rays or by coronal and axial CT scans and is essential to do prior to a Caldwell-Luc procedure *(Figures 1, 7-13). Figures 7-10* demonstrate the coronal anatomy at the anterior, mid- and posterior maxillary sinus. *Figure 11)* is a slice immediately behind the maxillary sinus 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.

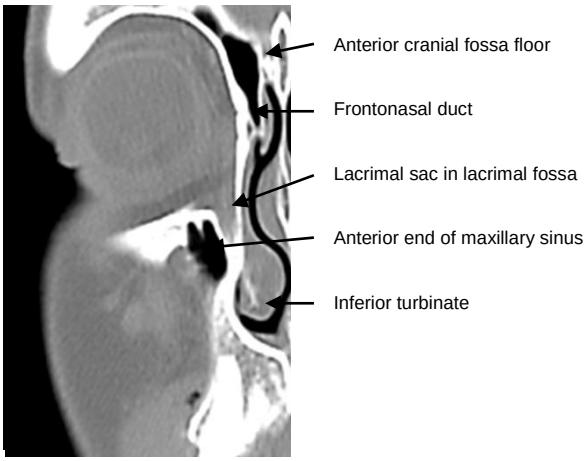


*Figure 7: Coronal CT slice through lacrimal fossa*

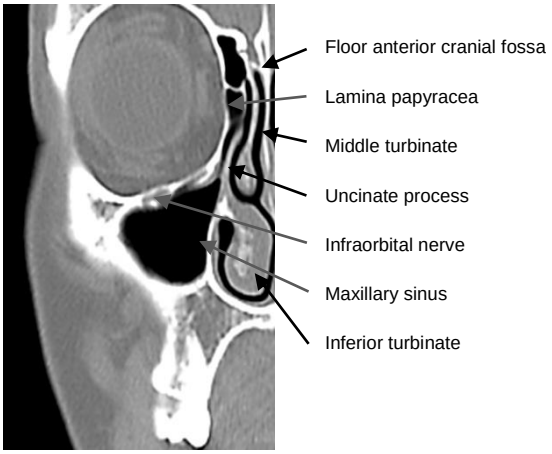


*Figure 8: Coronal plane through anterior ethmoids midway along the maxillary sinus*

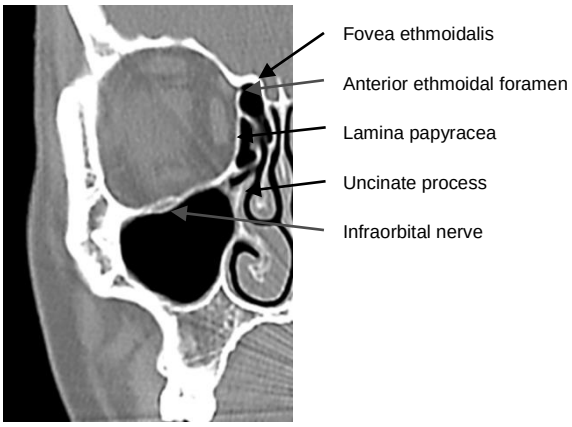


*Figure 9: Anatomy at uncinate process*

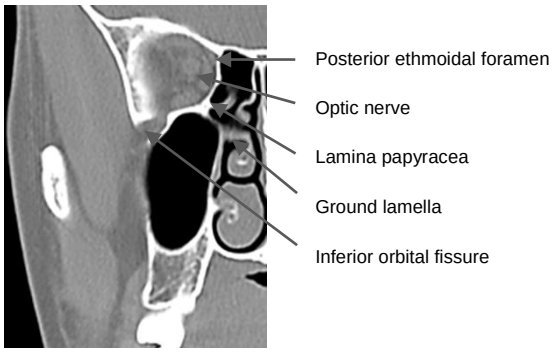


*Figure 10: Coronal slice through posterior maxillary sinus; note its relationship to the ethmoids*

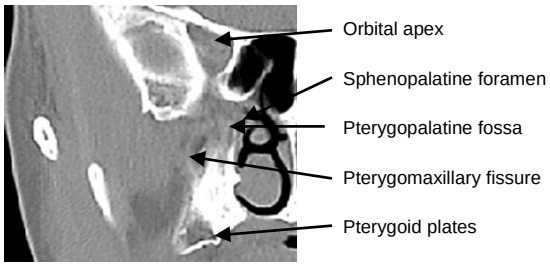


*Figure 11: Coronal cut immediately behind the maxillary sinus*

*Figures 12 & 13* show axial views demonstrating the pterygopalatine fossa, pterygomaxillary fissure and pterygoid plates. Imaging may also reveal important anatomical variations that can affect the surgical approach *e.g.* congenital hypoplasia (*Figure 14*).

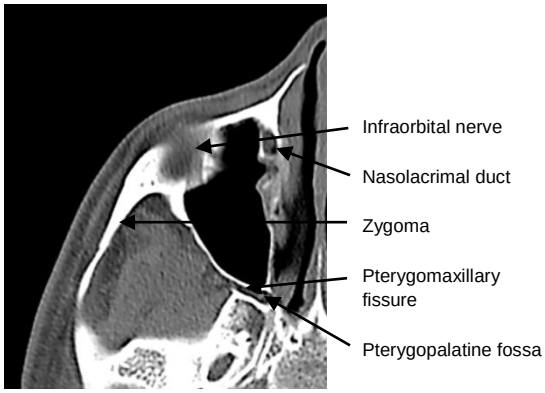


*Figure 12: Axial cut at level of infraorbital nerve and orbital floor*

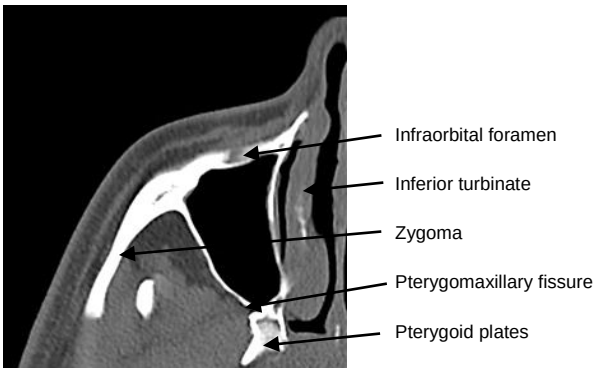


*Figure 13: Axial cut at level of infraorbital foramen and pterygoid plates*

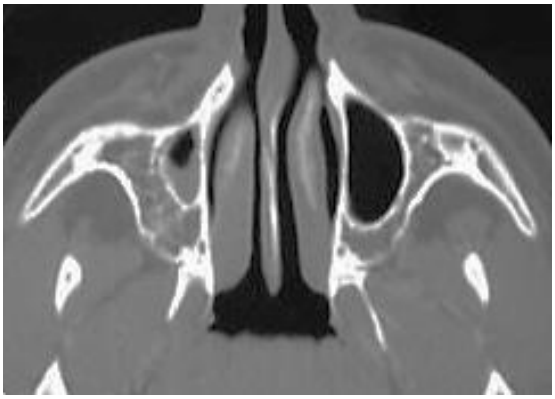

*Figure 14: Hypoplastic maxillary sinus*

***The dimensions of the maxillary sinus change with age, and may affect surgery***. Expansion at 2-3 mm/year of the maxillary sinuses continue until adulthood. At birth they are small and the floors of the sinuses are approximately 4mm above the nasal floor; at 8-9 years of age the floors of the sinuses and nasal cavity are at about the same levels and the sinus dimensions are 2 x 2 x 3cms. In adults the sinus floor is 0.5-1 cm below that of the nasal cavity *(Figure 15).* The maxillary alveolus atrophies in edentulous patients so that the floor may be even lower.

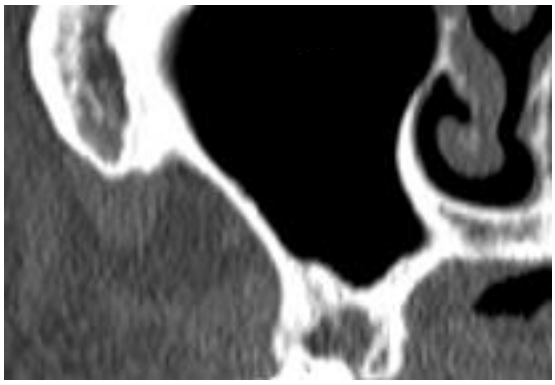

*Figure 15: Floor of sinus lower than nasal floor in adults*

No significant ***vessels*** are encountered during Caldwell-Luc antrostomy other than the small ***infraorbital vessels*** that exit the infraorbital foramen to supply the overlying soft tissues of the face *(Figure 16)*.

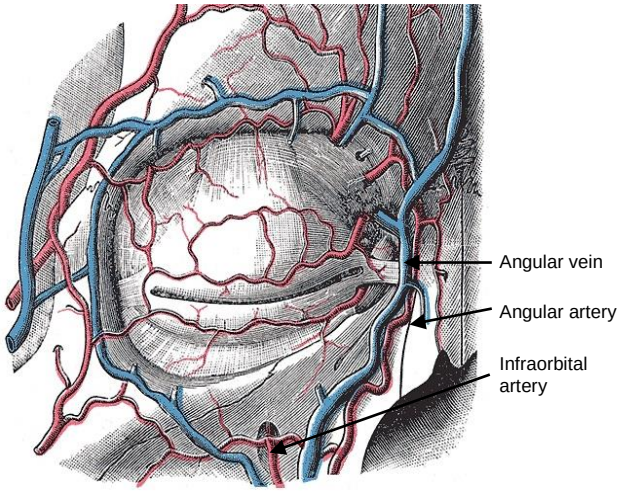


*Figure 16: Vasculature around the orbit*

Only if one breaks through the posterior wall of the sinus does one encounter the ***internal maxillary artery***, a branch of the external carotid artery, which, passes through the pterygomaxillary fissure to enter the pterygopalatine fossa *(Figures 17, 18)*.

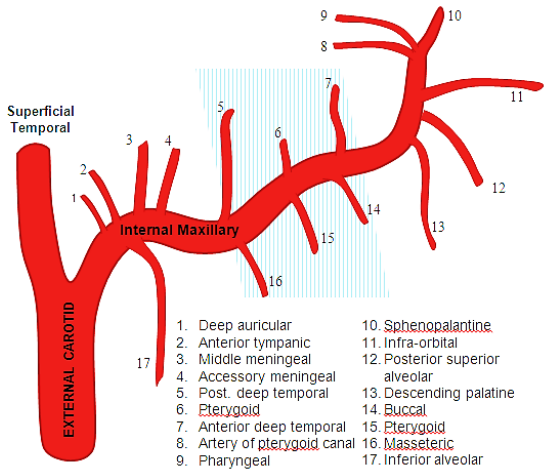


*Figure 17: Branches of internal maxillary artery; blue shaded area is the 2nd part of artery before it enters the pterygopalatine fossa*

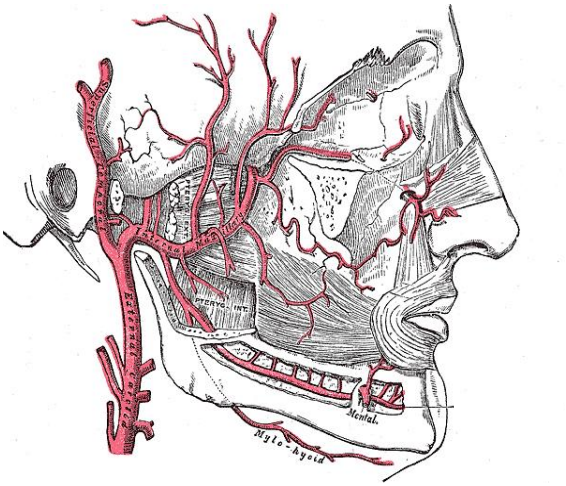

*Figure 18: Branches of internal maxillary artery*

**Caldwell-Luc / Radical antrostomy**

The Caldwell-Luc operation involves making an opening in the thin bone of the canine fossa and entering the maxillary sinus. It was first employed to remove infection and to strip diseased mucosa from the maxillary sinus; counter-drainage into the nose was established via an inferior meatal antrostomy. However with an improved understanding of sinus pathophysiology, and introduction of endoscopic, mucosa-sparing functional sinus surgical

techniques, the Caldwell-Luc procedure is now infrequently used to treat sinusitis.

### *Indications*

- Biopsy or resection of tumours of the nose and paranasal sinuses
- Transantral access for tumours in the pterygopalatine fossa
- Transantral ligation of internal maxillary artery and its branches for epistaxis
- Transantral access for fractures of the midface and orbital floor
- Orbital decompression
- As part of medial maxillectomy procedure *e.g.* to resect juvenile nasopharyngeal angiofibromas
- Removal of foreign bodies *e.g.* bullets or dental roots, from the antrum
- Removing base of antrochoanal polyp
- Transantral ethmoidectomy approach to ethmoids and sphenoid *e.g.* for pituitary resection
- Repairing oroantral fistulae
- Dental cysts
- Vidian neurectomy
- Chronic sinusitis in the absence of endoscopic sinus surgery facilities

### *Age considerations*

Caldwell-Luc is generally contraindicated if <7yrs of age

- Expansion of maxillary sinus continues until adulthood at 2-3 mm/year
- At birth, the floor of sinus approx. 4mm above nasal floor
- At 8-9 years: Floors of sinus and nasal cavity about at same level, and sinus dimensions 2 x 2 x 3cms
- Adult: Sinus floor usually 5-10 mm lower than nasal cavity

### *Imaging*

This is routinely done to assess the size of the sinus and the height of its floor relative to the nasal floor, to exclude hypoplasia and unerupted dentition, and to evaluate underlying pathology. Even though centres may only have access to sinus X-rays, CT scan is a far superior investigation. Both axial and coronal CT should be requested. Coronal views provide information about the orbit, orbital floor, sinus floor and alveolus, and lateral wall of the nose and sinus ostia. Axial views provide information about the anterior wall of the sinus, the pterygopalatine fossa and infratemporal fossa *(Figures 1, 12, 13)*. MRI may be useful to assess pathology as it distinguishes between soft tissue and mucus.

### *Consent*

- Sublabial incision
- Possibility of sensory loss of cheek, lower eyelid, side of nose, upper gum and teeth
- Change in facial contour: initial swelling of cheek, and if large antrostomy, hollowing of cheek
- Risk of oroantral fistula

### *Anaesthesia*

- General or local anaesthesia block of posterosuperior alveolar nerve and the buccogingival sulcus with lidocaine 1% with 1:100,000 epinephrine
- Prophylactic antibiotics and steroids are not routinely administered
- Supine position
- Decongest nasal mucosa with nasal decongestant if intranasal surgery is anticipated
- Intubation: transnasal (contralateral) or transoral
- Throat pack: author does not use a throat pack, but suction the throat at conclusion of surgery

***Surgical steps***

- Retract the upper lip with retractors *(Figure 19)*
- Incise the gingivolabial /gingivobuccal mucosa from the lateral incisor to the 2nd molar with a scalpel or with diathermy, 1cm from the gingivolabial sulcus to leave a free edge of mucosa that can be sutured at the end of the procedure *(Figure 19)*. Avoid placing the incision over the antrostomy to lessen the risk of an oroantral fistula

*Figure 19: Incising gingivolabial/gingivobuccal mucosa on (R) side*

- Extend the incision through periosteum onto the bone of the face of the maxilla
- Elevate the soft tissues superiorly off the face of the maxilla in a subperiosteal plane with a periosteal elevator *(Figure 20)*
- Identify and preserve the infraorbital nerve and its branches at the infraorbital foramen *(Figure 20)*
- Identify the following bony surface landmarks: canine eminence, infraorbital foramen, and canine fossa *(Figures 20, 21)*

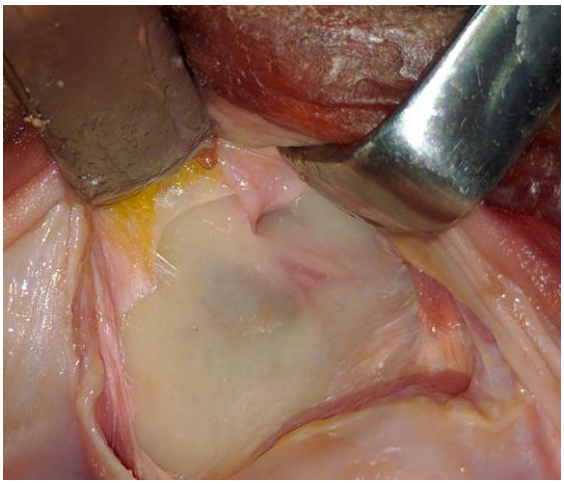

*Figure 20: Elevate soft tissues off face of maxilla and expose infraorbital nerve and foramen; note thin bone of canine fossa*

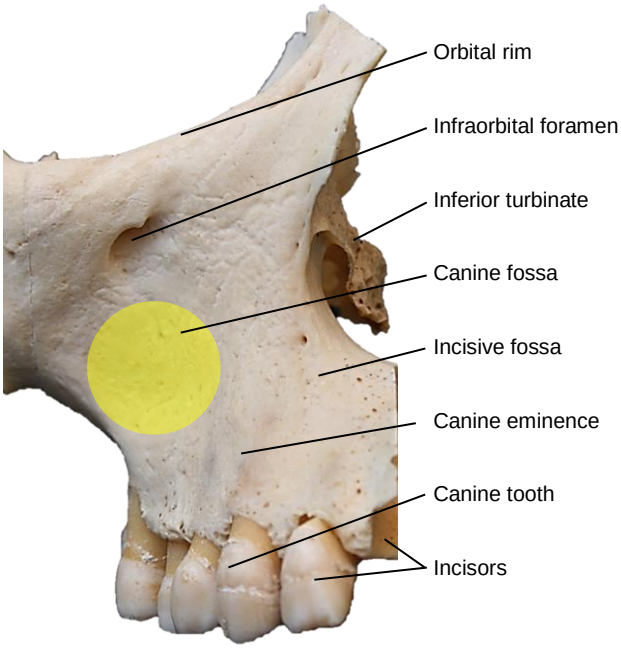


*Figure 21: Right canine fossa (yellow), incisive fossa and canine eminence*

- Use a small osteotome and mallet or a cutting burr to make an antrostomy in the thin bone of the canine fossa *(Figure 22)*
- Sample pus encountered in the maxillary sinus for culture
- Inspect the antrum

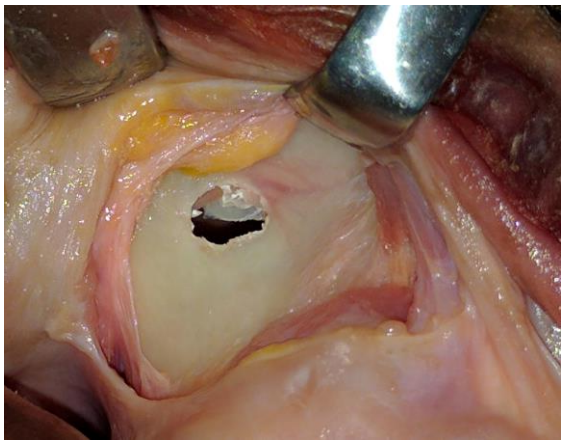

*Figure 22: Antrostomy in canine fossa*

- Enlarge the antrostomy with Kerrison's rongeurs or a bone nibbler or a drill as much as is required, taking care not to injure the neurovascular supply to the dental roots and the infraorbital nerve *(Figure 23)*

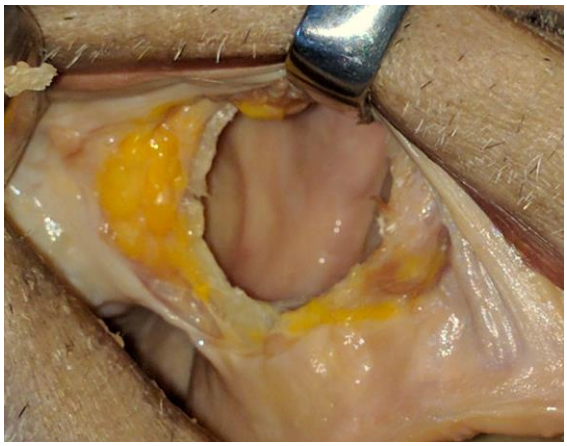

*Figure 23: Enlarge antrostomy avoiding injury to neurovascular supply to dental roots and infraorbital nerve*

- Address the underlying pathology
- Irrigate the sinus
- Control bleeding from the edges with electrocautery, or bone wax
- At conclusion of surgery, carefully close the incision with absorbable sutures *e.g.* catgut or vicryl to avoid an oroantral fistula

***Complications***

- Bleeding: pack nose
- Sensory loss of infraorbital nerve: most patients have temporary hypaesthesia due to traction on the nerve which resolves in 4- 6 weeks
- Numbness of canine and premolar teeth: this may occur when excessive removal of bone in dentate patients injures branches of the superior alveolar nerve as they traverse the inferior anterior maxillary wall
- Sublabial oroantral fistula
- Osteomyelitis of maxilla
- Injury to nasolacrimal duct with inferior meatal antrostomy

***Closing a Caldwell-Luc related oroantral fistula***

- Local mucosal flaps
- Buccal fat pad flap
- Superiorly-based buccinator myomucosal flap

**Inferior meatal antrostomy**

Inferior meatal antrostomy is done only in selected cases to provide drainage, aeration, and to remove packing from the antrum or to facilitate postoperative surveillance. Ciliary action continues to propel mucus towards the middle meatus; therefore inferior meatal antrostomy achieves only dependent drainage of antral secretions.

The inferior meatus is tucked under the inferior turbinate *(Figure 24)*. The turbinate is attached along the lateral bony nasal wall in an arc with its highest point (genu) situated at the junction of its anterior and middle thirds. The nasolacrimal duct opens at or just anterior to the most cephalic portion of the inferior meatus, under the genu of the turbinate.

The thinnest bone lies in the superior, central portion of the meatus *(Figure 25)*. The thickness and quality of the bone changes within the inferior meatus; there is a gradual switch from compact to lamellar bone as one moves from to top to bottom, and from the front to the back.

*Figure 24: The (R) inferior meatus is tucked under the inferior turbinate*

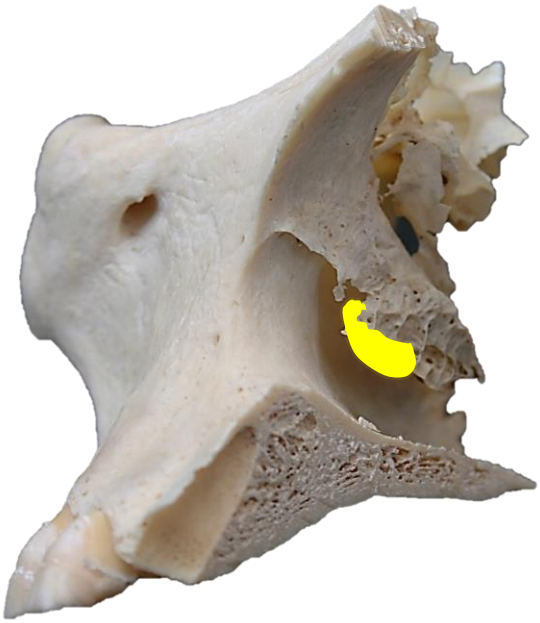

*Figure 25: Inferior meatal antrostomy is made through the thin medial wall of antrum medial to the inferior turbinate*

The thickness of the bone inferiorly makes it difficult to extend the antrostomy to the nasal floor. The bony thickness and decreasing height of the meatus prevents anterior surgical extension, hence making injury to the nasolacrimal duct unusual.

- Spray the nasal cavity with decongestant and wait a few minutes for shrinkage of the mucosa to occur; this facilitates insertion of cotton wool into the inferior meatus and drainage through the natural maxillary ostium
- Visualise the inferior turbinate and inferior meatus with a headlight using a Thudicum speculum *(Figure 26)*

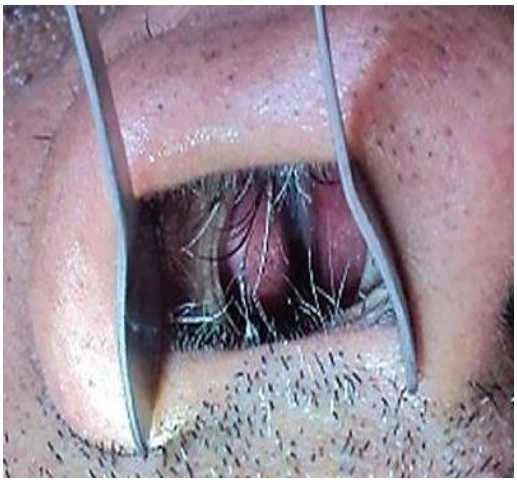

*Figure 26: Exposing inferior turbinate with Thudicum speculum*

- Elevate the inferior turbinate with an elevator and insert cotton wool soaked with topical anaesthesia/vasoconstrictor into the inferior meatus and/or infiltrate lidocaine 1% / epinephrine 1:100,000
- Advance a curved haemostat into the antrum from the inferior meatus and punch through the thin bone at the highest point under the genu of the turbinate at the junction of the anterior and mid-thirds of the inferior meatus *(Figures 27, 28)*

- Enlarge the antrostomy with side-biting forceps to make a 2 x 1cm window *(Figure 29)*

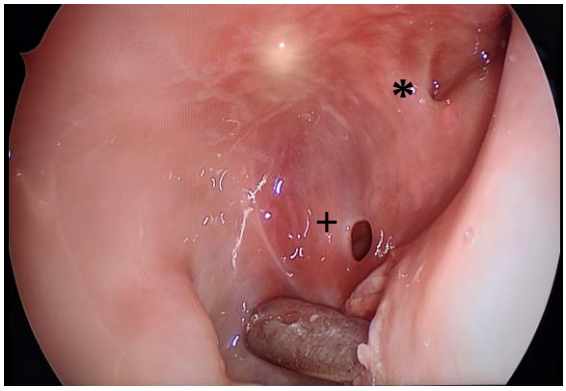


*Figure 27: View from inside antrum of instrument entering (R) antrum via inferior meatal antrostomy. Note accessory* (+) *and natural maxillary ostia* (*)

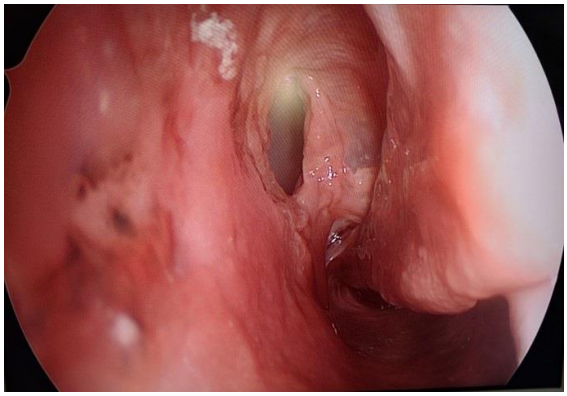

*Figure 28: (R) inferior meatal antrostomy through thin medial wall of antrum medial to the inferior turbinate*

- Lower the inferior rim as much as possible to minimise a sump effect
- Reposition the inferior turbinate
- Some surgeons trim a small anterior segment from the inferior turbinate
- Saline irrigation is used postoperatively

***Packing the antrum***

- This may be required for bleeding
- Pack the antrum with ribbon gauze impregnated with liquid paraffin or antiseptic cream
- Bring the end of the ribbon through the inferior meatal antrostomy for later removal through the nose

***Postoperative Care***

- Apply ice packs to the cheek to reduce oedema and discomfort
- Remove packing after 24 hours
- Avoid blowing the nose to prevent surgical emphysema
- Irrigate the nose with saline if an inferior meatal antrostomy has been done
- Avoid inserting an upper denture for 7-10 days to allow the gingivolabial incision to heal and to avoid an oroantral fistula

***Complications of inferior metal antrostomy***

- ***Haemorrhage*** from inferior meatal branch of the lateral sphenopalatine artery if the antrostomy is extended too far posteriorly haemorrhage
- ***Nasolacrimal duct injury*** is rare due to its position and the quality of the surrounding bone

**Canine Fossa Puncture (CFP)**

CFP is employed to obtain a sample of mucus or pus from the maxillary sinus, and to irrigate the sinus *(Figure 29)*. It is particularly useful in a patient lying supine *e.g.* in intensive care, and is preferred to inferior meatal puncture in a patient with a coagulopathy as bleeding can be controlled by applying local pressure to the puncture site.

*Figure 29: Trocar with outer cannula for proof puncture and sinus irrigation*

CFP is also used to insert an endoscope into the maxillary sinus as an adjunct to transnasal endoscopic sinus surgery to improve visualization of *e.g.* the anterior sinus or the pterygopalatine fossa *(Figure 30).*

*Figure 30: Thicker (4mm) trocar with outer cannula through which an endoscope can be passed into the antrum*

- Positioning
  - Sitting position to allow sinus contents to drain through the nose into a bowl held under the nose
  - In unconscious patients, suction the oropharynx during sinus puncture to protect the airway
- Anaesthesia: In adults it is usually done using local anaesthesia/vasoconstrictor (*e.g.* lidocaine 1% with epinephrine 1:100,000) infiltrated into the region of the canine fossa; a general anaesthetic is usually required with children
- Apply the tip of the trocar to the mucosa overlying the canine fossa, and push it through the thin bone into the antrum, keeping in the same vertical plane as the hard palate to avoid the orbital floor. As the sinus measures 38-45mm in length in the adult, you are unlikely to penetrate its posterior wall
- Remove the inner trocar leaving the outer cannula in the sinus
- Advance the cannula until it makes contact with the posterior wall of the sinus
- Retract the cannula 1- 2cms so that the tip is in the center of the sinus cavity
- Fit a saline-filled syringe to the cannula
- Aspirate and send the aspirate for MCS
- Refill the syringe with saline, and gently flush the sinus while observing the eye for swelling in the event that the floor is dehiscent or has been entered with the trocar
- Keep irrigating the sinus until the fluid exiting the nose is clear
- Remove the cannula

**Inferior Meatal Puncture**

Inferior meatal puncture is employed to obtain a sample of mucus or pus from the maxillary sinus, and/or to irrigate the sinus using a trocar and cannula *(Figure 31).*

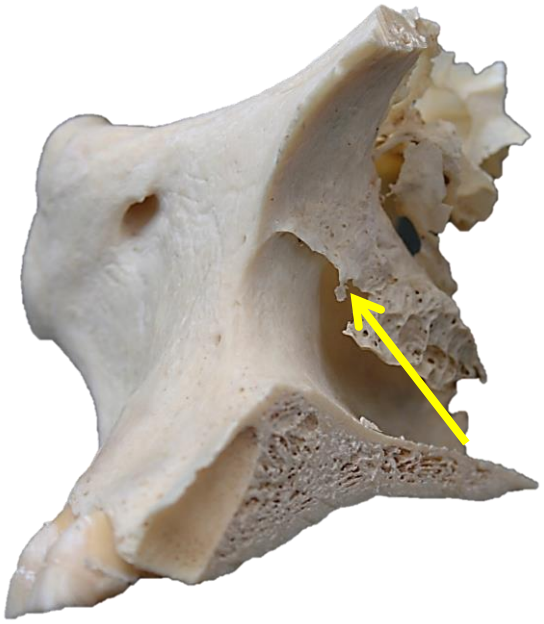

*Figure 31: Thin medial wall of antrum medial to inferior turbinate through which inferior meatal puncture is done*

The inferior meatus is tucked under the inferior turbinate *(Figures 24, 31).* The turbinate is attached along the bony lateral nasal wall in an arc with its highest point (genu) situated at the junction of its anterior and middle thirds. The nasolacrimal duct opens at or just anterior to the genu. The thinnest bone lies in the superior central portion of the meatus. Hence IMP is done through the thin bone at the genu

of the turbinate high up in the middle meatus at the junction of the anterior and mid-thirds of the inferior meatus.

- Place the patient in a sitting position to allow sinus contents to drain through the nose into a bowl held under the nose
- Spray the nasal cavity with decongestant and wait a few minutes for shrinkage of the mucosa to occur; this facilitates insertion of cotton wool into the inferior meatus and drainage through the natural maxillary ostium
- Visualise the inferior turbinate and inferior meatus with a headlight using a Thudicum speculum *(Figure 27)*
- Insert cotton wool soaked with topical anaesthesia/vasoconstrictor into the inferior meatus and/or infiltrate lidocaine 1% / epinephrine 1:100,000 into the region of the canine fossa; a general anaesthetic is usually required with children
- Pass the tip of the trocar into the nose (curved trocar preferred to reduce risk of orbital injury); control the trocar by holding its body in the palm of the hand and the index finger on the shaft
- Advance the tip of the trocar superiorly below the inferior turbinate along the inferior meatus towards its genu (1cm above the floor of the nose, one third of the way along the length of the turbinate)
- Steady the back of the head with opposite hand
- Direct the trocar through the thin bone, aiming for the tragus of the patient's ear to avoid the orbital floor *(Figure 32)*
- Advance the trocar into the sinus
- Remove the trocar, leaving the cannula in place
- Advance the cannula until you feel the posterior wall of the sinus
- Retract the cannula 1- 2cms so that the tip is in the center of the sinus cavity
- Lean the patient forward while holding a bowl under the chin to collect the irrigation fluid, and tell him/her to breathe through the mouth
- Fit a saline-filled syringe to the cannula
- Aspirate and send the aspirate for MCS
- Refill the syringe with saline and gently flush the sinus while observing the cheek and the eye for swelling in the event that the floor is dehiscent or has been entered with the trocar

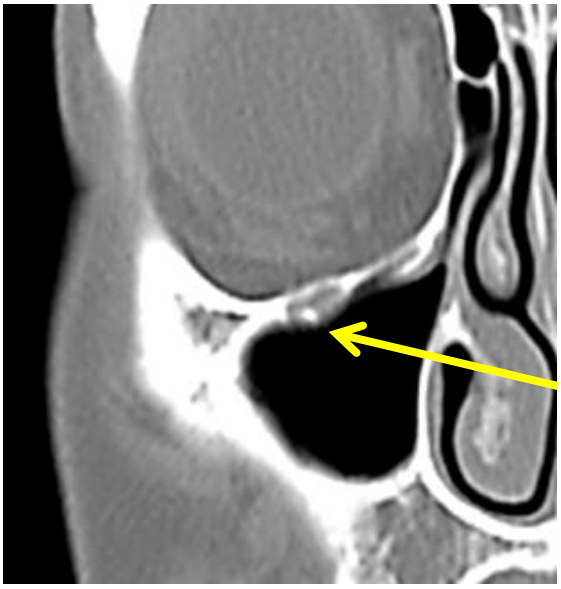

*Figure 32: Note proximity of orbital floor making it easy to direct the trocar into the orbit*

- Avoid insufflating the sinus with air as a fatal air embolus may ensue
- Keep irrigating the sinus until the fluid exiting the nose is clear
- If the sinus ostium is occluded, introducing a second cannula alongside the first drainage may facilitate lavage
- Remove the cannula

***Contraindications for meatal punctures***

- Children < 3 years: Proximity of orbital floor and teeth in a small maxillary sinus; underdeveloped maxilla has thick bony walls

- Untreated febrile acute maxillary sinusitis: inferior meatal puncture may cause osteomyelitis and septicaemia
- Midfacial trauma: may have disrupted the orbital floor

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